INKOMATI-USUTHU

CATCHMENT MANAGEMENT AGENCY

ECOSTATUS OF THE USUTHU-LUSUTFU CATCHMENT

INKOMATI RIVER SYSTEM PHASE II (2019)

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VISION

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

MISSION

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

VALUES

Integrity
Batho Pele (Stakeholders Orientation)
Accountability
Diversity
Transparency

ECOSTATUS OF THE USUTHU-LUSUTFU CATCHMENT, INKOMATI RIVER SYSTEM

Phase II (2019)

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Inkomati-Usuthu Catchment Management Agency

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List of Abbreviations

cfu	=	colony forming units
CMAs	=	Catchment Management Agencies
DO	=	Dissolved Oxygen
DWA	=	Department of Water Affairs
DWAF	=	Department of Water Affairs and Forestry (pre-April 2010)
DWS - RQIS	=	Department of Water and Sanitation - Resource Quality Information Services
DWS	=	Department of Water and Sanitation
EC	=	Ecological Category
EI	=	Ecological Importance
ES	=	Ecological Sensitivity
EWR	=	Ecological Water Requirements
FRAI	=	Fish Response Assessment Index
GE	=	Google Earth
GPS	=	Global Positioning System
IHI	=	Index of Habitat Integrity
IUA(s)	=	Integrated Unit(s) of Analysis
IUCMA	=	Inkomati-Usuthu Catchment Management Agency
m.a.s.l.	=	metres above sea level
MIRAI	=	Macro-invertebrate Response Assessment Index
MTPA	=	Mpumalanga Tourism and Parks Agency
PAI	=	Physico-chemical driver Assessment Index
P-C (category)	=	physico-chemical (category)
PES	=	Present Ecological State
PES/EI/ES	=	Present Ecological State / Ecological Importance / Ecological Sensitivity
PES-EIS	=	Present Ecological State - Ecological Importance and Sensitivity
RC	=	Reference Condition

RDM	=	Resource Directed Measures
REC	=	Recommended Ecological Category
REMP	=	River Ecostatus Monitoring Programme
RHP	=	River Health Programme
RIVDINT	=	River Data Integration
RQO(s)	=	Resource Quality Objective(s)
RU	=	Resource Unit
RWQO(s)	=	Receiving Water Quality Objective(s)
SASS5	=	South African Scoring System, Version 5
SQR	=	Sub-quaternary Reach
TDS	=	Total Dissolved Solids
TEC	=	Target Ecological Category
TIN	=	Total Inorganic Nitrogen
TPC	=	Threshold of Potential Concern
TPTC	=	Tripartite Permanent Technical Committee
TWQR	=	Target Water Quality Range
VEGRAI	=	Riparian Vegetation Response Assessment Index
WMA	=	Water Management Area
WMS	=	Water Management System
WQ	=	water quality
WRCS	=	Water Resoure Classification System
WWTW	=	Waste Water Treatment Works

1. INTRODUCTION

Aquatic ecosystems all over the world are severely stressed by the ever-increasing demand for water, linked to growing industrial and agricultural developments as well as large-scale urbanization. This situation is exacerbated in South Africa by our dry climatic conditions, resulting in most of our rivers being small non-perennial rivers with erratic flow. Although aquatic ecosystems are frequently subjected to extreme events such as floods or droughts they can recover, which suggests that rivers can be used without causing permanent damage or change to their physical and chemical properties. However, a water resource is an aquatic ecosystem that comprises the physical aquatic habitat with its biota (both instream and riparian), linked to its physical, chemical and ecological processes. An understanding of its natural structure and function and its responses to development and exploitation are therefore essential to conserve it in a state where it can maintain its natural biodiversity. A recent analysis of the long-term trends in the water quality of rivers in the Olifants-Limpopo and Inkomati catchments, indicated a general decrease in "water quality at sites in mid to low catchments" (Griffin et al. 2014). Indeed, the quality of South Africa's water resources are deteriorating (CSIR 2010). Some of the main known challenges include the following (Dallas & Day 2004; Davies et al. 1993; Davies & Day 1998; Griffin et al., 2014):

- over abstraction;
- habitat alteration (e.g. sedimentation, bank and bed scouring, flow regulation, and more);
- eutrophication;
- acid mine drainage;
- sewage effluents;
- anthropogenic salinization;
- toxic organic compounds, and
- invasive species (fauna and flora).

Although water quality state at present appears to be Good across the Upper Usuthu (DWS, 2014d), with the Usuthu River being approximately in balance (DWA, 2013), the extent of current and future mining activities poses a threat to water quality. According to the South African Mine Water Atlas (2018) the *Mineral Risk*, i.e. the assessed risk of acid production and/or leaching of constituents of concern into the environment, is high for a number of quaternary catchments in the study area.

A world-wide trend since the 1980's has been the introduction of instream biomonitoring as part of water resources management. This type of monitoring commonly referred to as biomonitoring is increasingly being recognized as an important component in the overall assessment of water resources. The use of biological field assessments of fish and/or macro-invertebrate communities provides an integrated and sensitive measurement of environmental problems and represents progress in the assessment of ecological impacts and in the management of aquatic ecosystems (Karr et al., 1986).

A national bio-monitoring program for South African Rivers, the River Health Program (RHP) was implemented and launched in September 1996 to monitor and thus improve and manage the health of South African freshwater ecosystems. The RHP has been established to provide water managers with relevant information to manage the resource. The RHP focuses on selected ecological indicators that are representative of the larger ecosystem and are practical to measure (http://www.dwa.gov.za/iwqs/rhp/rhp_background.aspx). In 2016 the RHP programme was replaced with the River Ecostatus Monitoring Programme (REMP) as captured in the Department of Water and Sanitation Business plan also stipulated as a function of the Catchment Management Agencies (CMA's) (http://www.dwa.gov.za/iwqs/).

The Inkomati – Usuthu Catchment Management Agency (IUCMA) appointed the Mpumalanga Tourism and Parks Agency (MTPA – Scientific Services: Aquatic Systems) as a service provider to conduct follow-up biomonitoring surveys (first surveys in 2015, IUCMA Report January 2016 - IUCMA, 2016) within the Usuthu-Lusutfu River catchment in the 2019/2020 financial year to determine the Present Ecological State of this river system.

Biomonitoring in the Usuthu-Lusutfu catchment was conducted during the months August to October 2019. During this survey forty one (41) sites were sampled in the Usuthu-Lusutfu River and its tributaries, including Assegaai-Mkhondvo, Hlelo, Ngwempisi, Mpuluzi and Lushushwane, as well as the tributaries in the sub-catchment. Previously monitored sites (2010/2015) 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 models and methods (DWAF 2008; Kleynhans, 2008; Thirion, 2008; Kleynhans et al., 2009) as listed below:

- Fish Response Assessment Index (FRAI)
- Macro-Invertebrate Response Assessment Index (MIRAI)
- Riparian Vegetation Response Assessment Index (VEGRAI)
- Index of Habitat Integrity (IHI) models
- Available water quality data for the sites identified by the IUCMA, i.e. the *Ecological Water Requirement (EWR) site* on the Assegaai River, EWR AS1, and sites where international water quality obligations need to be met, according to the agreement signed by the Tripartite Permanent Technical Committee (TPTC) of South Africa, Mozambique and Swaziland (TPTC, 2002). Data were analysed using standard methods, i.e. the Physico-chemical driver Assessment Index (PAI) model, and present state and compliance with monitoring objectives assessed.

1.1 Objectives of the Survey

The objective of this study is to determine the current Ecostatus (2019) of the Usuthu- Lusutfu Catchment and some of its main tributaries based on the rapid assessment of aquatic macro-invertebrates using the South African Scoring System version 5 (SASS5) with the Macro-invertebrate Response Assessment Index (MIRAI) (Thirion, 2008), the Fish Response Assessment Index (FRAI) (Kleynhans, 2008), Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al., 2007), Index for Habitat Integrity (Kleynhans et al., 2009), the Physico-chemical driver Assessment Index (PAI) model (DWAF 2008), and the integration of these indices to provide an integrated Ecostatus per sub-quaternary reach (SQR) (Kleynhans & Louw, 2008). This study will provide useful ecological information through an aquatic assessment, the determination of the Present Ecological State (PES) of the associated aquatic habitat of the Usuthu-Lusutfu River and trends in aquatic health over time, as well as a comparison with previous surveys (2015) to inform on management interventions required to address systemic and point specific impacts. Monitoring is only a valid term to use if the results of this survey are measured against targets (Greenwood & Robinson, 2006.)

The Preliminary Reserve study for this system provide background information, ecological objectives and monitoring targets. The Chief Directorate: Resource Directed Measures (CD: RDM; now CD: Water Ecosystems) commissioned the Intermediate Reserve Determination study during 2013 which was undertaken by Tlou Consulting (Pty) Ltd. three-year period between 2013 and 2015. Water Resource Classification has not yet been undertaken for the Usuthu-Lusutfu River system.

The results of this 2019 survey should therefore be compared to the EcoSpecs and other monitoring objectives defined for water quantity and quality, and habitat and biota during the Reserve study. These objectives were published in DWS, 2014c.

1.2. Study Area

Usuthu-Lusutfu catchment description

The Greater Usuthu basin is part of the Maputo River basin which is shared by the Republic of South Africa, Kingdom of Swaziland and Republic of Mozambique (Figure 1 and 2). The source of the Greater Usuthu River is in South Africa on the Drakensberg Mountains in Mpumalanga Province, this river then flows in an easterly direction and enters Swaziland where it meanders for about 202km until it forms a border between South Africa and Swaziland (Lebombo Mountains). It then flows north-eastwards to enter Delagoa Bay (Mozambique), which is south-east of the city of Maputo, before finally emptying itself into the Indian Ocean (Vilane & Tembe, 2016). The Maputo River's total catchment surface area is 30,439 km^2, of which 16,697 km^2 (55 %) incorporates the Usuthu-Lusutfu Catchment (Midgley et al. 1994).

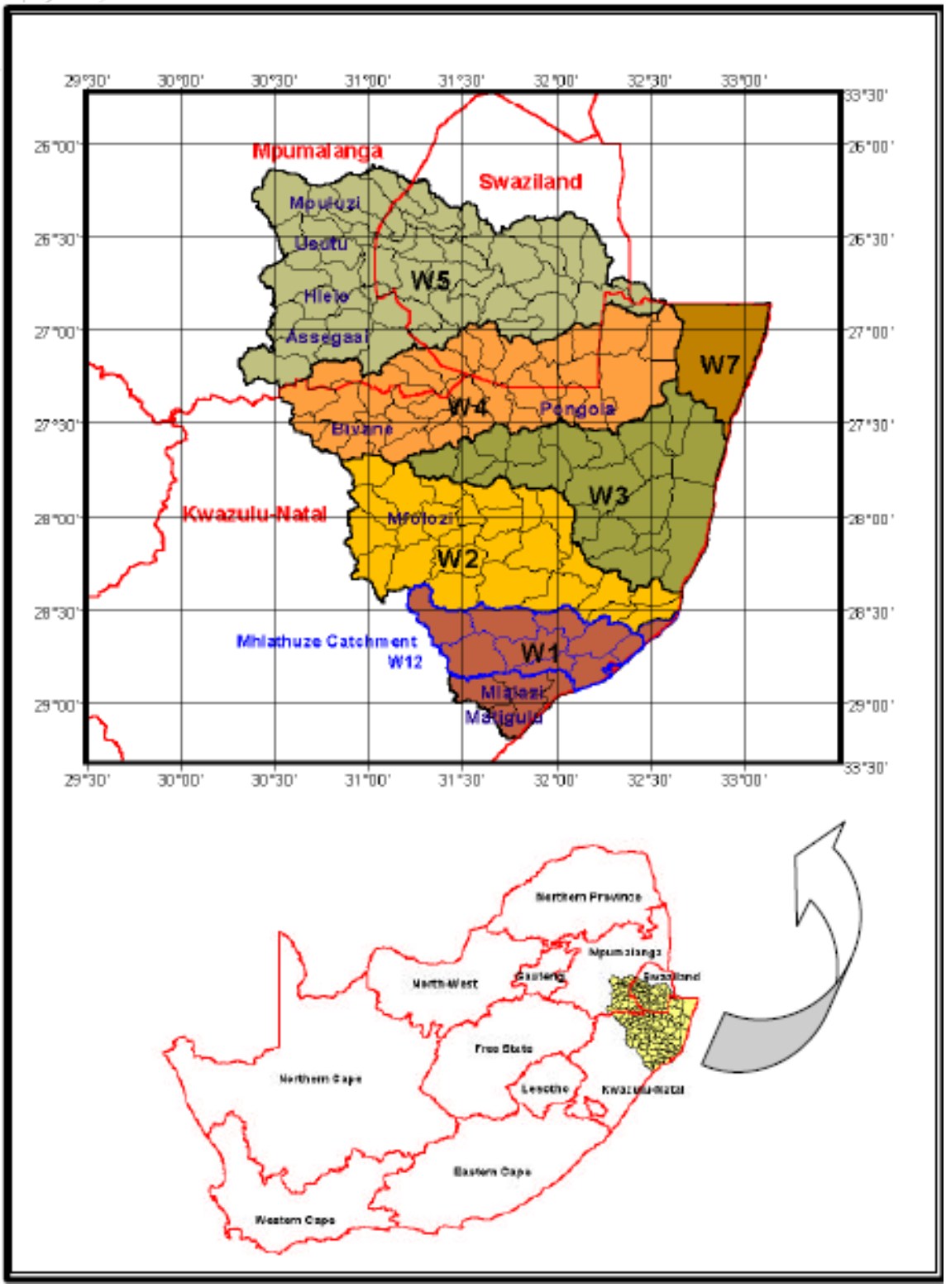


Figure 1: Map indicating the location of the Usuthu-Lusutfu catchment within southern Africa (DWAF 2004).

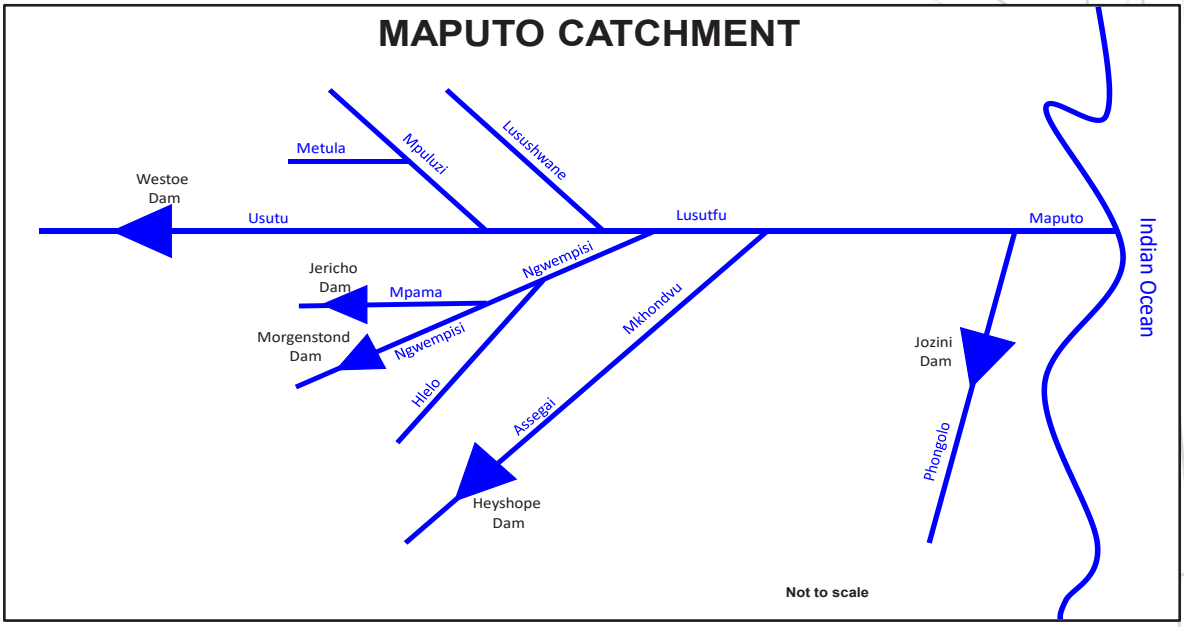


Figure 2: Schematic drawing of Maputo catchment indicating tributaries and dams

There are numerous inter-basin water transfers between the different tertiary-catchments to supply Eskom with high quality water for use in cooling systems for coal-fired power stations in the Vaal (C) and Olifants (B) catchment areas (DWAF 2004). The four dams in the Assegai, Ngwempisi and Usuthu catchments were specifically constructed to support these transfers. The Westoe Dam is situated in the Usuthu River, the Jericho Dam is within the Mpama River with the Morgenstond Dam in the Ngwempisi River and lastly the Heyshope Dam in the Assegai River (Figure 3).

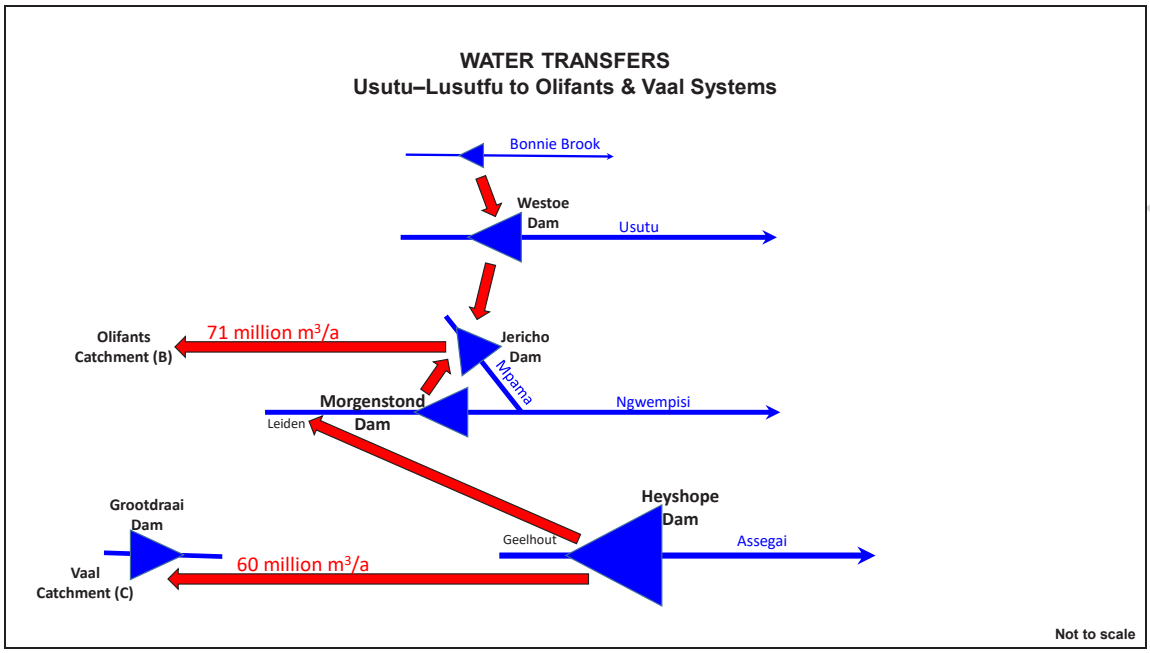


Figure 3: Schematic drawing indicating the location of dams and water tranfers in the Usuthu-Lusutfu catchment within southern Africa.

Water availability in the South African portion of the Usuthu (including tertiary catchments) catchment is calculated as gross 249 million m^3 per annum, and the net 196 million m^3 per annum (Table 1). The ecological reserve and invasive plants usage is based on estimates, and the water use of invasive plants is likely to be more, especially during drought conditions in the growing season.

Table 1: Water availability in the Usuthu Catchment in South Africa at 1:50,000 year assurance (DWAF 2004).

CATEGORY		Million m^3
Gross Surface Water Resource		**249**
Subtract	Ecological Reserve	-52
	Invasive Alien Plants	-1
	Dryland Sugar Cane	0
Net Surface Water Resource		**196**
Add	Groundwater	2
	Return Flows	4
Total Yield		**202**

For more information on the water availability, water use and water transfers in the Usuthu Catchment see Usuthu-Lusutfu Report 2015 (IUCMA, 2016).

The Greater Usuthu River's water quality situation have been worsening due to the drought which affected the South African region over the past decade. Development in the upper Usuthu catchment is generally limited with the only towns of significant size being Piet Retief and Amsterdam. The main land-use is forestry with limited commercial and subsistence agriculture in the south-west (DWA, 2013; DWS, 2014d). General land use practices that pose water quality problems within the study area include the following:

- Non-point source pollution from agriculture (pesticides, fertilizers), although limited in extent.
- Non-point source pollution from residential areas (urban and rural townships) e.g. stormwater run-off, washing in rivers, but again limited in extent as the Upper Usuthu is not highly populated. Low growth is expected for this area (DWA, 2013), meaning that the quality status quo could be maintained.
- Point source pollution from urban infrastructure, e.g. Waste Water Treatment Works (WWTW) around Piet Retief and Amsterdam towns in particular.
- Microbiological counts and nutrient concentrations are problematic in some catchments, but appear to be localised issues.
- The presence of alien invasive plants, removal of vegetation and overgrazing within the riparian zone of rivers, which results in erosion and sedimentation.
- The dams and weirs impact on the movement of sediment, and temperature and oxygen levels.
- Mining activities, i.e. Cascade Iron Ore west of Piet Retief in W51C, and coal mining in the following areas: Taaiboschspruit Colliey in W53A, Panbult in W52A, Savmore and Balgarthan collieries in W51B, Kwasa Anthracite Colliery in W51C and Assegai coal mine in W51A. Bauxite Fields

Aluminium are located in W51A, Transvaal Supergroup uranium deposits in W53D, and Usushwana Iron Complex in W51F (South African Mine Water Atlas, 2018).

Although water quality state at present appears to be **Good** across the Upper Usuthu (DWS, 2014d), the extent of current and future mining activities poses a threat to water quality. According to the South African Mine Water Atlas (2018) the *Mineral Risk*, i.e. the assessed risk of acid production and/or leaching of constituents of concern into the environment, is **High** for the following quaternary catchments: W51A and B, W52A, W53A, W54A, part of W55A, sections of W52C and W53D (uranium deposit area) and part of W61D. The *Surface Water Threat Risk*, i.e. risk of impact of mining on surface water resources at a quaternary catchment level, is **High** for W53A. A **Moderate risk** is shown for the following quaternary catchments: W54A, W53C, W52B, and W51A-C.

Reductions in flows, e.g. due to drought or over-abstraction, results in the increase of heavy metal concentrations and other pollutants in the river, which is affecting aquatic ecosystems. Climatic models assessing the impact of climate change in the Greater Usuthu River basin, indicate a maximum reduction of annual runoff of up to 12.6% or 113.6 million m^3 annually. (Vilane & Tembe, 2016).

Ecoregions are founded on the premise that ecosystems and their components display regional patterns reflected in spatially variable combinations of causal factors such as physiology, climate, geology, soils and natural vegetation. Based on the Level 1: River Ecoregional Classification System for South Africa (Kleynhans et al., 2005) the Usuthu- Lusutfu Catchment falls within the following Ecoregions:

- Ecoregion 3: Lowveld

  This hot and dry region can be characterised by plains with a low to moderate relief and vegetation consisting mostly of Lowveld Bushveld types (Mopane Bushveld; mixed Lowveld Bushveld). Towards the west on the boundary with the North Eastern Highlands, open hills and low mountains with high relief are present. The mean annual precipitation tends to be moderate towards the west, but low over most of the region (200 mm to 1000 mm). The stream frequency is mostly low to medium, but high in some of the central areas with slopes < 5% to >80% of the area (Kleynhans et al., 2005).
- Ecoregion 4: North Eastern Highlands

  This is a mountainous area characterised by closed hills and mountains with moderate to high relief. The vegetation type comprises of North-Eastern Highveld Grassland and Lowveld Bushveld types although patches of Afromontane Forest is scattered throughout the region. This Ecoregion is a transitional zone between the Lowveld and Northern Escarpment. The mean annual precipitation varies between 400 mm to 1000 mm and is described as moderate to high. The stream frequency varies between low, medium, and medium high with slopes <5%: varying between <20% to 25% – 50 % (Kleynhans et al., 2005).
- Ecoregion 11: Highveld

Mostly plains with low to moderate relief, dominated by moist grasslands. The mean annual precipitation is high in most areas and range between 400 mm to 1000 mm. The stream frequency for the ecoregion is mostly low to high with slopes <5% consisting <80 % of the ecoregion (Kleynhans et al., 2005).

- Ecoregion 15: Eastern Escarpment Mountains

This high lying region is characterized by closed hills, mountains with moderate and high relief with prominent escarpments towards the east. The vegetation consists of a range of grassland types with Afro Mountain and Alti Mountain Grassland being the defining types. The mean annual precipitation is described as moderate to very high and range between 400 to 100mm. The stream frequency for the ecoregion is medium high with slopes < 5% consisting of 20% of the ecoregion (Kleynhans et al., 2005).

Table 2: Geomorphological zonation of River Channels according to Rowntree and Wadeson (1999).

Longitudinal zone	Macro-reach characteristics			Characteristic channel features
	Valley form	Gradient class	Zone class	
A. Zonation associated with a "normal" profile				
Source zone	*V10*	*Not specified*	S	Low gradient, upland plateau or upland basin able to store water. Spongy or peaty hydromorphic soils.
Mountain headwater stream	*V1. V3*	*>0.1*	A	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascade.
Mountain stream	*V1. V3*	*0.04 – 0.039*	B	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool. Approximate equal distribution of "vertical" and "horizontal" components.
Transitional	*V2. V3. V4. V6*	*0.02 – 0.039*	C	Moderately steep stream dominated by bedrock and boulder. Reach types include plain-bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited flood plain development.
Upper Foothills	*V4. V6*	*0.005 – 0.019*	D	Moderately steep, cobble-bed or mixed bedrock-cobble, bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles rapids similar. Narrow flood plain of sand, gravel or cobble often present.
Lower Foothills	*V8. V10*	*0.001 – 0.005*	E	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids of riffles. Floodplain often present.
Lowland river	*V4. V8. V10*	*0.0001 – 0.001*	F	Low gradient alluvial fine bed channel, typically regime reach type. May be confined but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.

2. REACH AND SITE DESCRIPTION

A total of 41 sites were sampled in the Usuthu-Lusutfu Catchment (Figure 4), of which

- Usuthu-Lusutfu River mainstem 6 sites 5 SQ reaches
- Assegai-Mkhondvo sub-catchment 12 sites 10 SQ reaches 1 EWR site monitored
- Hlelo River sub-catchment 5 sites 5 SQ reaches
- Ngwempisi River sub-catchment 10 sites 10 SQ reaches
- Mpuluzi River sub-catchment 5 sites 4 SQ reaches
- Lushushwane River sub-catchment 3 sites 3 SQ reaches 1 EWR site monitored

The Usuthu-Lusutfu catchment (W5) (quaternary sub-catchments W51, W52, W53, W54, W55, W56 & W57) drains a total area of approximately 16 697 km^2. Table 3 lists the biomonitoring points surveyed in the Usuthu-Lusutfu River Catchment.

2.1. Assegai-Mkhondvo Sub-Catchment

The Assegai River originates at an elevation of 2,073 m.a.s.l, flowing in a general direction of NNE (20.2°) towards the Lusutfu River. The fluvial length of the Assegai-Mkhondvo is 302 km, entering the Lusutfu River in Swaziland at an elevation of 289 m.a.s.l. The headwaters of the Assegai River with some of its tributaries feeds the Heyshope Dam, from where the river flows past Piet Retief towards Swaziland. The name of the Assegai River changes to Mkhondvo when it flows into Swaziland. The Mkhondvo River merges with the Lusutfu River 3.6 km SSE (157°) from the town of Sidvokodvo. The Assegai-Mkhondvo River drain a catchment area of 3,894 km^2, with a net mean annual run-off (MAR) of 570.5 million m^3 (Midgley et al. 1994). A schematic diagram of the Assegai-Mkhondvo catchment is included as (Figure 5) to roughly indicate the location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry makes up 67,500 ha, and irrigated areas 1,300 ha. Most of the commercial forestry areas in the Assegai Catchment are located downstream from the Heyshope Dam. The Heyshope Dam is located in the upper catchment of the Assegai, with a catchment area of 1,120 km^2, a MAR[1] 129 million m^3, and the dam's capacity 453 million m^3 (Midgley et al. 1994). The Heyshope Dam supplies 60 million m^3/annum into the Grootdraai Dam in the upper Vaal River catchment, for use by Eskom in the cooling of coal fired power stations. In addition, infrastructure exists and were operational during field sampling (August 2015) to transfer water into the Ngwempisi River at Leiden, upstream from the Morgenstond Dam (DWAF 2004).

Of concern to the ecological health of the Assegai Catchment is water quantity and quality. In terms of water quantity, specifically the management of inter-basin transfers out of the catchment, water release from the Heyshope Dam and growing water demands within Piet Retief.

[1]MAR = Mean Annual Run-off

In terms of quality, concerns were raised on the risk of future coal mining activities on water quality where there are coal mine deposits in the upper Assegai catchment (DWAF 2004). There are old and operational coal mining sites have been identified from Google Earth Pro, with seven locations located in the Anysspruit catchment, and seven upstream from the Heyshope Dam.

Other water quality concerns in the catchment raised in the DWAF (2004) report included industrial effluent from a tannery, which was, until recently, irrigated into the riparian and wetland areas adjacent the Farroloop. The related industrial site is located 9.2 km north (357.1°) from Piet Retief, with the Farroloop draining towards the Blesbokspruit.

Municipal waste water from Piet Retief and surrounding municipal areas are also of concern, with regular reports in local media of sewage spills. In addition, storm-water run-off from urban areas in poorly managed municipal areas (e.g. hydrocarbons and other pollutants from petrol stations, workshops, shops, domestic and discarded liquid wastes in storm-water drains, etc.) are often high sources of pollution to receiving aquatic ecosystems.

2.2. Hlelo Sub-Catchment

The Hlelo River originates at an elevation of 1,870 m.a.s.l, flowing in a general direction of East by North (83°) towards the Ngwempisi River in Swaziland. The fluvial length of the Hlelo River is 134 km, entering the Lusutfu River in Swaziland at an elevation of 1,002 m.a.s.l. The Hlelo and Ohlelo Rivers make up the main streams in the headwaters of the Hlelo River. The Hlelo River merges with the Ngwempisi River 2.2 km west to northwest (295.9°) from the village Bosch Hoek. The Hlelo River drain a catchment area of 922 km2, with a net mean annual run-off (MAR) of 114 million m3 (Midgley et al. 1994). A schematic drawing of the Hlelo catchment is included as (Figure 6) to roughly indicate the location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry makes up 29,800 ha (32%), and irrigated areas 2,600 ha (0.3%). There are no large impoundments in the catchment, but there are several weirs. Water abstraction from the one weir which is located upstream from the regional R33 road between Piet Retief and Amsterdam, is for the industrial area located 9.2 km north of Piet Retief.

The Hlelo River is regarded as one of the few remaining free-flowing rivers, and man-made barriers to fish movement is therefore of concern. In terms of water quantity, there is anecdotal evidence of illegal afforestation, and there is also high densities of wattle infestation (Acacia mearnsii) in parts of the upper catchment. There are a few areas noted on Google Earth Pro (Imagery date: 12 February 2014), where commercial forestry is planted in riparian zones, wetlands, oxbow lakes, and floodplains of the main Hlelo River, specifically on the farms Stralsund 435 IT and Springbokkraal 434 IT portion 2. These plantings will negatively affect river health, biodiversity and ecosystem functioning, as well as international agreements.

In terms of quality, concerns were raised on the risk of future coal mining activities on water quality where there are coal mine deposits in the upper Hlelo catchment (DWAF 2004). There are old and operational coal mining sites have been identified from Google Earth Pro, with six locations located in the Hlelo River, all upstream from the W5HLEL-WITBA sampling location.

2.3. Ngwempisi Sub-Catchment

The Ngwempisi River originates at an elevation of 1,870 m.a.s.l, flowing in a general east by southerly direction (99.4°) towards the Lusutfu River in Swaziland. The fluvial length of the Ngwempisi River is 210 km, entering the Lusutfu River in Swaziland at an elevation of 317 m m.a.s.l. Several large tributaries feed the Ngwempisi River, which is also to some degree the main reason why the river recovers further downstream from the Morgenstond and Jericho dams. The Ngwempisi River drains a catchment area of 2,649 km^2, with a net mean annual run-off (MAR) of 400.5 million m^3 (Midgley et al. 1994). A schematic drawing of the Ngwempisi catchment is included as Figure 7 to indicate the approximate location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry in the catchment makes up 566,000 ha (21.4%), and irrigated areas 2,600 ha (0.2%). There are two large impoundments in the catchment, the Morgenstond on the Ngwempisi and the Jericho on the Mpama rivers, with several small dams and weirs. Water is transferred into the catchment from the Heyshope Dam (Assegai River) and out of the catchment into the Olifants catchment.

In terms of water quantity, there is evidence of illegal afforestation, and there are also high densities of wattle (Acacia mearnsii) in parts of the upper catchment. There are areas where large wetland systems have been channelized, where there is planting in riparian zones, wetlands, oxbow lakes, and floodplains, specifically on the farms Pampoenkraal 318 IT portions 2, 3 & 6 435 IT, Zandspruit 302 IT and Vlakplaats 248 IT portion 19. These plantings will negatively affect river health, biodiversity and ecosystem functioning, as well as international agreements.

In terms of quality, there are concerns about storm-water run-off and municipal effluent waters from Amsterdam and inter-basin transfer from the Heyshope Dam into the Ngwempisi River upstream from the Morgenstond Dam.

2.4. Mpuluzi Sub-Catchment

The Mpuluzi River originates at an elevation of 1,812 m.a.s.l, flowing in a general east-south easterly direction (115.2°) towards its confluence with the Lusutfu River in Swaziland. The fluvial length of the Mpuluzi River is 153 km, entering the Lusutfu River in Swaziland at an elevation of 572 m.a.s.l. The Mpuluzi River drain a catchment area of 1,871 km^2, with a net mean annual run-off (MAR) of 260.3 million m^3 (Midgley et al. 1994). A schematic drawing of the Mpuluzi catchment is included as Figure 8 to indicate the approximate location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry in the catchment makes up 577,000 ha (30.8%), and irrigated areas 100 ha (0.1%). There are no large impoundments in the catchment, but there are several smaller farm dams and weirs.

2.5. Lusushwane Sub-Catchment

The Lusushwane River originates at an elevation of 1,740 m.a.s.l, flowing in a general east-south easterly direction (146.5°) towards its confluence with the Lusutfu River in Swaziland. The fluvial length of the Lusushwane River is 146 km, entering the Lusutfu River in Swaziland at an elevation of 361 m.a.s.l. The Lusuhwane River drains a catchment area of 1,389 km^2, with a net mean annual run-off (MAR) of 302 million m^3 (Midgley et al. 1994). A schematic drawing of the Lusutfu catchment is included as Figure 9 to indicate the approximate location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry in the catchment makes up 298,000 ha (21.5%), and irrigated areas 1,220 ha (0.9%). There are several weirs in the systems, as well as the Luphohlo Dam in Swaziland.

2.6. Usuthu-Lusutfu Catchment

The Usuthu River originates at an elevation of 1,714 m.a.s.l, flowing in a general southeast by easterly direction (118.4°) towards its confluence with the Phongolo River on the border between South Africa (KwaZulu-Natal) and Mozambique. The fluvial length of the Usuthu-Lusutfu River is 451 km, merging with the Phongolo River at an elevation of 29 m.a.s.l. The Usuthu River (W54) drains a catchment area of 1,506 km^2, with a net mean annual run-off (MAR) of 251.9 million m^3 (Midgley et al. 1994). A schematic drawing of the Usuthu-Lusutfu catchment is included as Figure 10 which indicates the approximate location of the tributaries and sampling sites in relation to the rest of the catchment.

Commercial forestry in the catchment makes up 403,000 ha (26.8 %) of the Usuthu Catchment, and 300 ha (0.1 %) of the Lusutfu catchment (W57). Irrigated areas comprise 24,400 ha (1.6 %) of the Usuthu and 122,500 ha (2.7 %) of the Lusutfu catchment. The Westoe Dam is the main large impoundment on the system, but there are several smaller dams and weirs on the system. It is very rare to see water flowing over the Westoe Dam during the dry season, with inter-basin transfers out of the dam to the Jericho Dam. Water is also transferred from the Bonnie Brook, a tributary entering the Usuthu River downstream from Westoe Dam. Natural flow from the Bonnie Brook potentially could have alleviated the impact of no flow release from Westoe Dam on the aquatic system.

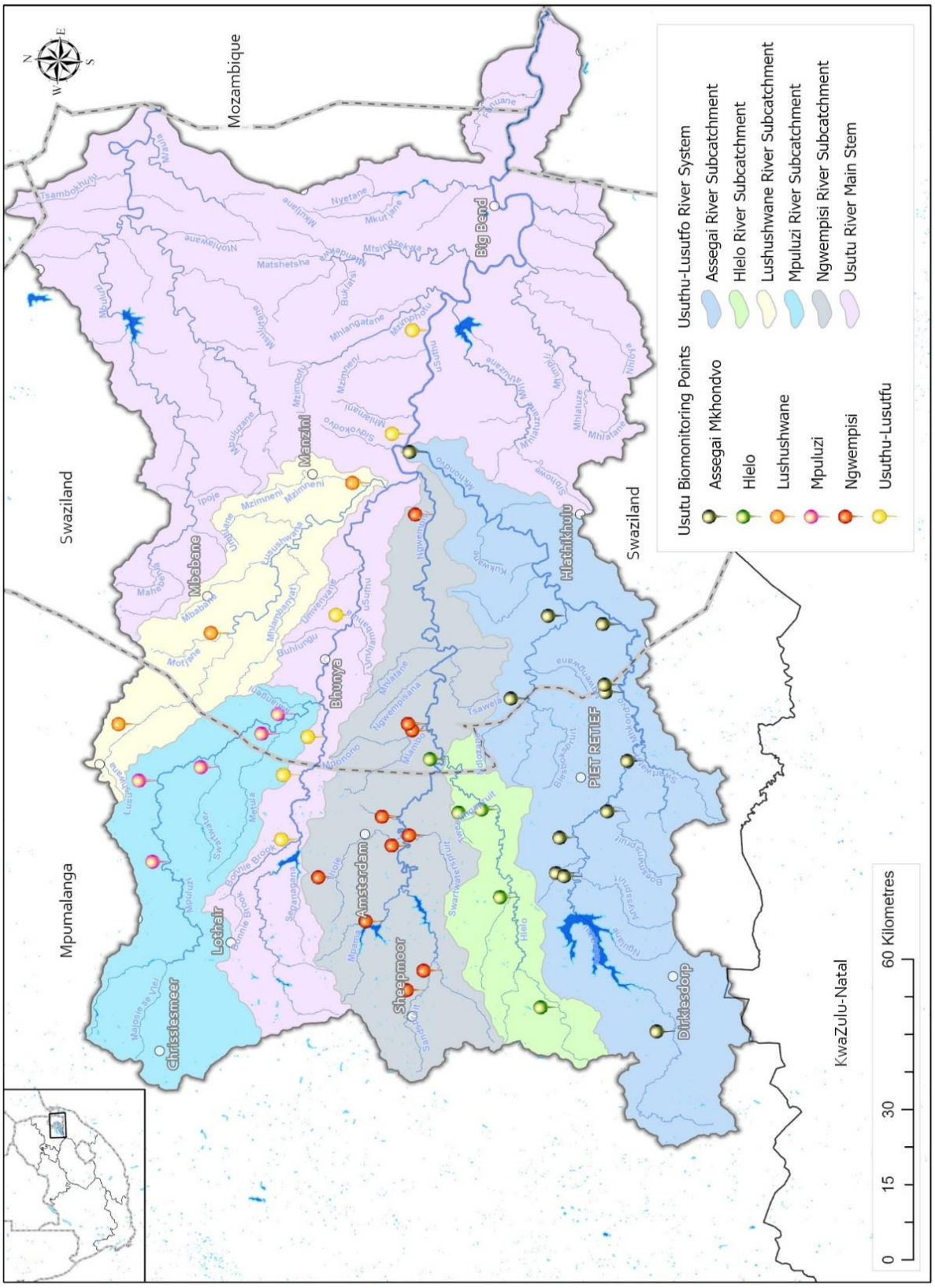


Figure 4: Map of Usuthu-Lusutfu Catchment indicating all biomonitoring points.

Table 3: A list of sites sampled on the Usuthu-Lusutfu Catchment during the 2019 survey, including details such as aquatic ecoregion, site code, quaternary sub-catchment (QC), PESEIS Reach Code, River, GPS location and elevation. EWR sites indicated in blue text.

Sub-Catchment	Aquatic Ecoregion		QC[2]	Reach Code	Site Code	Geomorphological zone	GPS[3] (dd.ddddd)		Altitude[4]	SQR Length
	Level 1	Level 2					S	E	(m a.s.l.)	(km)
Assegai-Mkhondvo sub-catchment										
Assegai-Mkhondvo	Eastern Escarpment Mountains	15.05	W51A	W51A-02082	W5ASSE-PLATJ	(E) Lower foothills	-27.18344	30.29556	1,344	84.9
	Highveld	11.04	W51C	W51C-02022	W5ASSE-KLIPS	(E) Lower foothills	-26.99312	30.60575	1,230	23.3
				W51C-02074	W5ANYS-KLOPP	(E) Lower foothills	-27.00776	30.59989	1,253	31.7
				W51C-01981	W5ASSE-WITK1	(E) Lower foothills	-26.99655	30.67699	1,169	22.6
	North Eastern Highlands	4.06		W51C-02109	W5BOES-ANHAL	(D) Upper foothills	-27.07833	30.73460	1,181	35.5
			W51D	W51D-02151	W5SWAR-ZWART	(E) Lower foothills	-27.10922	30.83852	1,129	12.0
				W51E-02049	W5ASSE-ZANDB	(E) Lower foothills	-27.06465	30.97461	2,170	62.0
				W51E-02049	W5ASSE-ZAND1 (EWR AS1)	(E) Lower foothills	-27.06241	30.98977	1,011	62.0
			W51E		W5MKHO-NHLAN	(D) Upper foothills	-27.05378	31.11166	908	62.0
			W51F	W51F-01986	W5BLES-WEEHO	(D) Upper foothills	-26.89837	30.95267	1,080	4.4
				W51F-01973	W5NDHL-SWAZI	(B) Mountain stream	-26.95675	31.12299	810	22.0
			W51H	W51H-01808	W5MKHO-SWAZI	(E) Lower foothills	-26.69709	31.43789	294	29.1
Hlelo River sub-catchment										
Hlelo	Highveld	11.02	W52A	W52A-01983	W5HLEL-WITBA	(D) Upper foothills	-26.97702	30.33379	1,394	37.7
			W52B	W52B-01964	W5HLEL-TWYFE	(F) Lowland river	-26.89647	30.55205	1,356	31.0
			W52C	W52C-01867	W5HLEL-HOLDE	(E) Lower foothills	-26.85632	30.72652	1,226	33.9
				W52C-01888	W5TWEE-MONDI	(D) Upper foothills	-26.81641	30.71804	1,229	11.2
	North Eastern Highlands	4.06	W52D	W52D-01862	W5HLEL-SWAZI	(D) Upper foothills	-26.76133	30.82307	1,009	27.1
Ngwempisi sub-catchment										
Ngwempisi	Highveld	11.04	W53A	W53A-01853	W5NGWE-POMPO	(E) Lower foothills	-26.76743	30.39716	1,408	26.1
				W53A-01757	W5SAND-ZANDS	(E) Lower foothills	-26.73906	30.35637	1,420	33.1
			W53D	W53D-01764	W5MPAM-GLENE	(D) Upper foothills	-26.66113	30.49137	1,447	15.8
				W53D-01773	W5NGWE-STERK	(E) Lower foothills	-26.70081	30.64582	1,184	23.9

[2] QC = Quaternary Sub-catchment code
[3] Map Datum = WGS84
[4] The elevation was obtained from a Garmin Dakota, with Garmap's Southern Africa TOPO 2013 PRO, run on Garmin Base Camp Version 4.4.7.

Sub-Catchment	Aquatic Ecoregion		QC[2]	Reach Code	Site Code	Geomorphological zone	GPS[3] (dd.ddddd)		Altitude[4]	SQR Length
	Level 1	Level 2					S	E	(m a.s.l.)	(km)
				W53D-01814	W5SWAR-WOLVE	(D) Upper foothills	-26.73056	30.66792	1,223	21.5
			W53C	W53C-01679	W5THOL-ATHOL	(D) Upper foothills	-26.57401	30.57522	1,321	35.1
			W53E	W53E-01790	W5NGWE-SKURW	(D) Upper foothills	-26.68126	30.70271	1,117	23.8
	North Eastern Highlands	4.06		W53E-01841	W5NGWE-MPONO	(E) Lower foothills	-26.72707	30.87921	957	10.9
				W53E-01785	W5MPON-SWAZI	(D) Upper foothills	-26.71907	30.89173	949	5.6
			W53G	W53G-01788	W5NGWE-MZIMN	(E) Lower foothills	-26.71303	31.31287	368	55.0
Usuthu-Lusutfu sub-catchment										
Usuthu-Lusutfu	Highveld	11.04	W54D	W54C-01556	W5BONN-BROAD	(D) Upper foothills	-26.50559	30.64736	1,489	21.4
				W54D-01593	W5USUT-STAFF	(E) Lower foothills	-26.50336	30.77666	1,413	42.5
					W5LUSU-MANGC	(D) Upper foothills	-26.54346	30.85552	1,287	42.5
	North Eastern Highlands	4.06	W54F	W54F-01729	W5LUSU-MABUZ	(D) Upper foothills	-26.58243	31.10297	774	13.8
Mpuluzi sub-catchment										
Mpuluzi	Highveld	11.04	W55C	W55C-01395	W5MPUL-BUSBY	(D) Upper foothills	-26.28034	30.59140	1,520	83.4
					W5MPUL-ARDE1	(D) Upper foothills	-26.24958	30.75242	1,377	83.4
				W55C-01489	W5SWAR-IZIND	(D) Upper foothills	-26.35762	30.78534	1,332	28.6
			W55D	W55D-01506	W5METU-SWAZI	(D) Upper foothills	-26.46191	30.85806	1,187	50.7
			W55E	W55E-01651	W5MPUL-VELAB	(D) Upper foothills	-26.48943	30.89898	1,153	6.1
Lushushwane sub-catchment										
Lusushwane	Highveld	11.04	W56A	W56A-01372	W5LUSU-IFRSI (EWR KU1)	(D) Upper foothills	-26.20865	30.86326	1,403	4.0
	North Eastern Highlands	4.06	W56B	W56C-01514	W5LUSU-FORES	(D) Upper foothills	-26.36328	31.05485	1,068	58.4
			W56F	W56F-01762	W5LUSU-MALUN	(D) Upper foothills	-26.59915	31.36973	386	30.4
Lusutfu sub-catchment										
Lusutfu	North Eastern Highlands	4.06	W57A	W57A-01803	W5LUSU-LIBET	(E) Lower foothills	-26.66424	31.47224	271	5.7
	Lowveld	3.07	W57E	W57E-01810	W5LUSU-SIPHO	(E) Lower foothills	-26.68981	31.68215	180	7.7

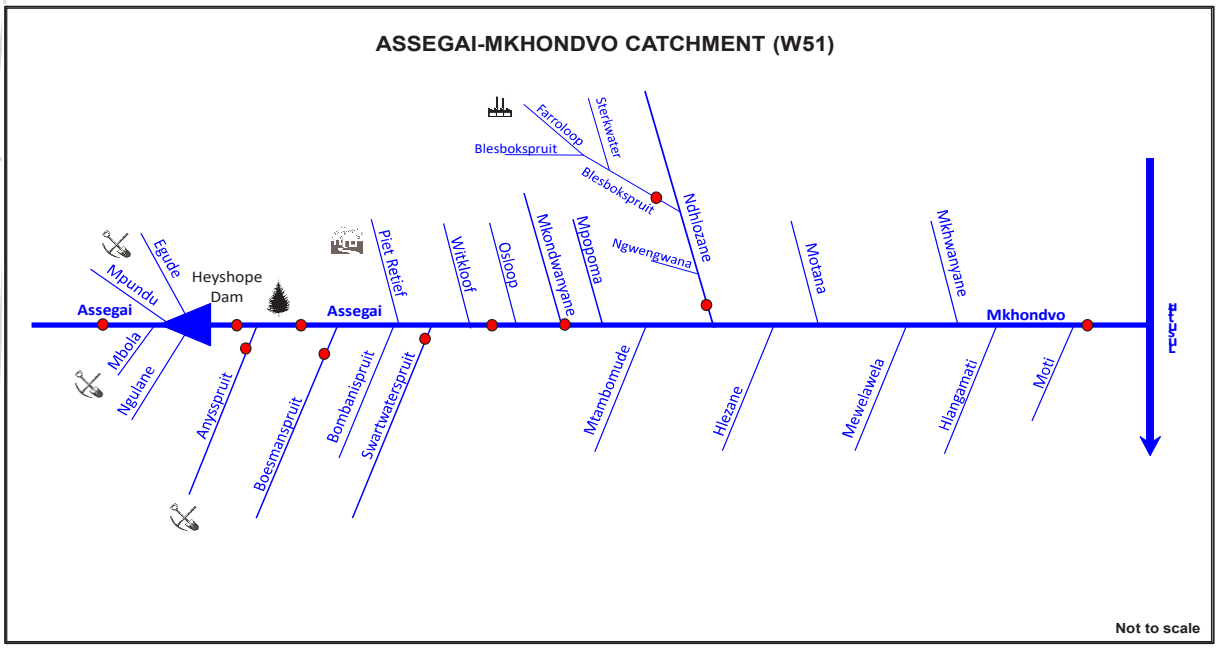


Figure 5: Diagrammatic representation of the Assegai-Mkhondvo Catchment indicating biomonitorings sites.

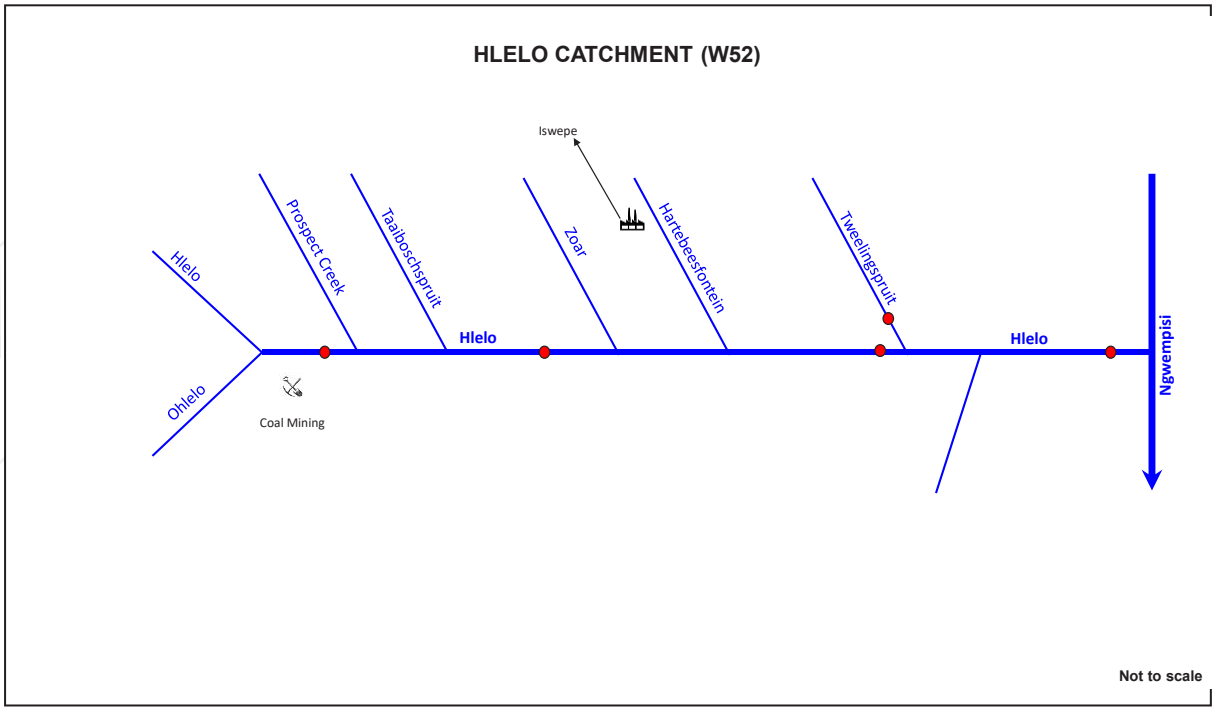


Figure 6: Diagrammatic representation of the Hlelo Catchment with biomonitoring sites indicated

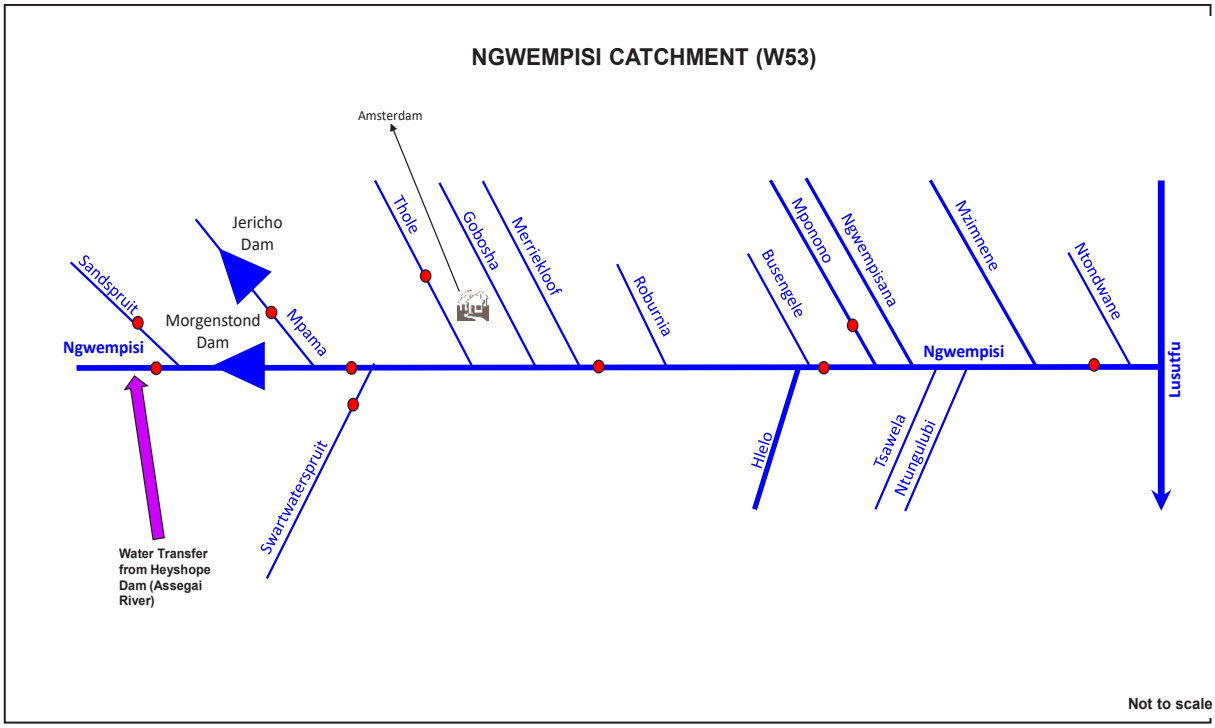


Figure 7: Diagrammatic representation of the Ngwempisi Catchment indicating biomonitoring sites.

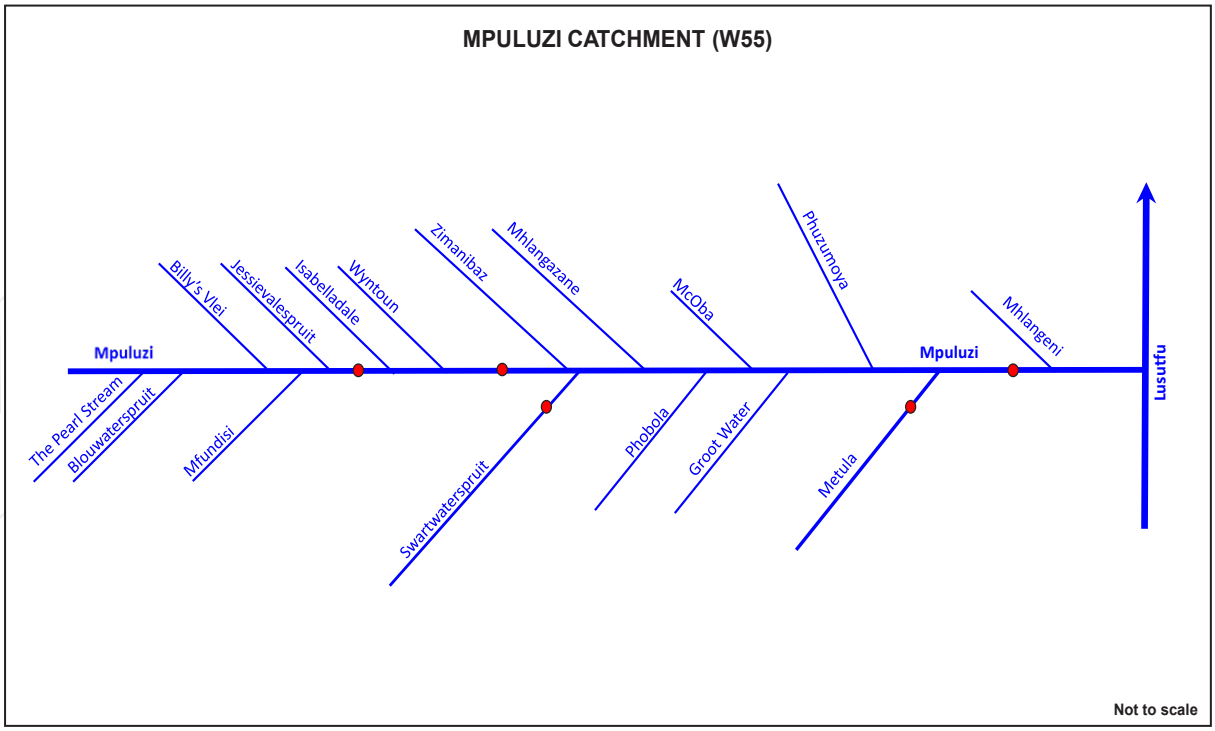


Figure 8: Diagrammatic representation of the Mpuluzi Catchment with biomonitoring sites indicated.

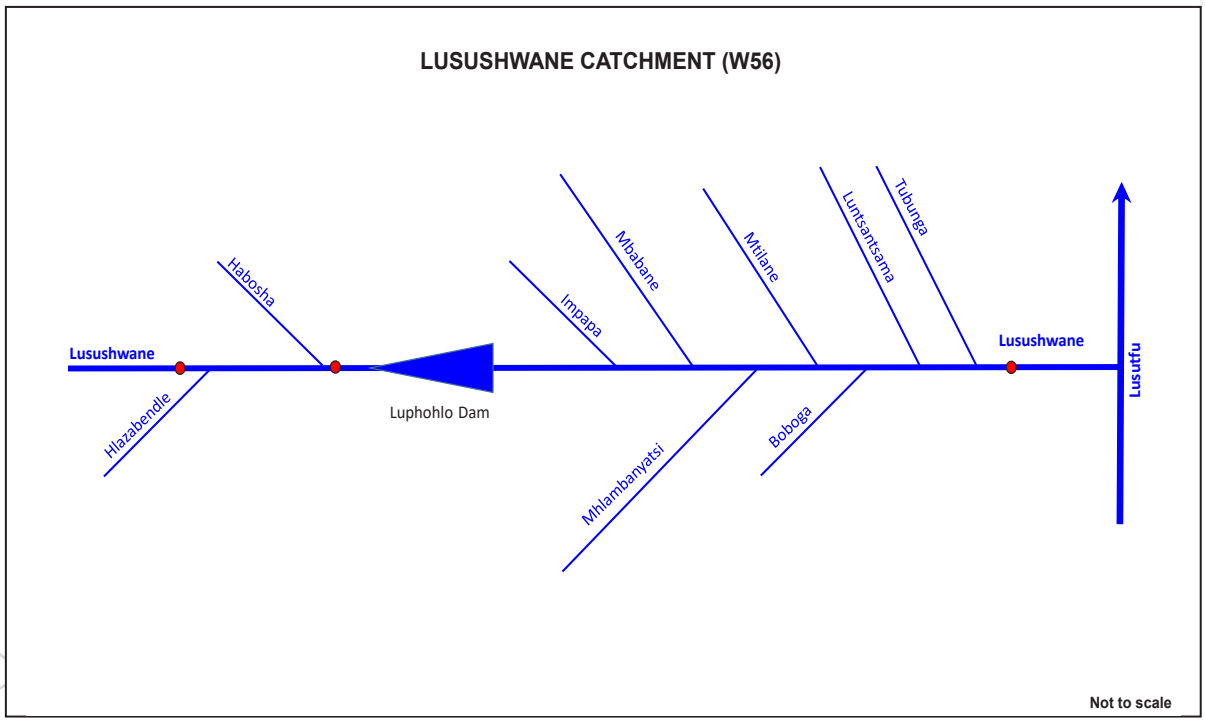


Figure 9: Diagrammatic representation of the Lusushwanei Catchment with biomonitoring sites indicated.

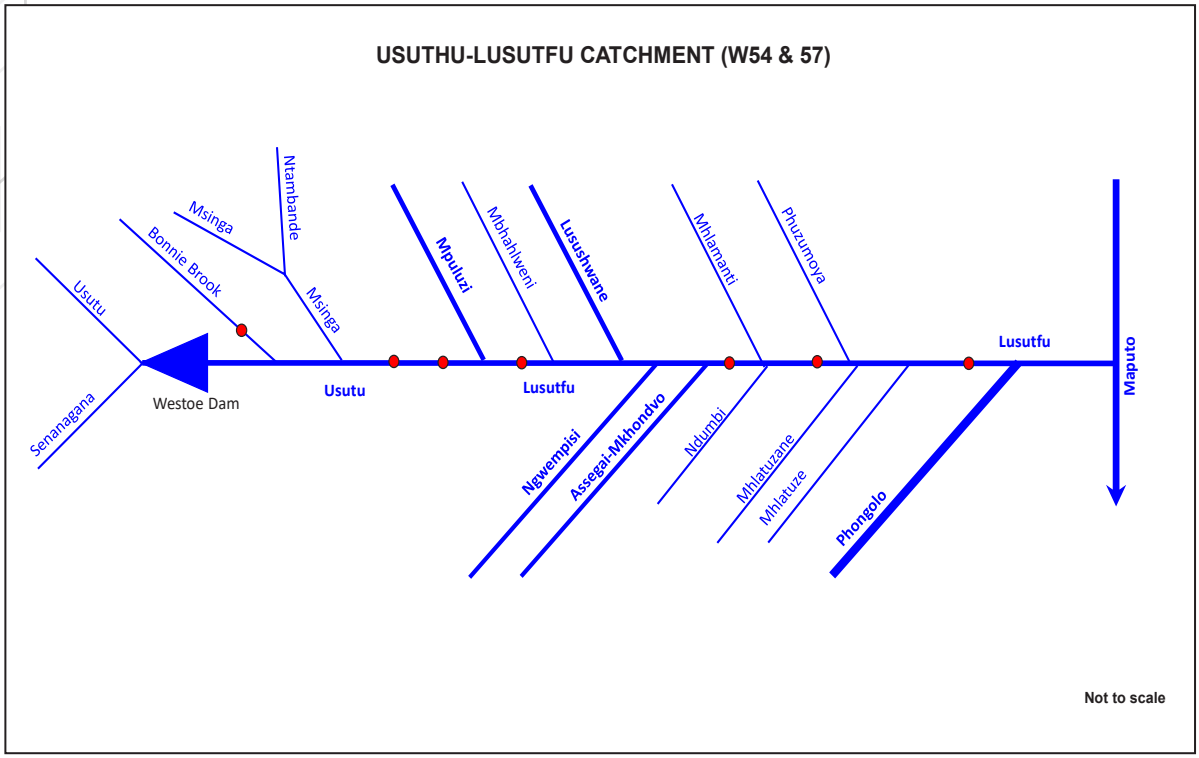


Figure 10: Diagrammatic representation of the Usuthu-Lusutfu Catchment with biomonitoring sites indicated

Usuthu-Lusutfu Catchment continue

The water quality assessment sites (as required by the IUCMA) are shown in Table 4 below.

Table 4: Water quality assessment sites of the Usuthu-Lusutfu Catchment

IUCMA site code/quaternary	River name	Point description	Type of site
U-26 / W51D	Assegai	Assegai River on Road Bridge to Mahamba Border Gate	Internation Obligations and EWR Site AS1
U-43 / W52C	Hlelo	Hlelo River on R33 Birdge to Amsterdam	International Obligations
U-44 / W53E	Ngwempisi	Ngwempisi River on R33 Road Bridge to Amsterdam	International Obligations
U-53 / W54D	Usuthu	Usuthu River @ weir before Nerston Border Gate	International Obligations
U-57 / W55C	Mpuluzi	Mpuluzi River Downstream of Mpuluzi Oxidation Ponds	International Obligations
U-61 / W56A	Lushushwane	Lushushwane River Bridge at Zwalunest Village before Swaziland Border	International Obligations

The following two biomonitoring sites were identified by the macroinvertebrate specialist on the study as potentially having poor water quality, which may contribute to low macro-invertebrate scores. The two sites were therefore considered during the water quality assessment.

- W51G-01986, Blesbokspruit
- W56F-01762, Lusushwane River

3. METHODS

The general approach used for this study was based on the rapid appraisal methods accepted by the Department of Water and Sanitation (DWS) in their guidelines for Resource Directed Measures for the Protection of Water Resources (MacKay, 1999). 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 (Figure 11) (Kleynhans & Louw, 2008). 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 provides 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. Several of the aquatic species and taxa that have been recorded in the Usuthu-Lusutfu River catchment are considered highly sensitive to changes in the above-mentioned physical drivers and are expected to respond rapidly to any changes. The purpose of this study is to use resident aquatic biota to characterize the existence and severity of impairments in the Usuthu-Lusutfu River catchment and to attempt to identify any sources and causes of impairment related to the catchment.

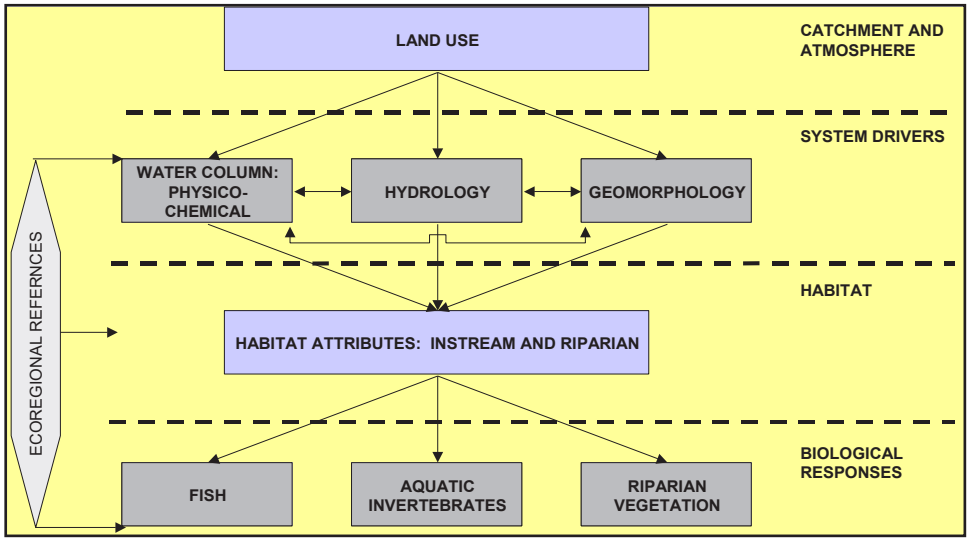


Figure 11: A simplified integration of influence of land use on physical driver determinants, habitats and the associated biological responses (Kleynhans & Louw, 2008).

3.1. Fish assemblage

Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr, 1981). This is because fish are close to the “top of the food chain”, relatively long-lived and mostly highly mobile. Assemblages often include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, and piscivores). They tend to integrate effects of

lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health, as well as requirements for different habitat types, cover requirements and sensitivity to flow and physico-chemical modifications.

The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2014a). All scientific fish species name changes were done in accordance to Skelton (2016).

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 flow of direct electric current (DC) in water causing an anode reaction (galvanotaxis) in fish. Apart from the critical electric parameters to be considered, the electrical 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 (Cowx, 2001). All fish species were identified and anomalies and general age structure were recorded. Sampling effort (time electricity applied in water) per site was kept to about 30 minutes.

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) and Reference Frequency of Occurrence (FROC) (Kleynhans *et al*., 2008) 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 (Kleynhans, 2008).

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.

3.2. Aquatic Macro Invertebrates

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

Aquatic macro invertebrates have therefore been used to assess the biological integrity of stream ecosystems with reasonably good success throughout the world (Rosenberg & 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 & Dickens, 2000) and aquatic macro-invertebrate communities offer a good reflection of the prevailing flow regime and water quality in a river.

Aquatic invertebrates were collected using a standard net and taxa were identified to at least family level per the SASS5 sampling technique (Dickens & Graham, 2001). Taxa collected from streams were analysed per the standard SASS technique. Chutter (1969) developed the SASS protocol as an indicator of water quality.

The interpretation of values can differ significantly for different eco-regions in the country (Davies & Day, 1998). 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 used to interpret the Ecological Condition of the macro invertebrate for the sites. The MIRAI is a rule-based model developed by DWAF (Thirion, 2008) considering water quality, flow preferences and habitat requirements of invertebrates. It integrates the ecological requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions.

NOTE:

In some of the Usuthu-Lusutfu Catcment reaches MIRAI results reported for the 2015 survey in the 2016 IUCMA report differs from those reprotedd for the 2015 in the 2020 report.

The discrepancy is as a result of changes to the reference staxa listed in the PESEIS for reaches in the catchment. Some of the taxa listed as reference taxa (based on available information) jave not been recorded in the catchment since 1999. The aim is always to work with the best available data. Therefore, some of the most notable taxa removed from the reference lists in 2019 included *Notonemouridae, Polycentropodidae, Lepidostaomatidae and Pisuliidae*

3.3. Riparian Vegetation

The riparian vegetation (riparian habitat) is described as the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas, clearly distinguished from wetland areas. The Riparian Vegetation Response Assessment Index (VEGRAI) is an impact-based, rapid, cause-and-effect assessment index, detecting changes in vegetation condition. The model compares the present day riparian vegetation condition to that in its reference state and determines the Ecological Category (Kleynhans et al., 2007). The products of VEGRAI are more than a measure of Ecological Category as the process and data are valuable in and of themselves. It is designed for qualitative assessment of the response of riparian vegetation to impacts in such a way that qualitative ratings translate into quantitative and defensible results. Results are defensible because their generation can be traced through an outline process (a suite of rules that convert assessor estimates into ratings and convert multiple ratings into an Ecological Category).

The metrics in the VEGRAI first describe the status of riparian vegetation in both its current and reference states and second, compare differences between the two states as a measure of vegetation response to an impact regime. The riparian zones (Marginal, Lower and Upper) were used as the metric groups. For the simplified Level 3 version, the Lower and Upper Zones were combined to form the Non-marginal metric group. The metrics are then rated and weighted and an Ecological Category (A – F) determined which represents the Ecological Category for the riparian vegetation state (Kleynhans, et al., 2007).

3.4. Habitat Integrity

The habitat integrity of an aquatic water body refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans, et al., 2009). Assessment of habitat integrity using the Index of Habitat Integrity (IHI) model is based on an interpretation of the deviation from the reference condition. Specification of these reference condition follows an impact based approach where the intensity and extent of anthropogenic changes are used to interpret the impact on the habitat integrity of the system. Habitat integrity assessment is considered from an instream and riparian zone perspective. Metric groups are formulated, each with a number of metrics that enables the assessment of habitat integrity. The model functions in an integrated way, using the results from the assessment of metric groups. Interpretation of the severity of impacts is based on the natural characteristics of the river (Kleynhans, et al., 2009)

3.5. Water Quality

Information from the PES/EI/ES (Present Ecological State/Ecological Importance/Ecological Sensitivity; also referred to as PESEIS) study (DWS, 2014b), which includes a desktop assessment of water quality impacts in the area, is the first information source used to inform a water quality assessment for rivers (see results in Section 4.1). This overview is then built on through information and data collection and analysis.

Methods as outlined in DWAF (2008) were used for the present state assessment, i.e. data analysis to provide summary statistics, and use of the PAI model to provide an integrated water quality category.

Variables

The methods and approach are not detailed in this document but follow those outlined in DWAF (2008). Note that the following parameters are generally evaluated by this method, as available, with the associated summary statistic used for the assessment.

- pH: 5th and 95th percentiles.
- Electrical conductivity, ions, metals, toxics: 95th percentiles. Metals and toxics include those listed in the *South African Water Quality Guidelines for Aquatic Ecosystems* (DWAF, 1996a), which include ammonia, toxic metal ions, toxic organic substances, and/or substances selected from the chemical inventory of an effluent/discharge.
- Nutrients, i.e. Total Inorganic Nitrogen (TIN) and ortho-phosphate: 50th percentile.
- Chlorophyll-a (phytoplankton): average or mean of values – used as available.
- Diatoms: average or mean of values – used as available.
- Turbidity, dissolved oxygen (DO), temperature: narrative descriptions when no data are available; alternatively 5th percentile for DO. Although temperature is considered to be particularly important in the instances of thermal impacts, e.g. outputs from power stations, it is also important to consider if the monitoring site is located below a dam, or if changes in flow result in extreme temperature changes in rivers.

Water quality data were utilized in the following way: Nutrients, pH, turbidity, DO, temperature and electrical conductivity data were compared to values in DWAF (2008), while all ionic data (i.e. macro-ions and salt ions) were compared to benchmark tables in DWAF (2008) and the Target Water Quality Ranges (TWQR) of the aquatic ecosystem guidelines (DWAF, 1996a) where available.

Data Selection

To select representative data to be used for the water quality assessment, it is necessary to have information regarding the location and names of DWS monitoring stations, any other monitoring points, towns, the length of the data record at each monitoring station or sample size (n), frequency of sampling, variables sampled etc., EcoRegion Level II and quaternary catchment boundaries.

It is also necessary to identify the data that will be used to define the PES for water quality, i.e. the current state for water quality. As the principle of EcoClassification[5] is to determine and categorise the PES (health or integrity) by assessing deviation from natural state (Kleynhans and Louw, 2007), it is essential to also define natural conditions (or Reference Conditions) for water quality.

Setting the Reference Condition (Rc)

The most critical part of a water quality assessment is setting the RC, i.e. the natural state before human intervention, as the change or deviation from RC defines the PES or present state. As early water quality data are

Sub-Catchment	Aquatic Ecoregion		QC[5]	Reach Code	Site Code	Geomorphological zone	GPS[5] (dd.ddddd)		Altitude[5]	SQR Length
	Level 1	Level 2					S	E	(m a.s.l.)	(km)
Assegai-Mkhondvo sub-catchment										
Assegai-Mkhondvo	Eastern Escarpment Mountains	15.05	W51A	W51A-02082	W5ASSE-PLATJ	(E) Lower foothills	-27.18344	30.29556	1,344	84.9
	Highveld	11.04	W51C	W51C-02022	W5ASSE-KLIPS	(E) Lower foothills	-26.99312	30.60575	1,230	23.3
				W51C-02074	W5ANYS-KLOPP	(E) Lower foothills	-27.00776	30.59989	1,253	31.7
				W51C-01981	W5ASSE-WITK1	(E) Lower foothills	-26.99655	30.67699	1,169	22.6
	North Eastern Highlands	4.06		W51C-02109	W5BOES-ANHAL	(D) Upper foothills	-27.07833	30.73460	1,181	35.5
			W51D	W51D-02151	W5SWAR-ZWART	(E) Lower foothills	-27.10922	30.83852	1,129	12.0
				W51E-02049	W5ASSE-ZANDB	(E) Lower foothills	-27.06465	30.97461	2,170	62.0
				W51E-02049	W5ASSE-ZAND1 (EWR AS1)	(E) Lower foothills	-27.06241	30.98977	1,011	62.0
			W51E		W5MKHO-NHLAN	(D) Upper foothills	-27.05378	31.11166	908	62.0
			W51F	W51F-01986	W5BLES-WEEHO	(D) Upper foothills	-26.89837	30.95267	1,080	4.4
				W51F-01973	W5NDHL-SWAZI	(B) Mountain stream	-26.95675	31.12299	810	22.0
			W51H	W51H-01808	W5MKHO-SWAZI	(E) Lower foothills	-26.69709	31.43789	294	29.1
Hlelo River sub-catchment										
Hlelo	Highveld	11.02	W52A	W52A-01983	W5HLEL-WITBA	(D) Upper foothills	-26.97702	30.33379	1,394	37.7
			W52B	W52B-01964	W5HLEL-TWYFE	(F) Lowland river	-26.89647	30.55205	1,356	31.0
			W52C	W52C-01867	W5HLEL-HOLDE	(E) Lower foothills	-26.85632	30.72652	1,226	33.9
				W52C-01888	W5TWEE-MONDI	(D) Upper foothills	-26.81641	30.71804	1,229	11.2
	North Eastern Highlands	4.06	W52D	W52D-01862	W5HLEL-SWAZI	(D) Upper foothills	-26.76133	30.82307	1,009	27.1
Ngwempisi sub-catchment										
Ngwempisi	Highveld	11.04	W53A	W53A-01853	W5NGWE-POMPO	(E) Lower foothills	-26.76743	30.39716	1,408	26.1
				W53A-01757	W5SAND-ZANDS	(E) Lower foothills	-26.73906	30.35637	1,420	33.1
			W53D	W53D-01764	W5MPAM-GLENE	(D) Upper foothills	-26.66113	30.49137	1,447	15.8
				W53D-01773	W5NGWE-STERK	(E) Lower foothills	-26.70081	30.64582	1,184	23.9
				W53D-01814	W5SWAR-WOLVE	(D) Upper foothills	-26.73056	30.66792	1,223	21.5
			W53C	W53C-01679	W5THOL-ATHOL	(D) Upper foothills	-26.57401	30.57522	1,321	35.1
			W53E	W53E-01790	W5NGWE-SKURW	(D) Upper foothills	-26.68126	30.70271	1,117	23.8
	North Eastern Highlands	4.06		W53E-01841	W5NGWE-MPONO	(E) Lower foothills	-26.72707	30.87921	957	10.9
				W53E-01785	W5MPON-SWAZI	(D) Upper foothills	-26.71907	30.89173	949	5.6
			W53G	W53G-01788	W5NGWE-MZIMN	(E) Lower foothills	-26.71303	31.31287	368	55.0
Usuthu-Lusutfu sub-catchment										
Usuthu-Lusutfu	Highveld	11.04	W54D	W54C-01556	W5BONN-BROAD	(D) Upper foothills	-26.50559	30.64736	1,489	21.4
				W54D-01593	W5USUT-STAFF	(E) Lower foothills	-26.50336	30.77666	1,413	42.5
					W5LUSU-MANGC	(D) Upper foothills	-26.54346	30.85552	1,287	42.5
	North Eastern Highlands	4.06	W54F	W54F-01729	W5LUSU-MABUZ	(D) Upper foothills	-26.58243	31.10297	774	13.8
Mpuluzi sub-catchment										
Mpuluzi	Highveld	11.04	W55C	W55C-01395	W5MPUL-BUSBY	(D) Upper foothills	-26.28034	30.59140	1,520	83.4
					W5MPUL-ARDE1	(D) Upper foothills	-26.24958	30.75242	1,377	83.4
				W55C-01489	W5SWAR-IZIND	(D) Upper foothills	-26.35762	30.78534	1,332	28.6
			W55D	W55D-01506	W5METU-SWAZI	(D) Upper foothills	-26.46191	30.85806	1,187	50.7
			W55E	W55E-01651	W5MPUL-VELAB	(D) Upper foothills	-26.48943	30.89898	1,153	6.1
Lushushwane sub-catchment										
Lusushwane	Highveld	11.04	W56A	W56A-01372	W5LUSU-IFRSI (EWR KU1)	(D) Upper foothills	-26.20865	30.86326	1,403	4.0
	North Eastern Highlands	4.06	W56B	W56C-01514	W5LUSU-FORES	(D) Upper foothills	-26.36328	31.05485	1,068	58.4
			W56F	W56F-01762	W5LUSU-MALUN	(D) Upper foothills	-26.59915	31.36973	386	30.4
Lusutfu sub-catchment										
Lusutfu	North Eastern Highlands	4.06	W57A	W57A-01803	W5LUSU-LIBET	(E) Lower foothills	-26.66424	31.47224	271	5.7
	Lowveld	3.07	W57E	W57E-01810	W5LUSU-SIPHO	(E) Lower foothills	-26.68981	31.68215	180	7.7

[5] EcoClassification (or the Ecological Classification process) refers to the determination and categorisation of the PES (health or integrity) of various physical attributes of rivers relative to the natural reference condition. A range of models are used during EcoClassification, each of which relate to the indicators assessed. This term is not to be confused with the National Water Resource Classification System, which is a defined set of guidelines and procedures for determining the different classes of water resources (South African National Water Act (Act 36 of 1998) Chapter 3, Part 1, Section 2(a)). The outcome of the Classification Process will be the setting of the class, Reserve and Resource Quality Objectives by the Minister or delegated authority for every significant water resource (river, estuary, wetland and aquifer) under consideration.

not often available, the generic benchmark boundary values (as shown in the EcoClassification tables of DWAF (2008)), or the recalibrated benchmark boundary values, can be used as proxies for RC.

Note the following guidance from DWAF (2008).

If no suitable RC data are available

Use existing data or reports, geological information and expert judgement to define RC if suitable RC data is not available, and benchmark boundary values not deemed suitable. The development of Reference Conditions for water quality has been identified as a development requirement and will be investigated as a separate study.

PAI MODEL

The PAI model is used to generate an integrated present state category for instream water quality. DWAF (2008) is used to compare summary statistics per variable to benchmark tables. The selected rating is then inserted into the PAI model. The output of the PAI model is therefore the physico-chemical category (P-C category) or Ecological Category (EC) for water quality.

Evaluation against available objectives

Once analysed, data were compared to available objectives, so Ecological Specifications (EcoSpecs)[6] from the Reserve study for the EWR site, and International Obligations for the other sites, as follows:

Step 1: Evaluate the water quality monitoring point to be used for the assessment. The EcoSpecs or Monitoring Report of a Reserve study defines the site from which water quality data should be obtained for the assessment. The Results section (Chatper 4) includes tables listing the sites used for the assessment.

Step 2: Focus on the High Priority sites in the system. The EWR site and sites monitored for meeting International Obligations were evaluated in this instance.

Step 3: Assess summary statistics of selected variables and determine the present state for water quality.

Note that the data set to be used to assess compliance has to be selected carefully as this can bias the result. This is particularly relevant as compliance data should preferably be taken from the same data used to set the baseline. It is obvious that a smaller dataset (as is often the case for measuring metals) or sampling time frame is potentially more sensitive to change in conditions, as fewer non-compliant samples are required for the data set to register as non-compliant. It should also be noted

[6] EcoSpecs, or Ecological Specifications, must be quantifiable, measurable, verifiable and enforceable to ensure protection of all components of the resource, which make up ecological integrity.

that where 50th percentiles are assessed (e.g. nutrients), monitoring data sets are generally less affected by extreme values.

Step 4: Evaluate present state against EcoSpecs for the EWR site, and against International Obligations for all sites.

Note that microbial indicators of pollution do not traditionally form part of the ecological water quality assessment, but are included in this study as they form part of International Obligations. The measurement of faecal and total coliforms was initiated by the IUCMA in September 2019, so are evaluated at the relevant sites. DWS's faecal coliform and *Escherichia coli* data were compared to recreational guidelines (DWAF, 1996b), i.e. 0-130 cfu/100 mL TWQR for recreational full contact use, where possible[7].

Step 5: Set up EcoSpecs as ecological monitoring objectives per site for future management purposes, where required or possible.

3.6. Present Ecological State

The Present Ecological State (PES) of the river is expressed in terms of various components that incorporate drivers (physicochemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates). The scale used for river health describes six different states of health, from an A category (natural) to an F category (critically modified). The results of applying the biological and habitat indices during a river survey provide the context for determining the degree of ecological modification at the monitoring site. Thus, the degree of modification observed at a particular site translates into Present Ecological State (Table 5) (Kleynhans & Louw, 2007).

The PESEIS Front End Model for the Usuthu-Lusutfu Secondary drainage area (W5) was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2014a). Data compilation was done according to models that were developed to determine the Ecostatus (Kleynhans, 2008). The River Data Integration Application (RIVDINT) was developed in a project between RQS and MTPA (Kleynhans et al., 2017) and was also utilised during the data compilation and analysis process.

The River Ecostatus Monitoring Programme (REMP) has evolved from the River Health Programme (RHP) and REMP replace the RHP. It is a component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP). The REMP focuses on the monitoring of the ecological conditions in River ecosystems as it is reflected by the system drivers and biological responses (instream and riparian). The basis of the REMP is the

[7] The recommendation is that the TWQR should not be exceeded by the geometric mean or median of fortnightly samples collected over a three-month period. The criteria used assume an average intake of water not exceeding 100 mL/recreational event (DWAF, 1996b).

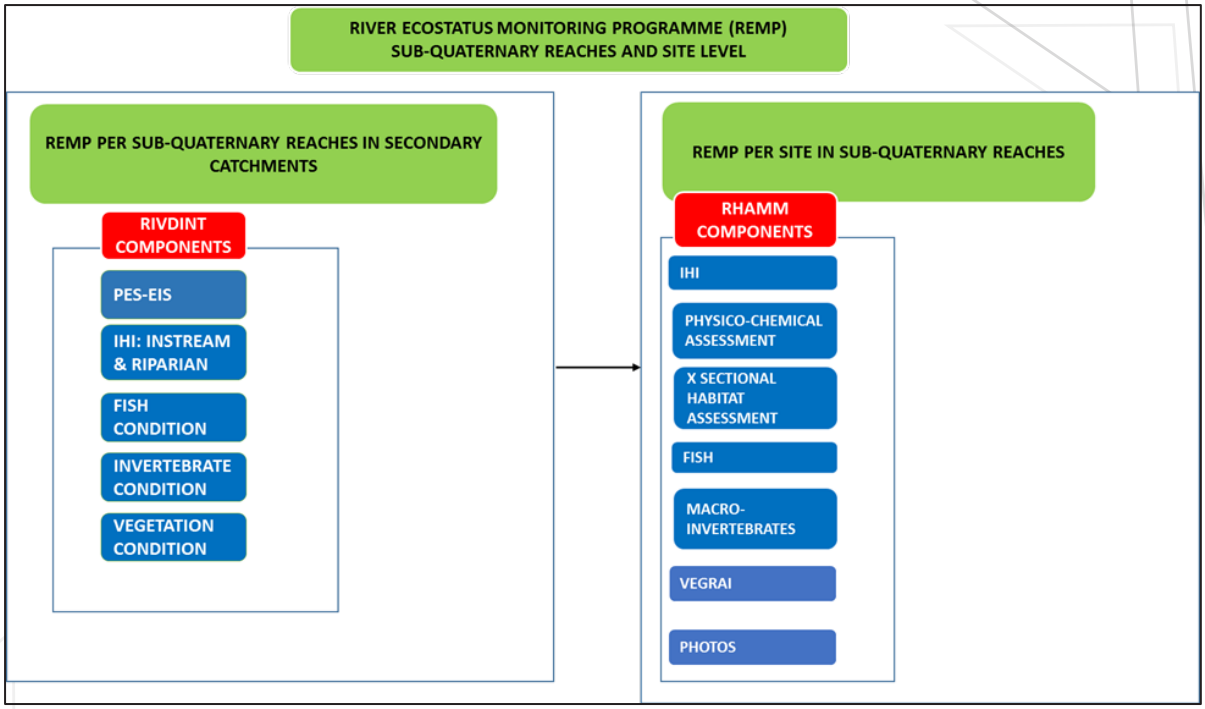


Figure 12: Diagrammatic representation of the River Ecostatus Monitoring Programme (REMP) at Sub-quaternary reaches and site level.

establishment of a relative reference condition, usually a natural or close to natural condition, derived from the best available information. In its formulation and characterization the relative reference condition considers the characteristics of the abiotic drivers of the system, namely, the hydrology, geomorphology and physico-chemical conditions that determine the habitat template for instream and riparian biota. It furthermore considers the characteristics of the instream and riparian biota as a response to the system drivers (http://www.dwa.gov.za/iwqs/rhp/rhp).

The REMP (River Ecostatus Monitoring Programme) (Figure 12, 13 and 14) is built upon the use of particular models incorporating existing approved Ecostatus models: River Data Integration (RIVDINT), Rapid Habitat Assessment Method and Model (RHAMM) and Fish Invertebrate Flow Habitat Assessment (FIFHA) (http://www.dwa.gov.za/iwqs/rhp/rhp; DWA, 2016).

River Data Integration (RIVDINT): Assessment is done on a Sub-Quaternary Reach (SQR) level and includes use of the Index of Habitat integrity model (Instream and Riparian), Fish Assemblage, Invertebrate Assemblage, Vegetation (Riparian) condition. Based on the available and approved RQOs, Targets for the various components are set (as well as TPCs) for a Sub-Quaternary reach (or a subdivision of the SQR where necessary). Where RQOs for a SQR have not been set according to the EWR-site approach, it is still possible to set ecological targets based on specific ecological considerations. The eventual result of this process is the Fish,

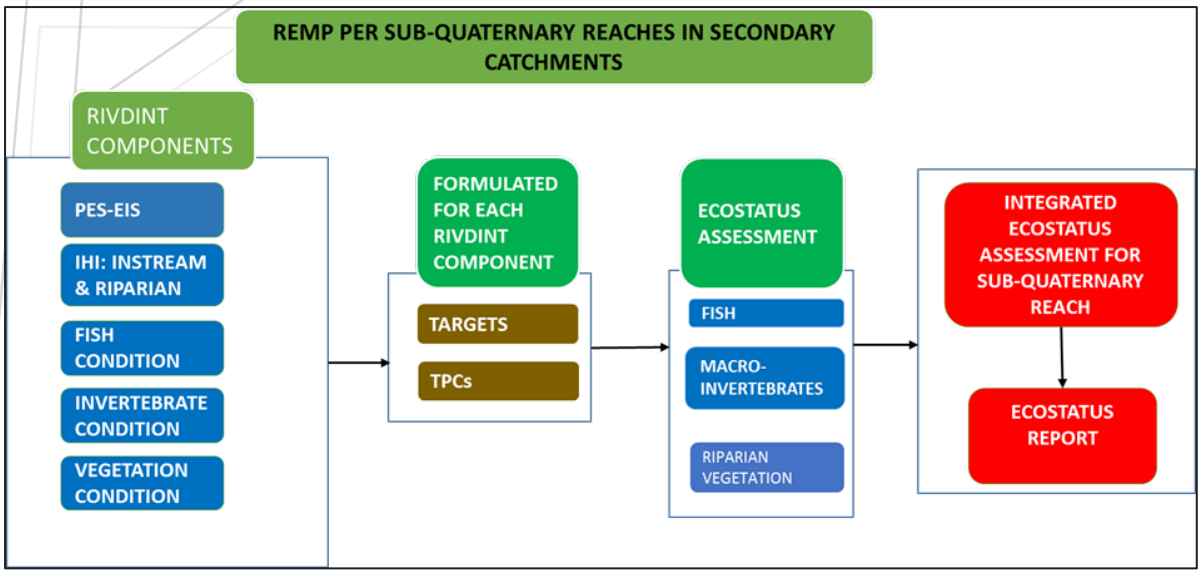


Figure 13: Diagrammatic representation of the REMP per sub-quaternary reaches in secondary catchments

Invertebrate, Vegetation and integrated Ecostatus for a SQR. The RIVDINT has been developed as data storage and retrieval system that allows the comparison of various components over time. The model includes the development of relative reference conditions for all components. The first detailed assessment of a SQR will be considered the baseline against which future assessments will be evaluated (Kleynhans, 2016 pers.comm).

Rapid Habitat Assessment Method and Model (RHAMM): Assessment is done on a site level where a site should be representative of a SQR or a subdivision thereof. Ecostatus models are incorporated into the RHAMM is IHI, FRAI, MIRAI, VEGRAI and the Integrated Ecostatus. Specific information for setting targets for indicator fish species (in terms of FRAI) and invertebrate taxa (e.g. in terms of SASS5) are provided for. The formulation of relative reference conditions is provided for in the RHAMM. Targets and TPC's can be set for available and approved RQOs (i.e. at EWR sites) in terms of biota and habitat requirements (also including the use of cross sections and habitat measurements). Where EWR-site data is not available, biological targets and TPCs can still be set for the site. Only a very limited number of physico-chemical measurements are included in the RHAMM.

Fish Invertebrate Flow Habitat Assessment (FIFHA): This model originates from the Fish Flow Habitat Assessment (FFHA) model that was used in some applications of the Habitat Flow Stressor Response (HFSR). The primary aim of the FIFHA is not to do instream flow requirements per se, but to use the data generated by the HFSR model (e.g. Hydrology and HABFLO: HABitat–FLOw simulation software) and the categories and flows that were set during the HFSR process to establish a basis for rapid assessment of fish and invertebrate habitat conditions at a EWR cross section. It follows that the FIFHA can only be used where a EWR site with the necessary hydraulic and hydrology are available.

It is evident from this explanation that the REMP logically includes the monitoring of ecological and specific biological components that have been established and approved as EcoSpecs from the EWR study (DWS, 2014c).

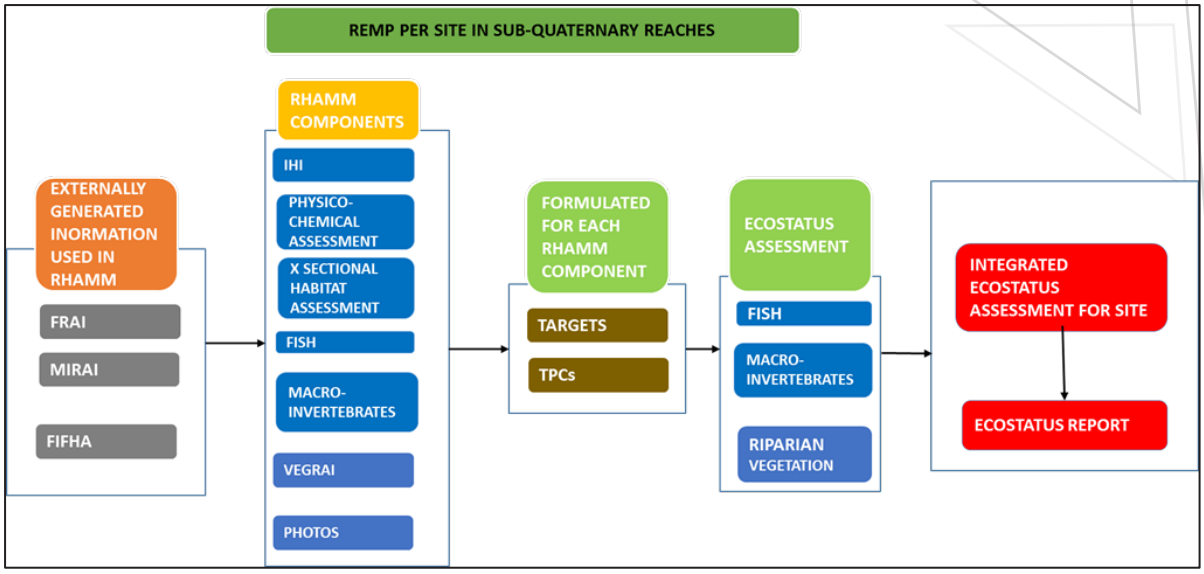


Figure 14: Diagrammatic representation of the REMP per site in Sub-quaternary Reaches.

Monitoring is only a valid term to use if the results of this survey is measured against targets (Greenwood & Robinson, 2006). The results of this survey are therefore compared to the Ecological Specifications (EcoSpecs) and associated Ecological Categories as defined for each prioritised RU in terms of water quantity and quality, as well as habitat and biota (DWA, 2014c). **To date Target Ecological Categories and associated RQO have not been defined and gazetted for Usuthu-Lusutfu Catchment (W5). Therefore biomonitoring results have been compared to Recommended Ecological Categories derived from RIVDINT model data 2015/2019 according to the process to set ecological targets based on specific ecological considerations: the eventual result of this process is the Fish, Invertebrate, Vegetation and integrated Ecostatus for a SQR.**

Table 5: Guidelines used to delineate Generic ecological categories for Ecological Integrity Categories (based on Kleynhans 1996).

ECOLOGICAL CATEGORY	GENERIC DESCRIPTION OF ECOLOGICAL CONDITIONS	ARBITRARY GUIDELINE SCORE (% OF MAXIMUM THEORETICAL TOTAL)
A	Unmodified/natural, close to natural or close to predevelopment conditions within the natural variability of the system drivers: hydrology, physico-chemical and geomorphology. The habitat template and biological components can be considered close to natural or to pre-development conditions. The resilience of the system has not been compromised.	>92 – 100
AB	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.	>88 - <= 92
B	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions and resilience are essentially unchanged.	>82 - <=88
BC	Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category.	>78 - <=82
C	Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The resilience of the system to recover from human impacts has not been lost and it is ability to recover to a moderately modified condition following disturbance has been maintained.	>62 - <=78
CD	The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category.	>58 - <=62
D	Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred. The resilience of the system to sustain this category has not been compromised and the ability to deliver Ecosystem Services has been maintained.	>42 - <=58
DE	The system is in a close to largely modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of an E category. The resilience of the system is often under severe stress and may be lost permanently if adverse impacts continue.	>38 - <=42
E	Seriously modified. The change in the natural habitat template, biota and basic ecosystem functions are extensive. Only resilient biota may survive and it is highly likely that invasive and problem (pest) species may dominate. The resilience of the system is severely compromised as is the capacity to provide Ecosystem Services. However, geomorphological conditions are largely intact but extensive restoration may be required to improve the system's hydrology and physico-chemical conditions.	20 - <=38
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete change of the natural habitat template, biota and basic ecosystem functions. Ecosystem Services have largely been lost This is likely to include severe catchment changes as well as hydrological, physico-chemical and geomorphological changes. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible. Restoration of the system to a synthetic but sustainable condition acceptable for human purposes and to limit downstream impacts is the only option.	<20

4. RESULTS

A total of 41 sites were sampled in the Usuthu-Lusutfu Catchment, of which 6 were sampled on the main Usuthu-Lusutfu River (Figure 20) and 35 on other sub-catchments in the system (e.g. Assegai-Mkhondvo, Hlelo, Ngwempisi, Mpuluzi and Lushushwane rivers (Figure15 to 19). At all these sites fish, invertebrate and habitat integrity assessments were conducted (Appendix A and B). The riparian and vegetation assessment (VEGRAI) was carried out on two (2). The Ecostatus ratings derived from the RIVDINT model are presented in Table 6 for each of the SQ reaches monitored during the 2019 survey. Water quality data were assessed at selected sites (as discussed in Chapter 2). Section 4.1 shows the results of the desktop water quality assessment for these sites. Detailed results are shown for each sub-catchment onwards, as relevant.

In Appendix A the fish species are listed in alphabetical order and illustrations of fish species from the Atlas of Southern African Freshwater Species - SAIAB (Scott et al., 2004) recorded at all the sampling sites are furthermore included. In Appendix B invertebrate data recorded on SASS5 data sheets are captured. Photos of each site for both 2015 and 2019 surveys are captured in Figures A1 to A151.

Table 6: Biomonitoring results derived from the RIVDINT model, summarised for each reach in the Usuthu-Lusutfu Catchment and its tributaries as well as the Recommended Ecological Category (REC). EWR sites indicated in blue font.

Reach Code	Site Code	River	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended EC
Assegai-Mkhondvo Catchment								
W51A-02082	W5ASSE-PLATJ	Assegai	C	BC	BC	BC	BC	BC
W51C-02022	W5ASSE-KLIPS	Assegai	C	C	C	C	C	C
W51C-02074	W5ANYS-KLOPP	Anysspruit	C	B	BC	C	BC	BC
W51C-01981	W5ASSE-WITK1	Assegai	C	BC	C	BC	C	BC
W51C-02109	W5BOES-ANHAL	Boesmanspruit	B	C	BC	B	BC	BC
W51D-02151	W5SWAR-ZWART	Swartwaterspruit	C	BC	C	B	BC	BC
W51E-02049	W5ASSE-ZANDB	Assegai	C	C	C	C	C	BC
W51E-02049	W5ASSE-ZAND1 (EWR AS1)	Assegai						
W51E-02049	W5MKHO-NHLAN	Mkhondvo						
W51F-01986	W5BLES-WEEHO	Blesbokspruit	C	D	CD	C	C	C
W51F-01973	W5NDHL-SWAZI	Ndlozane	C	B	C	B	BC	BC
W51H-01808	W5MKHO-SWAZI	Mkhondvo	C	C	C	C	C	C
Hlelo Catchment								
W52A-01983	W5HLEL-WITBA	Hlelo	C	C	C	B	C	C
W52B-01964	W5HLEL-TWYFE	Hlelo	C	C	C	C	C	C
W52C-01867	W5HLEL-HOLDE	Hlelo	C	C	C	BC	C	BC
W52C-01888	W5TWEE-MONDI	Tweelingspruit	C	C	C	BC	C	C
W52D-01862	W5HLEL-SWAZI	Hlelo	C	C	C	B	BC	B
Ngwempisi Catchment								
W53A-01853	W5NGWE-POMPO	Ngwempisi	C	C	C	BC	C	C
W53A-01757	W5SAND-ZANDS	Sandspruit	BC	C	C	B	C	C
W53D-01764	W5MPAM-GLENE	Mpama	C	CD	C	C	C	C

Reach Code	Site Code	River	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended EC
W53D-01773	W5NGWE-STERK	Ngwempisi	C	BC	C	C	C	C
W53D-01814	W5SWAR-WOLVE	Swartwaterspruit	C	C	C	C	C	B
W53C-01679	W5THOL-ATHOL	Thole	C	C	C	B	BC	BC
W53E-01790	W5NGWE-SKURW	Ngwempisi	C	BC	C	BC	BC	BC
W53E-01841	W5NGWE-MPONO	Ngwempisi	C	B	BC	C	BC	BC
W53E-01785	W5MPON-SWAZI	Mponono	BC	C	C	C	C	C
W53G-01788	W5NGWE-MZIMN	Ngwempisi	C	CD	C	BC	C	C
Mpuluzi Catchment								
W55C-01395	W5MPUL-BUSBY	Mpuluzi	C	C	C	B	C	C
W55C-01395	W5MPUL-ARDE1	Mpuluzi						C
W55C-01489	W5SWAR-IZIND	Swartwaterspruit	C	BC	C	BC	C	C
W55D-01506	W5METU-SWAZI	Metula	C	B	C	C	C	C
W55E-01651	W5MPUL-VELAB	Mpuluzi	BC	C	C	C	C	C
Lusushwane Catchment								
W56A-01372	W5LUSU-IFRSI (EWR KU1)	Lushushwane	C	C	C	B	BC	BC
W56C-01514	W5LUSU-FORES	Lushushwane	C	C	C	BC	C	C
W56F-01762	W5LUSU-MALUN	Lushushwane	B	C	C	C	C	C
Usuthu-Lusutfu Catchment								
W54C-01556	W5BONN-BROAD	Bonnie Brook	C	BC	C	C	C	BC
W54D-01593	W5USUT-STAFF	Usuthu	C	BC	C	B	BC	BC
W54D-01593	W5LUSU-MANGC	Lusutfu						
W54F-01729	W5LUSU-MABUZ	Lusutfu	C	BC	BC	C	BC	BC
W57A-01803	W5LUSU-LIBET	Lusutfu	C	C	C	C	C	C
W57E-01810	W5LUSU-SIPHO	Lusutfu	C	C	C	C	C	C

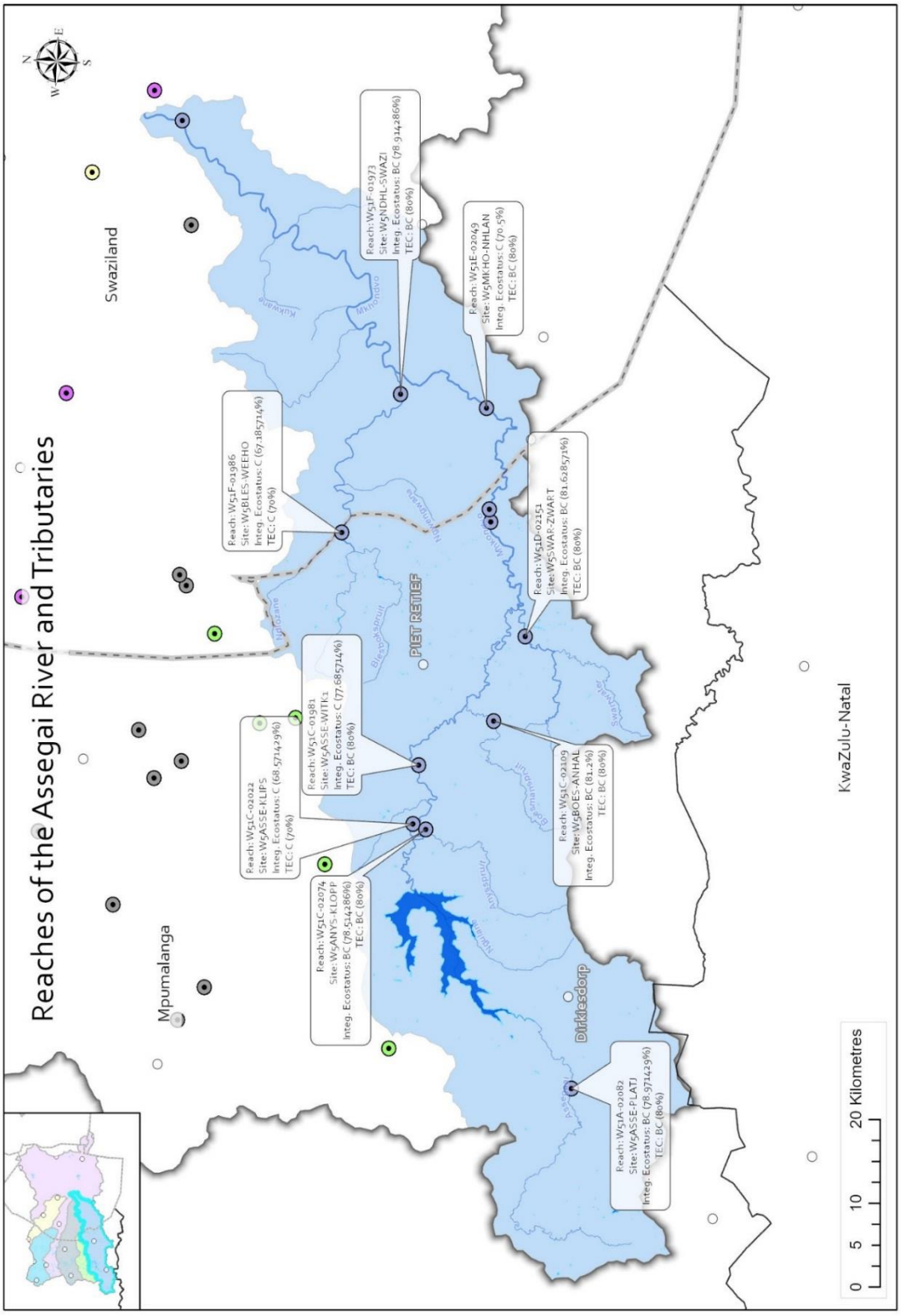


Figure 15: Map of the Assegai-Mkhondvo Sub-catchment indicating results of biomonitoring points.

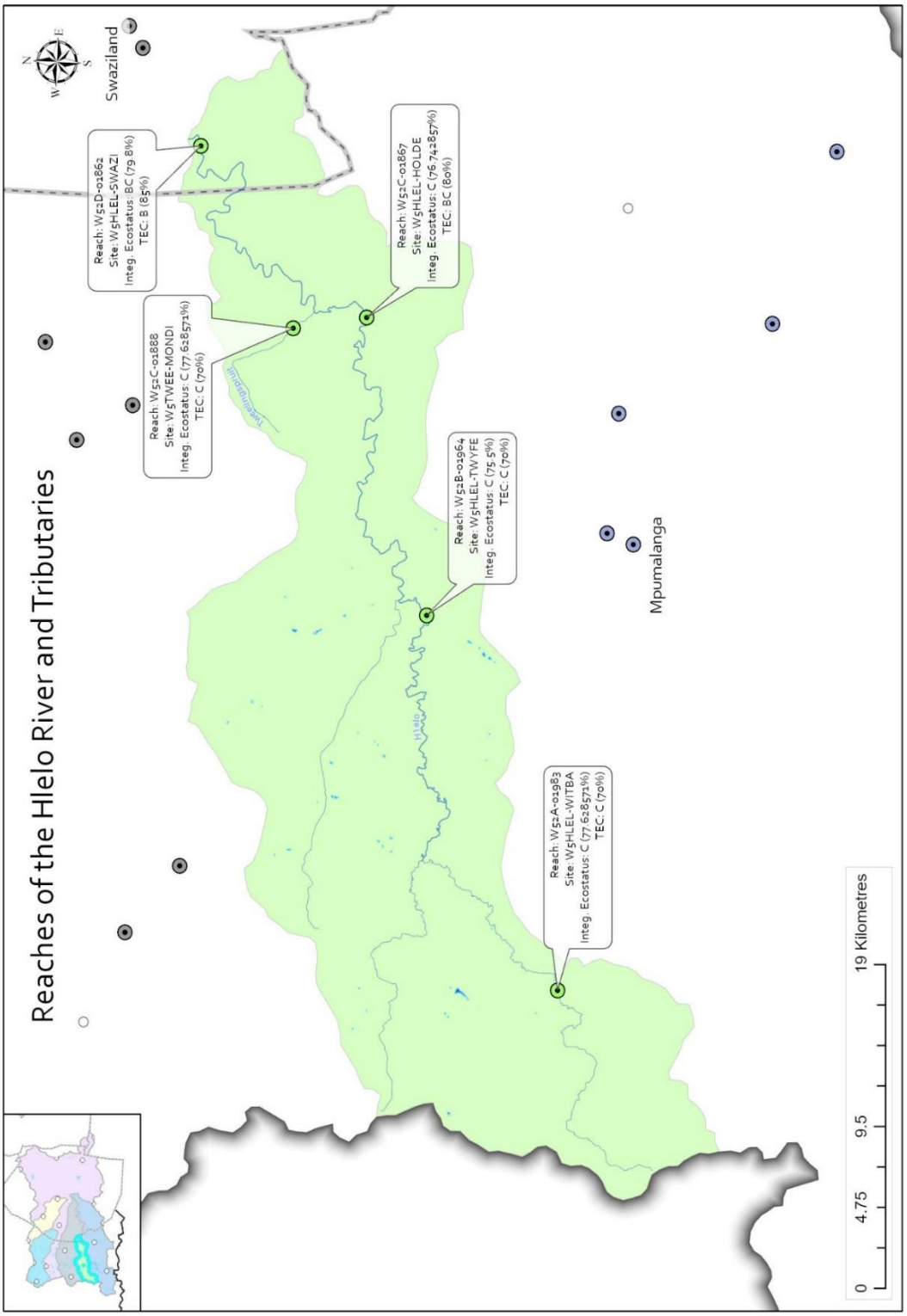


Figure 16: Map of the Hlelo Sub-catchment indicating results ofl biomonitoring points.

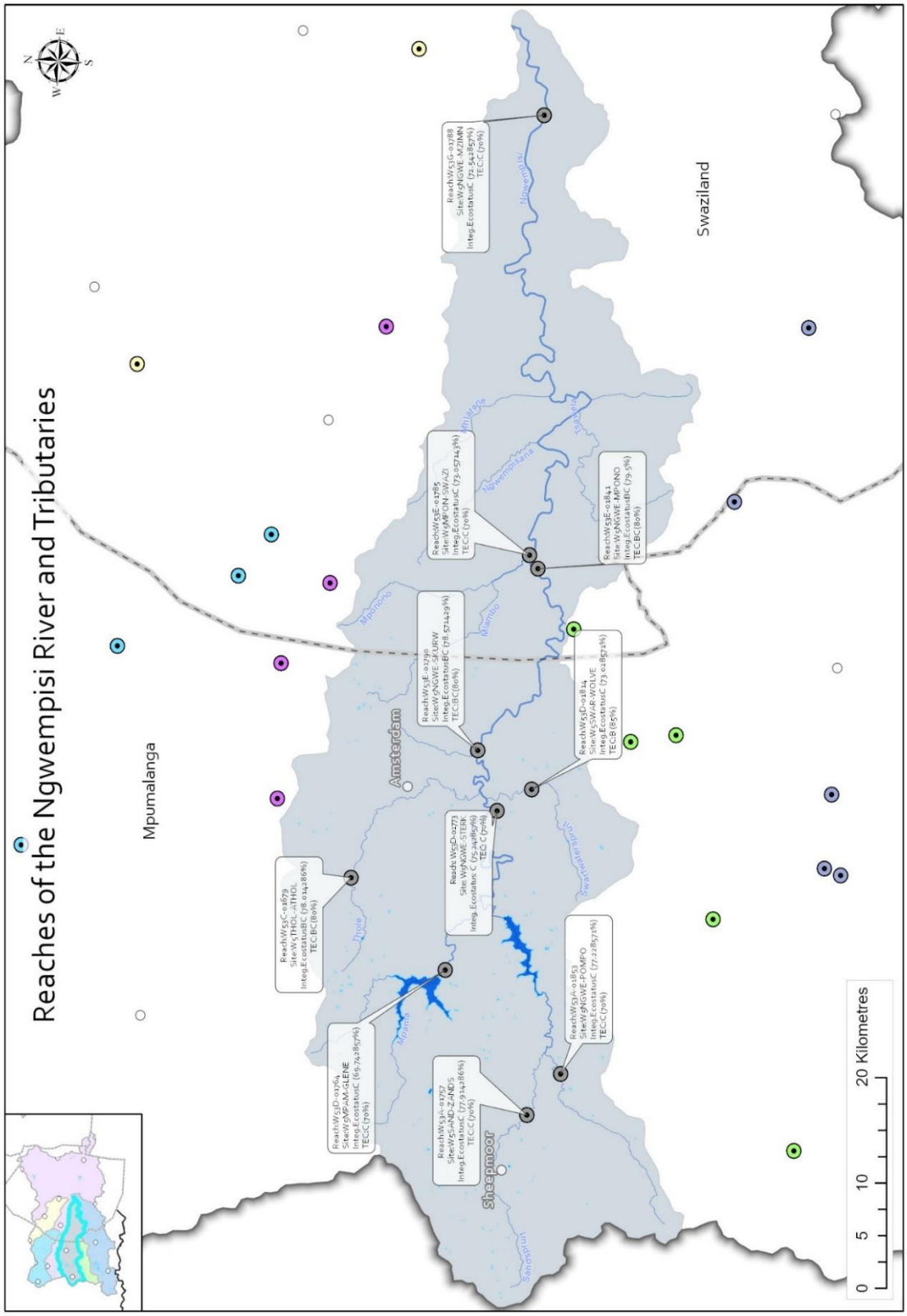


Figure 17: Map of the Ngwempisi Sub-catchment indicating results for the biomonitoring points.

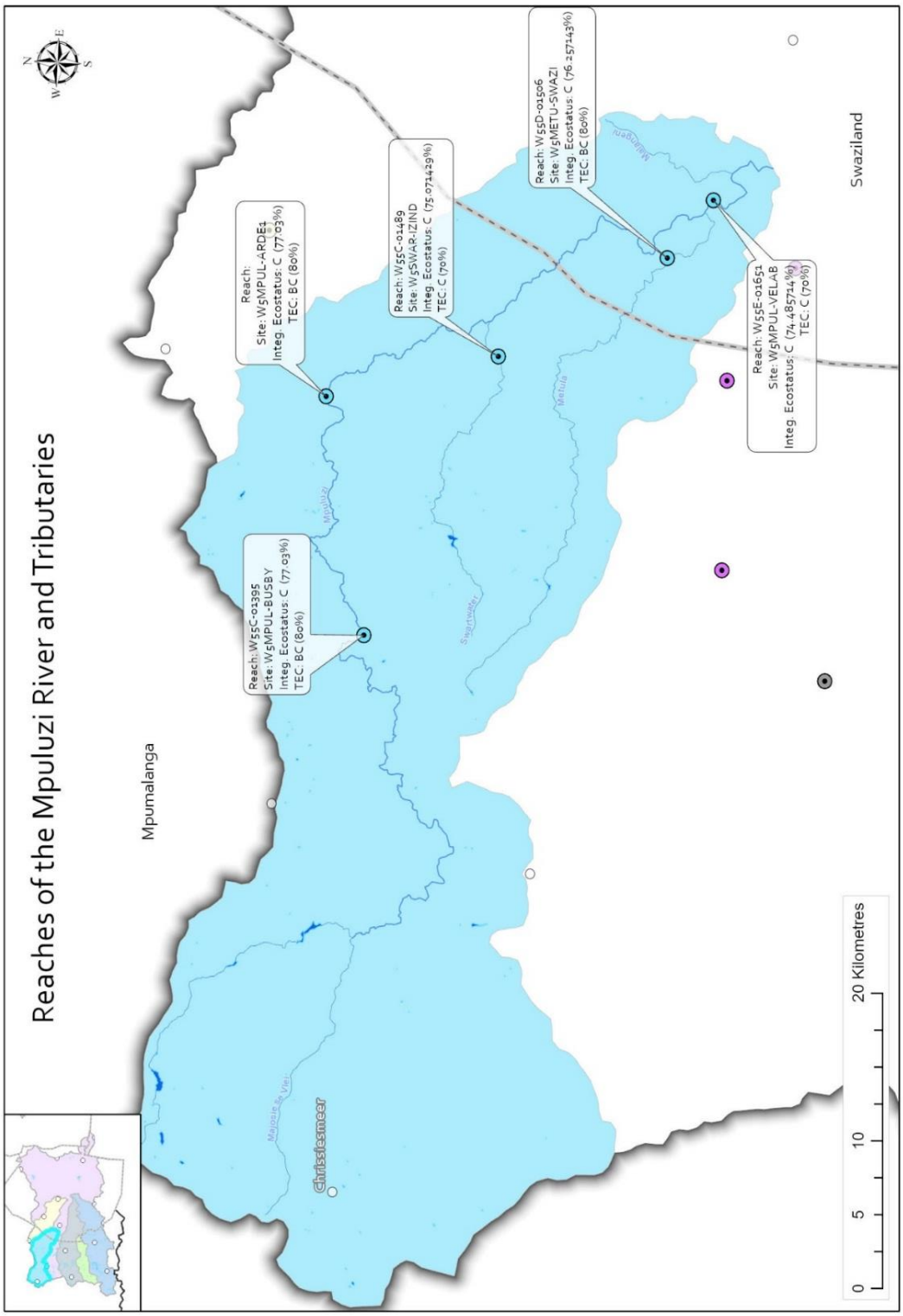


Figure 18: Map of the Mpuluzi Sub-catchment indicating results for the biomonitoring points.

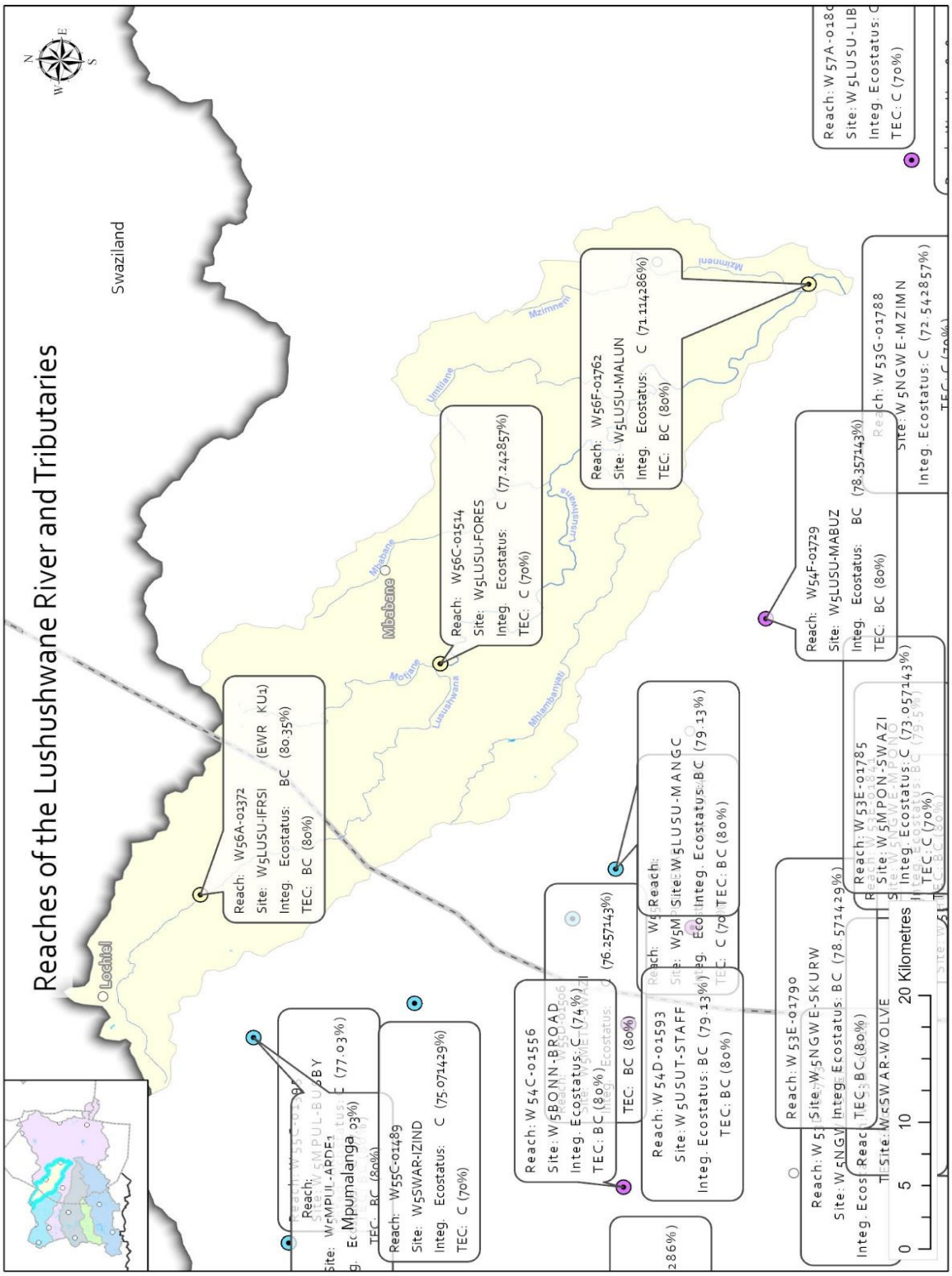


Figure 19: Map of the Lushushwane Sub-catchment indicating results for biomonitoring points.

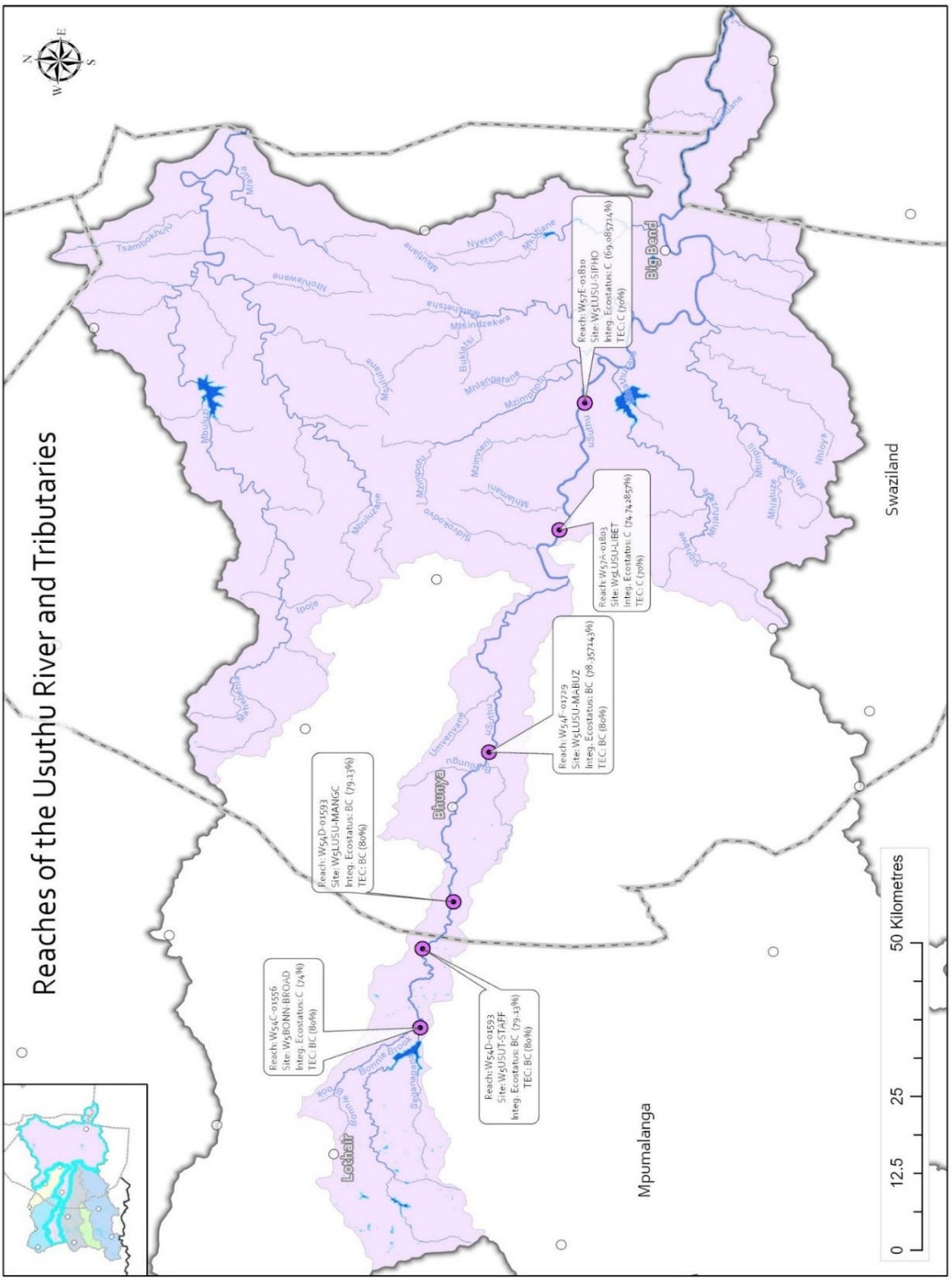


Figure 20: Map of the Usuthu-Lusutfu Catchment indicating results for the biomonitoring points.

4.1. Water Quality: Results of Desktop Assessment

Results of the desktop assessment from the PES/EI/ES study (DWS, 2014b) are shown below. These data inform the assessment of water quality status at selected sites. The PES/EI/ES study was funded jointly by the DWS and the Water Research Commission and rated significant water sources from the 1:500 000 spatial dataset of the rivers of South Africa. Rivers were assessed at a quinary or sub-quaternary reach (SQR) level in all Water Management Areas (WMAs) of South Africa. Input data were received from DWS in 2011 and then updated to include all known and more recent data, so as to produce the final PES and REC per identified river or stretch of river. Each SQR was also assessed thoroughly by a team of specialists using Google Earth to "groundtruth" assessed rivers. Note that these data should include results of known Reserve or Classification studies at the time of production (i.e. 2014).

During the PES/EI/ES study, the present state was assessed according to six metrics that represents a very broad qualitative assessment of both the instream and riparian components of a river. The metrics used in the PES/EI/ES model and an explanation of what they refer to is explained in Table 7 (DWS, 2014b). Each metric is scored from zero to five. The water quality metric is shaded in the table.

Table 7: PES metrics and explanations (DWS, 2014b)

Metrics	Comment
Potential instream habitat continuity modification	Modifications that indicate the potential that instream connectivity may have been changed from the reference. *Indicators:* Physical obstructions (e.g. dams, weirs, causeways). Flow modifications (e.g. low flows, artificially high velocities, physico-chemical "barriers").
Potential riparian/wetland habitat continuity modification	Modifications that indicate the potential that riparian/wetland connectivity may have been changed. *Indicators:* Physical fragmentation, e.g. inundation by weirs, dams; physical removal for farming, mining, etc.
Potential instream habitat modification activities.	Modifications that indicate the potential of instream habitats that may have been changed from the reference. Includes consideration of the functioning of instream habitats and processes, as well as habitat for instream biota specifically. *Indicators:* Derived likelihood that instream habitat types (runs, rapids, riffles, pools) may have changed in frequency (temporal and spatial). Assessment is based on flow regulation, physical modification and sediment changes. Land use/land cover (erosion, sedimentation), abstraction etc. may indicate the likelihood of habitat modification. The presence of weirs and dams are possible indicators of causes of instream habitat change. Certain introduced biota (e.g. carp, crustaceans and molluscs) may also cause habitat modification. Eutrophication and resulting algal growth as well as macrophytes may also result in substantial changes in habitat availability.
Potential riparian/wetland zone modifications	Modifications that indicate the potential that riparian/wetland zones may have been changed from the reference in terms of structure and processes occurring in the zones. Also refers to these zones as habitat for biota. *Indicators:* Derived likelihoods that riparian/wetland zones may have changed in occurrence and structure due to flow modification and physical changes due to

Metrics	Comment
	agriculture, mining, urbanisation, inundation etc. Based on land cover/land use information. The presence and impact of alien vegetation is also included.
Potential flow modification	Modifications that indicate the potential that flow and flood regimes have been changed from the reference. *Indicators:* Derived likelihood that flow and flood regimes have changed. Assessment based on land cover/land use information (urban areas, interbasin transfers), presence of weirs, dams, water abstraction, agricultural return flows, sewage releases, etc.
Potential physico-chemical modification activities	Activities that indicate the potential of physico-chemical conditions that may have changed from the reference. *Indicators:* Presence of land cover/land use that implies the likelihood of a change of physico-chemical conditions away from the reference. Activities such as mining, cultivation, irrigation (i.e. agricultural return flows), sewage works, urban areas, industries, etc. are useful indicators. Algal growth and macrophytes may also be useful response indicators.

The water quality state was rated from 0 to 5 as follows:

- Rating = 0: no impact (i.e. an A category)
- Rating = 1: small impact (i.e. an A/B to B category)
- Rating = 2: moderate impact (i.e. a B/C to C category)
- Rating = 3: large impact (i.e. a C/D to D category)
- Rating = 4: serious impact (i.e. a D/E to E category)
- Rating = 5: critical impact (i.e. E/F to F category)

Table 8 summarizes the water quality (wq) state at a desktop level per identified site. Information added to PES/EI/ES data during this assessment is italicized.

Detailed water quality results are then shown per site in the relevant sections of Chapter 4. Ecological monitoring objectives are proposed per site (other than the EWR site), and adherence to EcoSpecs (EWR site) and International Obligations (all sites) indicated where relevant. Table 9 lists the Usuthu water quality monitoring points sampled by the IUCMA where water quality data has been collected monthly since January 2016, so as to assess the water quality state of the selected river reaches of the Usuthu-Lusutfu catchment. Table 9 also shows the associated DWS wq monitoring points available, and data records. *In situ* water quality data – pH, DO, temperature, Electrical Conductivity and Total Dissolved Solids (TDS) were also collected by the invertebrate specialist for the study (Diedericks, pers. comm., November 2019)

Table 8: Water quality state based on the PES/EI/ES results (DWS, 2014b) for the selected water quality (wq) monitoring point in the Usuthu-Lusutfu catchment area. *Additional information is shown in italics.*

IUCMA wq site code	River	SQR catchment	Water quality rating	Identified impacts
U-26 (EWR AS1)	Assegaai	W51E-02049	1	Irrigation in lower reaches; roads; 50% of reach in Swaziland so not assessed.
U-43	Hlelo	W52C-01867	1	Extensive forestry; roads; small quarry in lower reaches.
U-44	Ngwempisi	W53E-01790	1	Extensive forestry; roads and erosion along river; lower reach in Swaziland so not assessed.
U-53	Usuthu	W54D-01593	1	Extensive forestry; cattle trampling; lower reach in Swaziland so not assessed.
U-57	Mpuluzi	W55C-01395	1	Plantations; dryland cultivation; roads; large sand-mining operation in lower reach close to rural township; sedimentation; WWTW.
U-61	Lusushwane	W56A-10372	3	Extensive forestry; erosion; subsistence farming; over-grazing; roads; lower 50% of reach in Swaziland so not assessed.
	Blesbokspruit*	W51F-01986	3	Irrigation and cultivation – *narrow riparian buffer*; wood plant (timber processing?) upstream.
	Lusushwane*	W56F-01762	*2-3*	Not assessed as in Swaziland. *Extensive dryland cultivation; roads; two tributaries join immediately upstream of the biomonitoring site. Matsapha town is drained by the Lusushwane in the upstream SQR (W56F-01648), with its associated urban impacts, including a WWTW and Swazi Paper Mills close to the river. The other upstream tributary is the Mzimneni (SQR W56F-01648) which drains the urban and rural area of Manzini, with its associated wq impacts, including a WWTW close to the lower reaches of the river.*

**biomonitoring sites where a wq assessment has been requested by the macroinvertebrate specialist*

Table 9: Monitoring points and data used for the water quality assessment of the selected Usuthu/Lusutfu catchment sites

IUCMA site code	SQR	Point description	Coordinates of IUCMA monitoring point	Type of site	WMS code / DWS gauge number	Length of data record	No of DWS data records (n)**
U-26	W51E-02049	Assegai River on Road Bridge to Mahamba Border Gate (R543)	-27.06519444 30.99355556	International Obligations and EWR site AS1 (Assegaai)	102914 / W5H022Q01	IUCMA: July 2016-Sept 2019 DWS: 1977/08/16-2019/08/08*	483
U-43	W52C-01867	Hlelo River on R33 Road Bridge to Amsterdam	-26.853952 30.731669	International Obligations	102911 / W5H005Q01	IUCMA: July 2016-Sept 2019 DWS: 1977/08/13-2013/02/19	482
U-44	W53E-01790	Ngwempisi River on R33 Road Bridge to Amsterdam	-26.679812 30.702529	International Obligations	102918 / W5H026Q01	IUCMA: July 2016-Sept 2019 DWS: 1977/05/03-2019/08/08	802
U-53	W54D-01593	Usuthu River at weir before Nerston Border Gate	-26.513054 30.786324	International Obligations	102917 / W5H025Q01	IUCMA: July 2016-Sept 2019 DWS: 1977/05/03-2019/08/08	452
U-57	W55C-01395	Mpuluzi River downstream of Mpuluzi Oxidation Ponds	-26.323670 30.805007	International Obligations	102916 / W5H024Q01	IUCMA: July 2016-Sept 2019 DWS: 1977/05/03-2010/10/07	770
U-61	W56A-01372	Lusushwane River bridge at Zwalunest Village before Swaziland border. Downstream from EWR KU1 (Klein Usuthu)	-26.265218 30.903379	International Obligations	-	IUCMA: July 2016-Sept 2019	-
-	W51F-01986	Blesbokspruit; biomonitoring site W5BLES-WEEHO	-	Biomonitoring site	-	Level II ecoregion 4.06	-
-	W56F-01762	Lusushwane; biomonitoring site W5LUSU-MALUN	-	Biomonitoring site	-	Level II ecoregion 4.06	-

- *No data or not relevant*

* *Data collected for selected variables until 2009, and then again from 2015 to 2019.*

** *Selected variables only*

Assegai-Mkhondvo Sub-catchment Reaches

The Assegai-Mkhondvo River catchment originates in the Eastern Escarpment Mountains aquatic ecoregion, and then flows in a north north eastern direction towards the Lusutfu River. A total of 12 biomonitoring points comprising of 10 SQ reaches (327.5 km) representing 30.5% of the river monitored on the Usuthu-Lusutfu Catchment were sampled during 2019.

SQ REACH NUMBER W51A-02082

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51A-02082	W5ASSE-PLATJ	Assegai	S-27.18344 E 30.29556	1 344	84.9	C	C 64%	C* 76.4%	C 70.2%	BC** 80%	C 74.4%	BC 80%	2015
							C 75.6%	BC 80.8%	BC 78.2%	BC 80%	BC 78.9%		2019

*Correcte MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51A-02082: Assegai River from source to Mpofana River

The site is located within the PESEIS Reach Code W51A-02082, which is reported as 84.9 km in length. The length is measured from the source of the Assegai to where the river merges with the Mpofana River in the Heyshope Dam (from Department of Water and Sanitation 2014). The river length from source to the W5ASSE-PLATJ sampling point measured on Google Earth Pro is 57.9 km, draining a catchment of 365.69 km^2. The main river channel originates at an elevation of 2,036 m a.m.s.l., flowing 57.9 km towards the sampling point at an elevation of 1,344 m a.m.s.l. The vegetation in the catchment is represented by the Wakkerstroom Montane and Pietersburg Moist Grassland (from Mucina & Rutherford 2006), and is located in the Eastern Escarpment Mountains aquatic ecoregion. Landcover consists mainly of open spaces with grasslands (70.6%). Landuse practises include mixed dry agriculture (8.4%) with cattle and irrigated crops (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W51A-02082 was calculated at 77.3% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic habitat sampled at site W5ASSE-PLATJ (W51A-02082), is upstream from Heyshope Dam. The habitat surveyed consisted mainly of shallow riffles with fast shallow habitat in abundance and slow shallow habitat moderately abundant. A long shallow pool providing slow shallow habitat was recorded and fast deep habitats were absent. The

substrate cover in the fast shallow habitats were abundant consisting of rocks and cobbles. The slow shallow habitat was silted up with very fine silt impacting on available fish habitat. Overhanging vegetation provided moderate cover with a few undercut banks. No aquatic macrophytes was present as cover for fish.

Table 10: Fish species expected based on the PESEIS Reach Code (W51A-02082) W5ASSE-PLATJ; is listed, and the fish species percentage composition during the different surveys is indicated.

W51A-02082	Expected Species	W5ASSE-PLATJ					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	11	9.09
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus marequensis	X	-	-	4	2.4	8	6.61
Labeobarbus polylepis	X	24	28.57	93	55.69	55	45.45
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	17	20.24	7	4.19	12	9.92
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	1	1.19	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	42	50.0	63	37.72	35	28.93
Chiloglanis emarginatus	X	-	-	-	-	-	-
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	-	-
Tilapia sparrmanii	X	-	-	-	-	-	-
Number of species recorded	11	4		4		5	
Number of individuals		84		167		121	
Electro-fishing time (minutes)		40 minutes		36 minutes		28 minutes	
Catch/Unit Effort (CPUE)		2.10		4.64		4.32	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 64%		**CATEGORY C** 75.6%	

The fish assemblage collected at this site consisted of five of an expected 11 indigenous fish species, one species more than during the 2010 and 2015 surveys (Table 10). The most abundant species collected was, as with the 2015 survey, the reophilic species, *Labeobarbus polylepis,* at 45.45% (55 individuals). This is slightly lower when compared to the 2015 collection of this species at 55.69% (93 individuals) of the total fish assemblage. The presence of the migratory species *Labeobarbus polylepis* is significant, indicating that this reach is still accessible to migratory species. No cichlids were found since 2005 when this site was surveyed for the first time.

The catch per unit effort (CPUE) was calculated at 4.32 (121 individuals: 28 minutes), remaining consistent with the 2015 survey, still indicating a relative high abundance of fish present at the times of the surveys.

A mean Fish Ecostatus rating of 75.6% was calculated for this SQR based on all available information, placing it in an ecological Category C (moderately impaired with low diversity and abundance of species) comparing slightly more favourably to the 2015 results, but still an ecological Category C (64%) for fish.

Invertebrates

Five SASS sampling events are on record for the W5ASSE-PLATJ site in this reach on the Assegai River. These sampling events occurred in October 2005, October 2006, May 2007, August 2015 and this survey in August 2019. These represent one high flow (May 2007) and four low-flow events (Aug and Oct). In total 44 SASS taxa have been recorded during these five sampling events, of which the 31 in August 2019 is the highest. Only Chironomidae (tolerant taxa) were recorded during all five sampling events. Flow conditions were lower in 2019 than during the 2015 survey, with a slight decrease in sensitive taxa.

The diversity of SASS5 taxa increased between the 2015 and 2019 surveys. Some taxa present in 2019 were not recorded in 2015, with sensitive rated taxa absent including Aeshnidae and one Hydropsychidae species. Taxa with a preference for fast to moderate flows dominated during both the 2015 and 2019 surveys.

Table 11: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51A-02082.

W51A-02082	W5ASSE-PLATJ	2015	2019	
	Total SASS Score	186	191	
	No. of SASS Families	28	32	Change
	Average Score Per Taxon	6.6	6.2	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76.4%	Category BC 80.8%	↑

The 2019 SASS5 results (Table 11) indicates improved conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 76.4%) in August 2015 improving to close to largely natural most of the time (Category BC – 80.8%) in August 2019. MIRAI indicates improved stream conditions but the change is mainly influenced by the increase in SASS taxa diversity. The 2019 stream flow was lower than in 2015, but the habitat and in situ water quality measured were similar.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category BC – close to largely natural with few modifications most of the time. The Riparian IHI was calculated at 76.3% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is moderately close to largely natural with few modifications and the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Stream bank trampling by domestic livestock
- Stream bank scouring downstream from the bridge
- High weed infestation in the marginal and lower zones of the riparian zone
- Sedimentation from roads

- Domestic waste dumped in the stream at the bridge

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78.9%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF		
Assegai-Mkhondvo			Lusutfu		
SITE NUMBER			QUATERNARY SUB-CATCHMENT		SITE NUMBER
W5ASSE-PLATJ			W51A		W5ASSE-PLATJ
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	GPS CO-ORDINATES (WGS84 – dd.ddddd):	
	S -27.18344	E 30.29556	S -27.18344	Lower foothill	
AQUATIC ECOREGION	Level I			AQUATIC ECOREGION	
	15. Eastern Escarpment Mountain			15.05	

Figure A-1. Upstream view of the site Assegai River at Platjesfontein (02 August 2015).

Figure A-2. Downstream view of the site on the Assegai River at Platjesfontein (02 August 2015).

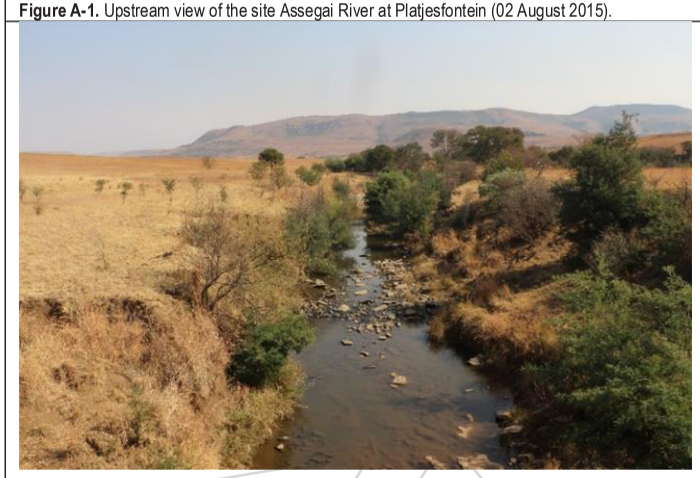


Figure A-3. Upstream view of the site on the Assegai River at Platjesfontein (21 August 2019).

Figure A-4. Downstream view of the site on the Assegai River at Platjesfontein (21August 2019).

SQ REACH NUMBER W51C-02022

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51C-02022	W5ASSE-KLIPS	Assegai	S-26.99312 E 30.60575	1 230	23.3	C	C 64.2%	C* 76%	C 70.9%	C** 75%	C 72.9%	C 70%	2015
							C 67.6%	C 77.9%	C 72.8%	C 63%	C 68.6 %		2019

*Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51C-02022: Assegai River from Mpofana to Anysspruit

The site is located within the PESEIS Reach Code W51A-02022, which is reported as 23.4 km in length. The length is measured from the confluence of the Assegai with the Mpofana River (in the Heyshope Dam) to the Assegai's confluence with the Anysspruit (from Department of Water and Sanitation 2014). The river length from source to the W5ASSE-KLIPS sampling point measured on Google Earth Pro is 114 km, draining a catchment of 1,044.3 km^2. The main river channel originates at an elevation of 2,036 m a.m.s.l., flowing 114 km towards the sampling point at an elevation of 1,230 m a.m.s.l. The sampling point is located 16.6 km downstream from Heyshope Dam. The vegetation types in the catchment is represented by the Wakkerstroom Montane Grassland; Pietersburg Moist Grassland; Eastern Highveld Grassland, and KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion.

Landcover is dominated by grasslands (29.4%) and woodlands (4.8%). Landuse practises include cultivated crops (8.5%), *Pinus and Eucalyptus* forestry (21.4%) (GEOTERRAIMAGE, 2015) and the Driefontein village above the Heyshope Dam.

Instream Habitat Integrity

The IHI for the SQ reach W51C-02022 was calculated at 43.6% rating this SQ reach as a D category indicating that the instream habitat integrity is largely modified. A large change or loss of natural habitat and biota and basic ecosystem functions have occurred. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The W5ASSE-KLIPS (W51C-02022) site is situated downstream from the Heyshope Dam. The fish velocity depth classes present were fast shallow (very abundant), fast deep (sparse) and slow shallow (moderate). The fish cover present consisted largely of substrate with rocks and cobbles. Overhanging vegetation was moderately present at both the shallow habitats, and undercut banks were only sparsely present at the slow shallow habitat. No aquatic macrophytes were present at the habitats sampled, but *Potamogeton crispus* was present just upstream in a deep pool which could not be sampled.

Table 12: Fish species expected based on the PESEIS Reach Code (W51C-02022) W5ASSE-KLIPS; is listed, and the fish species percentage composition during the different surveys is indicated.

W51C-02022	Expected Species	W5ASSE-KLIPS					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	1	0.48	-	-	1	2.38
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus marequensis	X	-	-	-	-	8	19.05
Labeobarbus polylepis	X	26	12.38	21	25	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	23	10.95	6	7.14	2	4.76
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	134	63.81	24	28.57	17	40.48
Chiloglanis emarginatus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	-	-	2	4.76
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	3	1.43	4	4.76	4	9.52
Tilapia sparrmanii	X	23	10.95	29	34.53	8	19.05
Number of species recorded	11	6		4		6 + 1	
Number of individuals		210		84		40 + 2	
Electro-fishing time (minutes)		43 minutes		40 minutes		27 minutes	
Catch/Unit Effort (CPUE)		3.0		2.10		1.56	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 64.2%		**CATEGORY C** 67.6%	

Red – Exotic species

During the present survey a fish assemblage of six indigenous fish species were recorded from an expected 11 species, as well as one alien and invasive species, *Micropterus salmoides* (Table 12).The reophilic, *Chiloglanis anoterus*, was the most abundant species collected during the 2019 survey with a relative abundance of 40.48% (17 individuals) of all fish species collected. During the 2010 survey this species was also the most abundant species collected (63.81%, 134 individuls of the fish assemblage) which was not the case with the 2015 survey when the limnophilic cichlid, *Tilapia sparrmanii*, was the most abundant species found (34.53% : 29 individuals). During the 2010 and 2015 surveys, *Labeobarbus polylepis* (an indigenous yellowfish species), was recorded for this site but for the 2019 survey this species was not found, however, *Labeobarbus marequensis,* also a yellowfish species was recorded at relative abundance (19.05% of fish assemblage; 8 individuals). The presence of both these yellowfish species is of importance as migration is part of their life history strategy, however, both these species are impacted on by flow regulation from Heyshope Dam. *Anguilla mossambica* was recorded during the 2010 and the present survey. The presence of this species is an indication that river connectivity is still in place for most of the Usuthu Catchment.

The CPUE (catch per unit effort) calculated for this site is 1.56 (individuals caught per minute) indicating a slightly lower abundance of fish collected compared to both the 2010 and 2015 surveys when a CPUE of 3.0 and 2.1 was calculated respectively.

A Fish Ecostatus rating of 67.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) remaining consistent with the 2015 survey (Ecological Category C - 64%).

Invertebrates

Nine SASS sampling events are on record for the W5ASSE-KLIPS site in this reach on the Assegai River. These sampling events occurred in August 1999, 2000, 2001, 2003, 2006, 2009, 2014, 2015 and 2019. In total 58 SASS taxa have been recorded, and in addition Cladocera and Machadorythidae, which are not SASS taxa. Total SASS scores range from 169 – 213 (avg.) – 266 during these nine sampling events. The site is located downstream from the Heyshope Dam, and therefore affected by flow regulation.

The diversity of SASS5 taxa diversity increased between the 2015 and 2019 surveys, with flow conditions slightly lower. Sensitive taxa are present and dominated in 2019, with some expected taxa absent. The family Unionidae was not recorded since 2006

Table 13: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51C-02022.

W51A-02022	W5ASSE-KLIPS	2015	2019	
	Total SASS Score	179	210	
	No. of SASS Families	28	33	Change
	Average Score Per Taxon	6.4	6.4	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76%	Category C 77.9%	→

The 2019 SASS5 results (Table 13) indicates a slight improvement in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 76%) in August 2015 slightly improving to higher moderately impaired (Category C – 77.9%) category in August 2019. The site experience flow regulation from the Heyshope Dam, with stream conditions ranging between largely natural (B) and moderately impaired (C) over the nine data sets.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 40.13% rating this reach as a Category DE indicating a close to largely modified conditions most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (63%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The bridge impounds the river above the crossing, with downstream bank scouring as a result of overtopping

- The bridge serves as a potential barrier to fish movement during low flow conditions
- High weed infestation on islands between channels
- Sediment inputs from the approaching road

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (68.6%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✔	

			TRIBUTARY OF	
Assegai-Mkhondvo			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5ASSE-KLIPS			W51C	W51C-02022
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.99312	E 30.60575	1 230	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-5. Upstream view of the site on the Assegai River, W5ASSE-KLIPS (05 August 2015).

Figure A-6. Downstream view of the site on the Assegai River, W5ASSE-KLIPS (05 August 2015).

Figure A-7. Upstream view of the site on the Assegai River, W5ASSE-KLIPS (21 August 2019).

Figure A-8. Downstream view of the site on the Assegai River, W5ASSE-KLIPS (21 August 2019).

SQ REACH NUMBER W51C-02074

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51C-02074	W5ANYS-KLOPP	Anysspruit	S-27.00776 E 30.59989	1 253	31.7	C	C 72%	C* 75.9%	C 73.9%	B** 82.5%	C 77.6%	BC 80%	2015
							C 76.2%	B 83.1%	BC 79.7%	C 77 %	BC 78.5 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51C-02074: Anysspruit from source to confluence with Assegai River

The site is located within the PESEIS Reach Code W51C-02074, which is reported as 31.7 km in length. The length is measured from the source of the Anysspruit to where the river merges with the Assegai River (from Department of Water and Sanitation 2014). The Vegkopspruit is the other major tributary of the Anysspruit. The length from the source of the Anysspruit to the W5ANYS-KLOPP sampling point measured on Google Earth Pro is 32.5 km, draining a catchment of 155.8 km^2. The main river channel originates at an elevation of 2,120 m a.m.s.l., flowing 32.5 km towards the sampling point at an elevation of 1,253 m a.m.s.l. The vegetation types in the catchment is represented by the Eastern Highveld and KaNgwane Montane Grassland.

Landcover consists mainly of grasslands (45.9%) with wetlands (8%). Landuse practises include several farm dams with cultivated crops (13.8%). Forrestry in the catchment (18.3%) consist mainly of *Pinus* and *Eucalyptus* (GEOTERRAIMAGE, 2015). Four open cast coalmines are recorded.

Instream Habitat Integrity

The IHI for the SQ reach W51C-02074 was calculated at 74.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site W5ANYS-KLOPP (W51C-02074) is on the Anysspruit, a tributary of the Assegai River. A diversity of shallow habitat types was present with slow shallow moderate and fast shallow abundant with riffles and runs. The river flow was however too shallow, not ideal for flow dependant species. Bedrock dominated the site and substrate cover was provided by small boulders and rocks on bedrock. Overhanging vegetation and undercut banks were sparsely present and provided some cover for fish, especially at the slow deep habitat. Aquatic macrophytes were observed in the reach, up- and downstream from the site, although not present at the site itself.

Table 14: Fish species expected based on the PESEIS Reach Code (W51C-02074) W5ANYS-KLOPP; is listed, and the fish species percentage composition during the different surveys is indicated.

W51C-02074	Expected Species	W5ANYS-KLOPP					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	1	0.43	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	9	10.98	-	-
Enteromius brevipinnus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus marequensis	X	88	38.10	3	3.66	18	27.27
Labeobarbus polylepis	X	21	9.09	7	8.54	2	3.03
Labeobarbus nelspruitensis	X	-	-	1	1.22	4	6.06
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	35	15.15	6	7.32	3	4.55
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	71	30.74	24	29.27	11	16.67
Chiloglanis emarginatus	X	-	-	-	-	-	-
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	15	6.49	-	-	-	-
Tilapia sparrmanii	X	-	-	32	39.01	28	42.42
Number of species recorded	13	6		7		6	
Number of individuals		231		82		66	
Electro-fishing time (minutes)		17.5 minutes		29 minutes		26 minutes	
Catch/Unit Effort (CPUE)		13.20		2.83		2.54	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 72%		**CATEGORY C** 76.2%	

The fish assemblage recorded during the present survey consisted of six indigenous fish species of an expected thirteen (13) species. To date a total of nine indigenous fish species were recorded for this site (Table 14). Only one of the two limnophilic Cichlids (*Tilapia sparrmanii*) expected to occur, was collected in abundance at the available slow deep habitat, making it the most abundant species (42.2%; 28 individuals) collected for the 2019 survey. All of the large yellowfish species (*Labeobarbus marequensis, Labeobarbus nelspruitensis* and *Labeobarbus polylepis*) were recorded during the 2015 and 2019 surveys. This tributary thus remain an important refuge area for fish.

The CPUE (catch per unit effort) calculated for the site is 2.54 (66 individuals; 26 minutes), remaining consistent with the CPUE of 2.83 (82 individuals; 52 minutes) recorded during the 2015 survey, indicating a relative low abundance of fish present.

A Fish Ecostatus rating of 76.2% was determined for this reach placing it in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey.

Invertebrates

Two SASS sampling events are on record for the W5ANYS-KLOPP site in this reach on the Anysspruit. These sampling events occurred in August 2015 and this survey in August 2019. In total 40 SASS taxa have been recorded during these two sampling events. In addition, Cladocera were recorded in high abundance during the 2015 survey.

The diversity of SASS5 taxa increased considerably between 2015 and 2019 surveys. Several taxa absent in 2015 were recorded in 2019, of which the most sensitively SASS-rated were Chlorocyphidae, Aeshnidae and Psephenidae. The Ephemeroptera family Tricorythidae was absent from the 2019 sample. In 2015, no Gastropoda were recorded, with Ancylidae, Bulinae, Lymnaedidae and Planorbidae present in 2019. Compared to 2015, scrapers increased and gathering- and filtering collectors decreased. Taxa tolerant to organic pollution decreased from 2015 to 2019.

Table 15: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51C-02074.

W51C-02074	W5ANYS-KLOPP	2015	2019	
	Total SASS Score	154	215	
	No. of SASS Families	25	36	Change
	Average Score Per Taxon	6.2	6.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 75.9%	Category B 83.1%	↑

The 2019 SASS5 results (Table 15) indicates improved conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 75.9%) in August 2015 improving to largely natural (Category B – 83.1%) in August 2019. The 2019 stream flow was lower than in 2015, but the habitat and in situ water quality measured were similar.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 64.7% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- On site loose soil enter the stream from hoed tracer belts below the power line.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78.5%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF	
Anysspruit			Assegai	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5ANYS-KLOPP			W51C	W51C-02074
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -27.00776	E 30.59989	1 253	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-9. Upstream view of the site on the Anysspruit, W5ANYS-KLOPP (05 August 2015).

Figure A-10. Downstream view of the site on the Anysspruit, W5ANYS-KLOPP (05 August 2015).

Figure A-11. Upstream view of the site on the Anysspruit, W5ANYS-KLOPP (21 August 2019).

Figure A-12. Downstream view of the site on the Anysspruit, W5ANYS-KLOPP (21 August 2019).

SQ REACH NUMBER W51C-01981

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51C-01981	W5ASSE-WITK1	Assegai	S-26.99655 E 30.67699	1 169	22.6	C	C 68.1%	BC* 80.8%	C 75.4%	B** 85%	BC 80.2%	BC 80%	2015
							C 69.6%	BC 80.8%	C 75.2%	BC 81%	C 77.7%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51C-01981: Assegai River from confluence with Kloppersprui to confluence with Boesmanspruit

The site is located within the PESEIS Reach Code W51C-01981, which is reported as 22.6 km in length. The length is measured from the confluence of the Assegai with the Kloppersprui to where the Assegai merges with the Boesmanspruit (from Department of Water and Sanitation 2014). The length from the source of the Assegai River to the W5ASSE-WITK1 sampling point measured on Google Earth Pro is 126 km, 12 km downstream from the upstream site, W5ASSE-KLIPS, and 28.6 km downstream from the Heyshope Dam wall. The main river channel originates at an elevation of 2,036 m a.m.s.l., flowing 126 km towards the sampling point at an elevation of 1,169 m a.m.s.l. The vegetation types in the catchment is represented by the Wakkerstroom Montane Grassland; Pietersburg Moist Grassland; Eastern Highveld Grassland, and KaNgwane Montane Grassland (from Mucina & Rutherford 2006).

The site is located in the KaNgwane Montane Grassland, and falls within Highveld aquatic ecoregion (see Table A-1).

Landcover consists of grasslands (18.1%), wetlands (4.2%) and dense thickets and bush (4.8%). Landuse practises include some agriculture with extensive plantations (67.5%) (GEOTERRAIMAGE, 2015) and open cast mines are recorded in the catchment. The Heyshope Dam as well as several farm dams are situated within this catchment.

Instream Habitat Integrity

The IHI for the SQ reach W51C-01981 was calculated at 77.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site is characteristic of a lower foothill stream with a steep gradient and fast flowing river. This river reach habitat presented similar to previous surveys with mostly fast habitat: The fish velocity depth classes present were fast shallow (abundant), fast deep (moderate) and slow shallow (sparse). The fish cover present rated sparse to moderately for overhanging vegetation created by grass in the riparian zone. The substratum varied from moderate to abundant and consisted of a few boulders, rocks, cobbles and pebbles.

Table 16: Fish species expected based on the PESEIS Reach Code (W51C-01981) W5ASSE-WITK1; is listed, and the fish species percentage composition during the different surveys is indicated.

W51C-01981	Expected Species	W5ASSE-WITK1					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	1	0.60	2	1.58	2	5.26
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius brevipinnus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus marequensis	X	14	8.33	37	29.13	7	18.42
Labeobarbus polylepis	X	2	1.19	-	-	-	-
Labeobarbus nelspruitensis	X	-	-	3	2.36	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	24	14.28	7	5.51	5	13.16
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	123	73.21	69	54.33	20	52.64
Chiloglanis emarginatus	X	3	1.79	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	-	-	2	5.26
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	1`	0.60	9	7.09	2	5.26
Tilapia sparrmanii	X	-	-	-	-	-	-
Number of species recorded	13	7		6		5 + 1	
Number of individuals		168		127		36 + 2	
Electro-fishing time (minutes)		11 minutes		32 minutes		30 minutes	
Catch/Unit Effort (CPUE)		6.46		3.97		1.27	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 68%		**CATEGORY C** 69.6%	

Red – Exotic species

Of the expected 13 fish species only five species were recorded, two species less than the 2010 survey and one species less than the 2015 survey (Table 16). The assemblage was dominated by the flow dependant species with *Chiloglanis anoterus* the most abundant species (52.64%; 20 individuals) and *Labeobarbus marequensis* (18.42%; 7 individuals) also found in relative abundance. The migratory specialist, *Anguilla mossambica*, was as for the 2010 and 2015 surveys, again recorded at this site. Of a concern is the alien and invasive *Micropterus salmoides* which was now recorded for the first time in the fast flowing habitat at this site. The presence of this predatory species will have an impact on the natural fish assemblage within this reach.

The CPUE (catch per unit effort) calculated for this site is 1.27 (38 individuals; 30 minutes) which is lower than both the 2010 and 2015 surveys.

A Fish Ecostatus rating of 69.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey.

Invertebrates

Nine SASS sampling events are on record for the W5ASSE-WITK1 site in this reach on the Assegai River. As with the W5ASSE-KLIPS site, these sampling events occurred in August 1999, 2000, 2001, 2003, 2006, 2009, 2014, 2015 and 2019. To date 49 SASS taxa have been recorded at this site, as well as Cladocera which are not SASS taxa. Total SASS scores range from 191 – 208 (avg.) – 277 during these nine sampling events. The site is located downstream from the Heyshope Dam and Anysspruit, and still affected by flow regulation.

The diversity of SASS5 taxa diversity increased between the 2015 and 2019 surveys, with the percentage sensitive taxa remaining similar. SASS taxa associated with moderate to slow flowing waters dominated, with those preferring fast flowing waters present. Sensitive taxa are present and dominated during all surveys.

Table 17: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51C-01981.

W51C-01981	W5ASSE-WITK1	2015	2019	
	Total SASS Score	202	212	
	No. of SASS Families	31	34	Change
	Average Score Per Taxon	6.5	6.2	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 80.8%	Category BC 80.8%	→

The 2019 SASS5 results (Table 17) indicates minimal improvement in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural with few modifications most of the time (Category BC – 80.8%) in August 2015 consistent with the (Category BC – 80.8%) in August 2019. The site experience flow regulation from the Heyshope Dam, with stream conditions ranging between largely natural (B) and moderately impaired (C) over the nine data sets.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 76.9% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (81%) indicating that the riparian vegetation for this SQ reach is close to largely natural most fo the time.

Impacts for SQR

- No site-specific impacts were noted.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.7%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus close to recommended Target Ecological Category 	

RIVER			TRIBUTARY OF		
Assegai			Lusutfu		
SITE NUMBER			QUATERNARY SUB-CATCHMENT		REACH
W5ASSE-WITK1			W51C		W51C-01981
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)		Geomorphological Zone
	S - 26.99655	E 30.67699	1 169		Lower foothill
AQUATIC ECOREGION	Level I			Level II	
	11. Highveld			11.04	

Figure A-13. Upstream view of the site on the Assegai River, W5ASSE-WITK1 (05 August 2015).

Figure A-14. Downstream view of the site on the Assegai River, W5ASSE-WITK1 (05 August 2015).

Figure A-15. Upstream view of the site on the Assegai River, W5ASSE-WITK1 (21 August 2019).

Figure A-16. Downstream view of the site on the Assegai River, W5ASSE-WITK1 (21 August 2019).

SQ REACH NUMBER W51C-02109

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51C-02109	W5BOES-ANHAL	Boesmanspruit	S-27.07833 E 30.73460	1 181	35.5	C	C 71.2%	BC* 78.1%	C 75.1%	B** 87.5%	BC 80.9%	BC 80%	2015
							B 83.3%	C 76.4%	BC 79.9%	B 83 %	BC 81.2%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51C-02109: Boesmanspruit from source to confluence with Assegai

The site is located within the PESEIS Reach Code W51C-02109, which is reported as 35.5 km in length. The length is measured from the source of the Boesmanspruit to where it merges with the Assegai River (from Department of Water and Sanitation 2014). The length from the source of the Boesmanspruit to the W5BOES-ANHAL sampling point measured on Google Earth Pro is 33.7 km, and 41.8 km from source to merging with the Assegai. The catchment size upstream from the W5BOES-ANHALT sampling point is 160.3 km. The main river channel originates at an elevation of 1,602 m a.m.s.l., flowing 33.7 km towards the sampling point at an elevation of 1,181 m a.m.s.l. The vegetation types in the catchment is represented by Paulpietersburg Moist Grassland, and KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within North Eastern Highlands aquatic ecoregion.

Landcover consists of open spaces with grasslands (54.6%), thickets and dense bush (5.3%) and wetlands (5.2%). Landuse practises include cultivated crops (5.1%) and forestry (20.1%) is prominent in the catchment (*Pinus and Eucalyptus*) (GEOTERRAIMAGE, 2015). Several small farm dams are situated within the catchment.

Instream Habitat Integrity

The IHI for the SQ reach W51C-02109 was calculated at 84.7% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. A small change in attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. The Ecosystem functions and resilience are essentially unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic site W5BOES-ANHAL (W51C-02109) is just downstream from a river crossing on the Boesmanspruit tributary to the Assegai River. All fish velocity depth classes were present at the time of the survey with slow shallow (sparse), slow deep (moderate), fast deep (sparse) and fast shallow (abundant). Aquatic macrophytes provided some cover in the slow deep habitat as overhanging vegetation with undercut banks and rootwads sparse to moderately abundant. The only other fish cover present was substrate varying from boulders to gravel.

Table 18: Fish species expected based on the PESEIS Reach Code (W51C-02109) W5BOES-ANHAL; is listed, and the fish species percentage composition during the different surveys is indicated.

W51C-02109	Expected Species	W5BOES-ANHAL					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	1	1.07
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius brevipinnus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	4	3.85	-	-	-	-
Labeobarbus marequensis	X	16	15.38	83	45.11	6	6.45
Labeobarbus polylepis	X	16	15.38	7	3.80	17	18.28
Labeobarbus nelspruitensis	X	-	-	71	38.59	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	4	3.85	5	2.72	7	7.53
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	64	61.54	14	7.61	52	55.91
Chiloglanis emarginatus	X	-	-	-	-	-	-
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	5	5.38
Tilapia sparrmanii	X	-	-	4	2.17	5	5.38
Number of species recorded	12	5		6		7	
Number of individuals		104		184		93	
Electro-fishing time (minutes)		32 minutes		31 minutes		29 minutes	
Catch/Unit Effort (CPUE)		3.25		5.94		3.21	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 71.2%		**CATEGORY B** 83.3%	

The fish assemblage consisted of seven indigenous fish species of an expected 12 species for this site (Table 18). *Chiloglanis anoterus,* a flow sensitive species, was the most dominant species comprising of 55.91% (52 individuals) of the fish assemblage. The other reophilic species, *Amphilius uranuscopus, Labeobarbus marequensis* and *Labeobarbus polylepis* were collected in lower abundance ranging from 6.45% (6 individuals) to 18.28% (17 individuals) of the total of fish collected. *Anguilla mossambica* was found for the first time at this site which indicates that this migratory species also migrates up into tributaries and not only along the mainstem river.

The CPUE (catch per unit effort) calculated for this site is 3.21 (93 individuals; 29 minutes), lower compared to the 2015 survey CPUE of 5.94 (184 individuals; 31 minutes) but very much the same as recorded for the 2010 survey of 3.25 (104 individuals; 32 minutes).

A mean Fish Ecostatus rating of 83.3% was calculated for this reach based on all available information, placing this reach in an Ecological Category B (largely natural with a high diversity and abundance of species) which is an improvement from the 2015 survey (Ecological Category C – 71.2%).

Invertebrates

Two SASS sampling events are on record for the W5BOES-ANHAL site in this reach on the Boesmanspruit. These sampling events occurred in August 2015 and this survey in August 2019. In total 40 SASS taxa have been recorded during these two sampling events.

The change in the diversity of SASS5 taxa between 2015 to 2019 was small, but the decrease in sensitive-rated SASS taxa considerable. Several sensitive taxa recorded in 2015 were absent in 2019. These include Perlidae, Prosopistomatidae, Chlorocyphidae, and Scirtidae. In 2015 three species of Hydropsychidae were recorded, and only one in 2019. There is also an increase in taxa tolerant to organic pollution between 2015 and 2019.

Table 19: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51C-02109.

W51C-02109	W5BOES-ANHAL	2015	2019	
	Total SASS Score	232	186	
	No. of SASS Families	32	31	Change
	Average Score Per Taxon	7.3	6.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 78.1%	Category C 76.4%	↘

The 2019 SASS5 results (Table 19) indicates deterioration when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural most of the time (Category BC – 78.1%) in August 2015 deteriorating to moderately impaired (Category C – 76.4%) in August 2019. The 2019 stream flow was slightly lower than in 2015, but the habitat and in situ water quality appeared to be similar.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 87.5% and is consistent with a Category B – largely natural condition with few modifications. The Riparian IHI was calculated at 65.28% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (83%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Impacts for SQR

- There are signs of historical drainage and channel straightening through a large wetland system located in the headwaters of the Boesmanspruit
- Portions of commercial tree compartments and agricultural crops are in the riparian zone and in some cases very close to the stream banks.
- High quantities of domestic waste dumped in the stream and riparian zone.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (81.2%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF		
Boesmanspruit			Assegai		
SITE NUMBER			QUATERNARY SUB-CATCHMENT		REACH
W5BOES-ANHAL			W51C		W51C-02109
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)		Geomorphological Zone
	S -27.07833	E 30.73460	1 181		Upper foothill
AQUATIC ECOREGION	Level I				Level II
	4. North Eastern Highlands				4.06

Figure A-17. Upstream view of the site on the Boesmanspruit, W5BOES-ANHAL (04 August 2015).

Figure A-18. Downstream view of the site on the Boesmanspruit, W5BOES-ANHAL (04 August 2015).

Figure A-19. Upstream view of the site on the Boesmanspruit, W5BOES-ANHAL (08 August 2019).

Figure A-20. Downstream view of the site on the Boesmanspruit, W5BOES-ANHAL (08 August 2019).

SQ REACH NUMBER W51D-02151

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51D-02151	W5SWAR-ZWART	Swartwaterspruit	S-27.10922 E 30.83852	1 129	12	C	C 64.9%	BC* 81.5%	C 73.2%	AB** 90 %	BC 80.4%	BC 80%	2015
							C 76.7%	BC 78.5%	C 77.6%	B 87%	BC 81.6%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51D-02151: Swartwaterspruit from confluence of Klein-Assegai to confluence in the Assegai River

The Swartwaterspruit is made up from several tributaries, of which the ones with names include the Klein Assegai and Swartwaterspruit. The sampling point (W5SWAR-ZWART) is located within the PESEIS Reach Code W51D-02151, which is reported as 12 km in length. The reach length is measured from the confluence of the Klein Assegai and Swartwaterspruit to the confluence of the Swartwaterspruit with the Assegai River (from Department of Water and Sanitation 2014). The length from the source of the Swartwaterspruit to the W5SWAR-ZWART sampling point measured on Google Earth Pro is 30.7 km, and 41.6 km from source to merging with the Assegai. The catchment size upstream from the W5SWAR-ZWART sampling point is 182 km^2. The main river channel originates at an elevation of 1,595 m a.m.s.l., flowing 30.7 km towards the sampling point at an elevation of 1,129 m a.m.s.l. The vegetation types in the catchment is represented by Paulpietersburg Moist Grassland, and KaNgwane Montane Grassland (from Mucina & Rutherford 2006). The site is located in the KaNgwane Montane Grassland, and falls within North Eastern Highlands aquatic ecoregion.

Landcover consists of woodlands and open bush (6.1%) and open spaces with grasslands (42.5%). Landuse practises include forestry with *Pinus and Eucalyptus* species (plantations 43.9%) (GEOTERRAIMAGE, 2015). Several small farm dams are noted in the catchment.

Instream Habitat Integrity

The IHI for the SQ reach W51D-02151 was calculated at 84.7% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. A small change in attributes of natural habitat and biota may have taken place, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This W5SWAR-ZWART (W51D-02151) site is situated on the Swartwaterspruit tributary and the habitat remained relatively consistent since the 2015 survey. Fast deep habitat was absent with the slow shallow biotope (moderate), slow deep

(sparse) and fast shallow (abundant). Overhanging vegetation and undercut banks were only present at the slow habitat. Boulders, rocks and cobbles provide the necessary in-stream cover for especially the flow dependant fish species, but also provided cover for limnophilic fish in the slow shallow habitat.

Table 20: Fish species expected based on the PESEIS Reach Code (W51D-02151) W5SWAR-ZWART; is listed, and the fish species percentage composition during the different surveys is indicated.

W51D-02151	Expected Species	W5SWAR-ZWART			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	1	1.18
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius brevipinnus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeobarbus marequensis	X	30	27.52	19	22.35
Labeobarbus polylepis	X	6	5.51	-	-
Labeobarbus nelspruitensis	X	4	3.67	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	4	3.67	3	3.53
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	49	44.95	60	70.59
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	7	6.42	-	-
Tilapia sparrmanii	X	9	8.26	2	2.35
Number of species recorded	13	7		5	
Number of individuals		109		85	
Electro-fishing time (minutes)		38 minutes		26 minutes	
Catch/Unit Effort (CPUE)		2.87		3.27	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 64.9%		**CATEGORY C** 76.7%	

A total of 13 indigenous species of fish are expected to occur in this reach of which only five were collected during the present survey, two species less than recorded during the 2015 survey (Table 20). The reophilic species, *Chiloglanis anoterus* (60 individuals; 70.59%), was collected in the fast fish velocity habitats with an increase in abundance in comparison to the 2015 survey (49 individuals; 44.95%). Only two limnophilics, *Tilapia sparrmanii*, was recorded during the present survey, one species less and fewer individuals than collected for the 2015 survey when nine (8.2% of fish assemblage) *Tilapia sparrmanii* and and seven (6.42% of fish assemblage) *Pseudocrenilabrus philander* were recorded. *Anguilla mossambica* was also collected here for the first time since 2010.

The CPUE for the present survey was calculated at 3.27 (85 individuals; 26 minutes) indicating a slightly higher abundance of fish than recorded during the 2015 survey when a CPUE of 2.87 was calculated.

A Fish Ecostatus rating of 76.7% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) which is a slightly higher rating than determined for the 2015 survey, still remaining within the same Ecological Category (Category C – 64.9%).

Invertebrates

Two SASS sampling events are on record for the W5SWAR-ZWART site in this reach on the Swartwaterspruit. These sampling events occurred in August 2015 and this survey in August 2019. In total 40 SASS taxa have been recorded during these two sampling events.

Several taxa recorded in 2015 assemblage were absent in 2019. These include Porifera, Prosopistomatidae, Cordulidae, Ecnomidae and Athericidae. The stream community in 2019 suggests a slight decrease in the percentage SASS5-sensitive rated taxa, and an increase in taxa tolerant to organic pollution.

Table 21: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51D-02151.

W51D-02151	W5SWAR-ZWART	2015	2019	
	Total SASS Score	245	212	
	No. of SASS Families	36	31	Change
	Average Score Per Taxon	6.8	6.8	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 81.5%	Category BC 78.5%	→

The 2019 SASS5 results (Table 21) indicates slight deterioration when compared to 2015, but still rated as close to largely natural conditions most of the time. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural most of the time (Category BC – 81.5%) in August 2015 remaining consistent (Category BC – 78.5%) in August 2019. The 2019 stream flow was slightly lower than in 2015. The specific in situ electrical conductivity indicated a decrease from 128 µS/cm in August 2015 to 48 µS/cm in 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 90% and is consistent with a Category AB – close to largely natural conditions most of the time. The Riparian IHI was calculated at 77.1% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (87%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Impacts for SQR

- No site-specific impacts noted.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (81.6%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✓	

RIVER		TRIBUTARY OF		
Swartwaterspruit		Assegai		
SITE NUMBER		**QUATERNARY SUB-CATCHMENT**		**REACH**
W5SWAR-ZWART		W51D		W51D-02151
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -27.10922	E 30.83852	1 129	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highland		4.06	

Figure A-21. Upstream view of the site on the Swartwaterspruit, W5SWAR-ZWART (03 August 2015).

Figure A-22. Downstream view of the site on the Swartwaterspruit, W5SWAR-ZWART (03 August 2015).

Figure A-23. Upstream view of the site on the Swartwaterspruit, W5SWAR-ZWART (08 August 2019).

Figure A-24. Downstream view of the site on the Swartwaterspruit, W5SWAR-ZWART (08 August 2019).

SQ REACH NUMBER W51E-02049 (EWR AS1)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51E-02049	W5ASSE-ZANDB	Assegai	S-27.06465 E 30.97461	2 170	62	B	C 66.4%	C* 77.6%	C 72%	B** 87.5%	BC 78.6%	BC 80%	2015
	W5ASSE-ZAND1 (EWR AS1)	Assegai	S-27.06241 E 30.98977	1 011			C 69.5%	C 76.1%	C 72.8%	C 68.1%	C 76.2 %		2019
	W5MKHO-NHLAN	Mkhondvo	S-27.05378 E 31.11166	908									

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51E-02049: Assegai River from confluence with Swartwaterspruit to merge with Ndlozane River in Swaziland

The site is located within the PESEIS Reach Code W51E-02049, which is reported as 62 km in length. The length is measured from the confluence of the Assegai with the Swartwaterspruit to where the Assegai River flows into Swaziland (Mkhondvo River) and merge with the Ndlozane River (from Department of Water and Sanitation 2014). The length from the source of the Assegai River to the W5ASSE-ZWART sampling point measured on Google Earth Pro is 187 km and 16 km downstream from the W5ASSE-ZWART site. The main river channel originates at an elevation of 2,036 m a.m.s.l., flowing 187 km towards the sampling point at an elevation of 1,091 m a.m.s.l. The vegetation types in the catchment is represented by the Wakkerstroom Montane Grassland; Paulpietersburg Moist Grassland; Eastern Highveld Grassland, and KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within North Eastern Highlands aquatic ecoregion.

Landcover consists mainly of open spaces with grasslands (22.1%) and woodlands and open bush (4.3%). Land-use practises include agriculture (1.7% cultivated crops); Pinus and Eucalyptus Forestry (16.7%) (GEOTERRAIMAGE, 2015) as well as open cast mining is recorded in the Catchment. The town of Piet Retief and surrounding area contribute to 57% of urbanisation.Several farm dams as well as Heyshope Dam is situated in the catchment.

Instream Habitat Integrity

The IHI for the SQ reach W51E-02049 was calculated at 68.8% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

Fish biomonitoring on SQR W51E-02049 with a reach length of 62km were conducted at two sites, W5ASSE-ZANDB and W5MKHO-NHLAN, to be representative of this long reach. The W5ASSE-ZANDB site is situated on the Assegai mainstem river and consisted of mainly large riffles and runs and a deep pool under a river crossing. Fish velocity depth classes were in the form of fast shallow and slow shallow habitats with the slow habitat moderately present and fast riffle habitat in

abundance. The slow deep habitat, as well as fast deep habitat were moderately present. Marginal vegetation formed cover as overhanging vegetation moderately present with sparse undercut banks and rootwads. The substrate in the fast-shallow habitats was abundant consisting of large rocks, cobbles and pebbles providing the necessary fish habitat. The substrate as cover in the slow habitat was sparse with a lot of silt, especially in the slow deep habitat. Aquatic macrophytes as cover was mostly moderately present in the slow deep habitat.

The aquatic habitat surveyed at the location W5MKHO-NHLAN is downstream from a bridge. All of the fish velocity depth classes were present at this site with both fast shallow and fast deep abundant and both slow shallow and slow deep habitat moderately present. The fish cover present was moderate overhanging vegetation provided by terrestrial grasses on the riverbanks with sparse to moderate undercut banks and rootwads. The substrate rated sparse in the slow habitat and bedrock, boulders and rocks provided moderate to abundant cover in both the fast shallow and deep fish velocity depth classes.

Table 22: Fish species expected based on the PESEIS Reach Code (W51E-02049) W5ASSE-ZANDB and W5MKHO-NHLAN is listed, and the fish species percentage composition during the different surveys is indicated.

W51E-02049	Expected Species	W5ASSE-ZANDB					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Enteromius trimaculatus	X	-	-	-	-	-	-
Enteromius unitaeniatus	X	-	-	-	-	-	-
Enteromius viviparus	X	-	-	-	-	-	-
Labeo cylindricus	X	-	-	-	-	-	-
Labeo molibdinus	X	-	-	-	-	-	-
Labeobarbus marequensis	X	140	65.72	115	54.25	77	54.61
Labeobarbus polylepis	X	-	-	-	-	-	-
Labeobarbus nelspruitensis	X	11	5.16	-	-	-	-
Opsaridium peringueyi	X	-	-	-	-	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	8	3.76	24	11.32	5	3.54
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	42	19.72	72	33.96	41	29.08
Chiloglanis emarginatus	X	2	0.94	-	-	-	-
Chiloglanis swierstrae	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	1	0.47	1	0.71
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	7	3.29	-	-	17	12.06
Tilapia sparrmanii	X	3	1.41	-	-	-	-
Number of species recorded	19	7		3 + 1		4+1	
Number of individuals		213		212		140+1	
Electro-fishing time (minutes)		19 minutes		43 minutes		49 minutes	
Catch/Unit Effort (CPUE)		11.21		4.93		2.88	
Fish Ecostatus (FRAI Value) for W5ASSE-ZANDB				**CATEGORY C** 62%		**CATEGORY C** 66.3%	

W51E-02049	Expected Species	W5MKHO-NHLAN			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X			3	1.58
Petrocephalus wesselsi	X	1	0.75		
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	0.75	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius trimaculatus	X	-	-	32	16.84
Enteromius unitaeniatus	X	-	-	14	7.37
Enteromius viviparus	X	-	-	-	-
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	-	-	1	0.53
Labeobarbus marequensis	X	-	-	97	51.05
Labeobarbus polylepis	X	16	12.03	-	-
Labeobarbus nelspruitensis	X	-	-	-	-
Mesobola brevianalis	X	5	3.76	-	-
Opsaridium peringueyi	X	-	-	4	2.11
Characidae (Characins)					
Micralestes acutidens	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	9	6.77	1	0.53
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	3	2.26	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	81	60.90	20	10.52
Chiloglanis emarginatus	X	-	-	-	-
Chiloglanis swierstrae	X	6	4.51	-	-
Cichlidae (Cichlids)					
Oreochromis mossambicus	X	-	-	-	-
Pseudocrenilabrus philander	X	11	8.27	14	7.37
Tilapia sparrmanii	X	-	-	4	2.10
Number of species recorded	22	9		10	
Number of individuals		133		190	
Electro-fishing time (minutes)		46 minutes		28 minutes	
Catch/Unit Effort (CPUE)		2.89		6.79	
Fish Ecostatus (FRAI Value) for W5MKHO-NHLAN		**CATEGORY C** 73%		**CATEGORY C** 72.7%	
SQ REACH SUMMARY for Fish Ecostatus (FRAI Value)		**Category C** 66.4%		**Category C** 69.5%	

Red – Exotic species

The fish assemblage recorded at the W5ASSE-ZANDB for the present survey consisted of only four species of an expected 19 species of indigenous fish for this reach, one species more than found during the 2015 survey, but three species less for the 2010 survey (Table 22). The most abundant fish species collected was *Labeobarbus marequensis*, a hardy reophilic species (moderately tolerant to modified water quality – 2.9 on Fish sensitivity Scales) which was also the most abundant species during the 2010 and 2015 surveys. The riffle dwelling fish species, *Chiloglanis anoterus,* was the second most abundant species for this site since 2010, collected in the fast-shallow habitat available. This species is intolerant to modified water quality (4.5 Fish sensitivity Scales) and may be an indication why it was not collected in high abundance. The alien and invasive species, *Micropterus salmoides,* was as with the 2015 survey, present at this site.

The CPUE for the present survey was calculated at 2.88 (141 individuals; 49 minutes) indicating a decline in abundance from the 2010 and 2015 surveys when a CPUE of 11.21 and 4.93 respectively was calculated. A possible reason for the lower abundance of fish and species collected, could be related to reduced water quality.

At the W5MKHO-NHLAN site ten of the expected 22 fish species were recorded (Table 22). Once again the large barb, *Labeobarbus marequensis* was the most abundant fish species collected at a relative abundance of 51.05% (97 individuals) of all fish collected at the site.The small barb species, *Enteromius trimaculatus* and *Enteromius unitaeniatus* was only collected from this point and further downstream in the sub catchment. During the present survey only one *Chiloglanis* species, *Chiloglanis anoterus*, was recorded and in low abundance (10.52% -20 individuals). During the 2015 survey this species was the most abundant at 60.90% and *Chiloglanis swierstrae* was also collected. These *Chiloglanis* species have a high preference for fast shallow (ranging between 4.4 and 4.9) habitat and is intolerant (4.8) to no flow conditions. The absence of a *Chiloglanis* species and the reduction of the abundance of *Chilolganis anoterus* can be related to prevailing drought conditions in 2017 and 2018. The limnophilic species recorded were *Pseudocrenilabrus philander and Tilapia sparrmanii* which favours slow flowing water. During the 2015 survey longfin eels (*Anguilla mossambica*) were recorded, but was not found at this site during the present survey.

The CPUE (catch per unit effort) calculated for this site is 6.79 (190 individuals; 28 minutes) which indicates a higher abundance of fish found than recorded during the 2015 survey when a CPUE of 2.89 was recorded.

A Fish Ecostatus rating of W5ASSE-ZANDB was calculated at 66.3% based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) consistent with the 2015 survey results (Category C – 62%). A Fish Ecostatus rating of 72.7% was calculated for the W5MKHO-NHLAN site based on all available information, placing this reach in an Ecological Category C (moderately impaired with moderate diversity and abundance of species), similar to the 2015 survey when an Ecological Category C (73%) was determined.

The combinded Fish Ecostatus rating for this reach W51E-02049 was calculated at 69.5% based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) consistent with the 2015 survey results (Category C – 66.4%).

Invertebrates

Two SASS sampling events are on record for the W5ASSE-ZANDB site in this reach on the Assegai River. These sampling events occurred in August 2015 and 2019. To date 40 SASS taxa have been recorded at this site, as well as Cladocera which is not in SASS. The site is located downstream from the town eMkhondo (old Piet Retief), affected by treated sewage inflow, stormwater run-off and polluted streams flowing through town. Several taxa recorded up- and downstream from the site during previous surveys, were absent during both the 2015 and 2019 surveys. These include Potamonautidae, Polymitarcidae, Prosopistomatidae, Tricorythidae, Chlorocyphidae, Aeshnidae, Nepidae, Notonectidae, Pleidae, Hydrophilidae, Tabanidae, and Unionidae.

Table 23: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51E-02049.

W51E-02049	W5ASSE-ZANDB	2015	2019	
	Total SASS Score	208	214	
	No. of SASS Families	31	32	Change
	Average Score Per Taxon	6.7	6.7	
	SITE SUMMARY Invertebrate Ecostatus	Category BC 78.6%	Category BC 78.2%	→
	W5MKHA-NHLAN	2015	2019	
	Total SASS Score	207	202	
	No. of SASS Families	34	35	Change
	Average Score Per Taxon	6.1	5.8	
	SITE SUMMARY Invertebrate Ecostatus	Category C 76.6%	Category C 73.9%	→
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 77.6%	Category C 76.1%	→

The SASS5 results for the 2015 and 2019 sampling events were very similar in all aspects. The 2019 SASS5 results (Table 23) suggests similar conditions when comparing to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 77.6 and 76.1%) in August 2015 and 2019 respectively.

Riparian Vegetation

The SASS-Fish and Riparian Vegetation sampling was carried out at different times at different sampling sites. The EWR site could not be traced during the SASS-Fish monitoring in August 2019, and the site sampled in 2015 was revisited. In September 2019, more time was available to find the access route to the EWR site, and the riparian vegetation sampling was carried at that location. The W5ASSE-ZANDB site is located 2.87 km (river length) upstream from the EWR AS1 site, with the Osloop the only major tributary entering the Assegai between the two sampling locations.

Conditions based on VEGRAI was rated as moderately impaired (Category C - 68%). The marginal vegetation was dominated by Phragmites and Typha, attributed to high nutrient inputs from the upstream eMkhondo Wastewater Treatment Works and tributaries drainage from the town and surroundings. High water using invasive tree species (*Acacia mearnsii*) dominate the left stream bank, with *Sesbania punicea* and *Lantana camara* abundant. Woody species are replacing grass and herbaceous species. No information could be traced for Resource Quality Objectives for this reach.

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 87.5% and is consistent with a Category B –largely natural with few modifications. The Level III VEGRAI Assessment range for the EWR site assessed in this reach is 68.1% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 68.8% rating this reach as a Category C indicating a moderately modified reach. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore determined as a Category C (68.1%) indicating that the riparian vegetation for this SQ reach is moderately modified.

Water Quality

The reach assessed is SQR W51E-02049, Assegaai River (U-26 / EWR AS1). The Google Earth (GE) image below (Figure 21) shows the wq monitoring sites related to EWR-AS1 against the Level II Ecoregion background. The proximity of the U-26 and W5H022Q01 wq points to the EWR site indicate their representivity of water quality state at the site. Note that W5H022Q01 monitoring station was closed between 2009 and 2015. Early data from W5H006Q01 (in the same Level II Ecoregion), and benchmark boundary tables for an A category river from DWAF (2008), were evaluated to represent Reference Condition (RC).

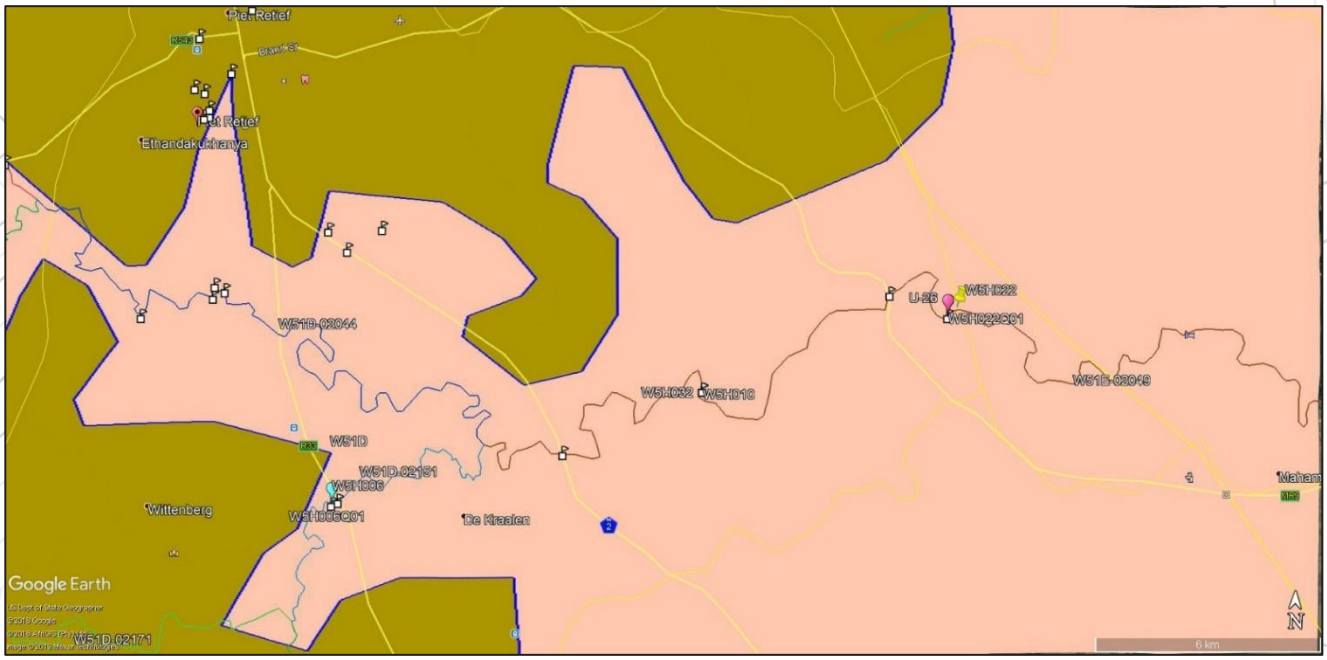


Figure 21: Google Earth image of EWR-AS1 and selected water quality monitoring points in Level II Ecoregion 4.06.

EWR Site AS1 is representative of the reach of the Assegaai River from Heyshope Dam to the SA/Swaziland border. EWR AS1 is the site of a previous EWR assessment (EWR site JMB2 – Maputo Basin Study; Louw et al., 2008). Upstream influences are Heyshope Dam, irrigation, afforestation and domestic water use. Commercial and subsistence agriculture takes place in the catchment around the Heyshope Dam with limited coal mining (DWAF, 2004). The town of Piet Retief is located well upstream of the site, with an outlet from the Piet Retief and Uthiza WWTWs into the Ndhlozane tributary (in W51F) of the Assegaai River.

The overall EC for this site is a C, with the water quality PES and recommended category being a B, according to the 2014 DWS study. Scherman's water quality report from the Maputo Basin Study indicated an overall BC category for the site (Scherman, 2007). Both studies show some level of eutrophication, particularly at times of low flow and changes in moderate flows.

Table 24 shows the present state assessment according to this study, with Table 25 showing the EcoSpecs developed during the 2014 Reserve study (DWS, 2014c) for the EWR site. Table 26 is the PAI table associated with the wq assessment.

Table 24: Water quality PES: SQR W51E-02049, Assegaai River (U-26 / EWR AS1)

RIVER EWR SITE	Assegaai River AS1	**Water Quality Monitoring Points**	
		RC	Benchmark boundary tables (DWAF, 2008). W5H006Q01, Swartwater River at Zwartwater: 1977-1981; n=145.
IUCMA site code	U-26	**PES**	IUCMA data, U-26: July 2016-Sept 2019; n=39 (most variables). W5H022Q01: 2015-2019; n=49.
Confidence assessment	Confidence in the assessment is **low-moderate**, as little DO, temp., turbidity or metal data.		
Water Quality Constituents		**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$	-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	PO_4-P (mg/L)	0.03: IUCMA 0.05: DWS	C/D (2.5)
	TIN-N (mg/L)	0.6: IUCMA 0.3: DWS	B (1)
Physical variables	pH (5^{th}+95^{th} percentiles)	6.74+8.0: IUCMA 6.9+8.2: DWS	B (1)
	Temperature	-	Although Heyshope Dam is upstream of the EWR site, little impact is expected due to the distance from the dam to the site. Ratings: B (1)
	Dissolved oxygen	-	
	Turbidity (NTU)	-	
	Electrical conductivity (mS/m)	22.6: IUCMA * 24.74: DWS	A (0)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category	C (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	0.20: IUCMA * 0.22: DWS (n=35)	E/F (4)
OVERALL SITE CLASSIFICATION (from PAI)		**BC (80.6%)**	

** Data of July 2016-Feb 2017 seems problematic and inconsistent with other and historical data sources. Data from March 2017 (n=31) used for the PES.*

- No data.

Table 25: EcoSpecs and Thresholds of Potential Concern (TPCs) for EWR site AS1 on the Assegaai River (DWS, 2014c)

RIVER		*Assegaai*		WATER QUALITY MONITORING POINTS				
WQSU		*2*		**DWAF WQ WMS**	*W5H022Q01 (W51 102914) @ Zandbank on Assegaai R (stopped 2009)*			
EWR SITE		*AS1*		**RHP**	*None*			
Confidence in PES assessment		**Medium confidence as WQ data not current and < 60 measurements, but some supporting evidence from other WQ monitoring stations.**						
Water Quality Constituents		**RC**	**PES**	**WQ EcoSpecs**	**Improvement required?**	**TPC**		**Monitoring frequency**
Salts (mg/L)	*SO4*	-	*Median =13*	-	*No*	*95th percentile to be < 20 mg/L*		*Every 2 months*
Nutrients (mg/L)	*PO4*	*0.005*	*Rating =3 (median = 0.05)*	*≤0.015 mg/L*	*Yes*	*50th percentile to be < 0.015 mg/L*		*Every 2 months*
	TIN	*0.25*	*Rating =2 (Suspect TIN is elevated)*	*≤0.07 mg/L*	*Probably*	*50th percentile to be < 0.7 mg/L*		*Every 2 months*
Physical variables	*pH (5 – 95%ile)*	*6.5-8.0*	*Rating =0 (95%ile = 8.0)*	*95%ile < 8.0*	*No*	*95th percentile to be < 8.0*		*Every 2 months*
	Temperature	-	*No data. Expected to be only small impact*	*Natural range*	*N/A*	*Natural temp. range*		*Every 2 months*
	DO (mg/L)	-		*>8 mg/L*	*N/A*	*5th percentile to be > 8 mg/L*		*Every 2 months*
	Turbidity (NTU)	-	*Rating = 1*	*No change*	*N/A*	*No change allowed.*		*Every 2 months*
	EC (mS/m)	*≤30*	*Rating =0 (median = 14)*	*≤30 mS/m*	*No*	*95th percentile to be < 30 mS/m*		*Every 2 months*
Response variables	*Chl a: periphyton*	*<1.7 mg/m²*	*No data.*	*≤ 1.7 mg/m² (A category)*	*N/A*	*50th percentile to be < 1.7 mg/m²*	*Quarterly*	
	Chl a: phytoplankton	*< 10 µg/L*		*≤ 10 µg/L (A category)*		*50th percentile to be < 10 µg/L*		
	Macroinvertebrates (Ec Cat)	-	*B (this study)*	*See EcoSpecs for fish and invertebrates respectively*				
	Fish community score	-	*B/C (this study)*					
	Instream toxicity	-	*No data*	*Sulphates low at this site but should be monitored because of the risk from mining in the area. Possibly toxic substances arise from the WWTW at Piet Retief and pesticides from farming and should be monitored through biomonitoring.*				
Toxics	*Sulphate (mg/L)*	-	*13*					
Current PES EcoClassification = B				**Recommended Ecological Category = B**				

Table 26: PAI table for SQR W51E-02049, Assegaai River (U-26 / EWR AS1)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**2-15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	1.00	N	4.00	60.00		50.00
Salts	0.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	2.50	NONE SPECIFIED	4.00	75.00		65.00
Water Temperature	1.00	N	2.50	55.00		70.00
Water clarity	1.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	1.00	N	2.50	65.00		70.00
Toxics	2.00	N	3.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.36	MEAN CONF →	3.21			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.36					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.32					
FINAL PC MODIFICATION RATING	1.36					
P-C CATEGORY %	P-C CATEGORY					
80.6	B/C	REVISED % & CATEGORY (2014)				

Table 27 shows the water quality state at this site as compared to the EcoSpecs and TPCs set during the 2014 Reserve study, as well as the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline. Pink indicates a small exceedance, and orange is used when it is uncertain whether guidelines have been exceeded. Although sulphate and faecal streptococci are variables to be assessed for International Obligations, data were not available for either variable at any sites evaluated during this study.

Table 27: Comparison to water quality guidelines: SQR W51E-02049, Assegaai River (U-26 / EWR AS1)

SQR W51E-02049, Assegaai River (U-26 / EWR AS1)				
Metric		**EcoSpec**	**TPC**	**International Obligations**
Physical variables	pH	95th percentile < 8.0		6.5-8.5
	Electrical Conductivity (mS/m)	≤ 30	95th percentile < 30	150
Nutrients	PO_4 (mg/L P)	≤ 0.015	50th percentile < 0.015	2
	TIN (mg/L N)	≤ 0.07	50th percentile < 0.07	N/A
	NO_2+NO_3 (mg/L N)	N/A		50
Toxics	Ammonia (mg/L N)	Not included in Reserve assessment		1
Microbial	Faecal coliforms (cfu/100mL)	N/A		2 000 (>1 000, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	N/A		10 000 (>2 420, n=1, Sept 2019)

N/A: not applicable

Note the following points regarding analysis:

- Data records are short, with the assessments therefore being of low-moderate confidence. Data indicates water quality of **Good – Moderate** state.
- It is recommended that the EcoSpecs set for the nutrients, i.e. PO_4-P and TIN-N, be re-evaluated during the Water Resource Classification process once initiated. Although improvement of nutrients levels are required for this river reach, it is unlikely that the levels set by the EcoSpecs could easily be achieved.
- Ammonia (as mg/L N) is clearly an issue in this river reach for meeting ecological requirements, and an EcoSpec should be set during Classification. Further investigation and longer-term monitoring of this variable is recommended, as levels are high.
- ***It is suggested that more definitive tests are assessed for coliforms, as it is unknown whether (for example) >1 000 cfu exceeds the 2 000 cfu or not.***
- *E. coli* data for the river reach were as follows; with both sets of records showing contravention of the 0-130 cfu/100 mL TWQR for recreational full contact use (DWAF, 1996b).
    - IUCMA data (n=1, Sept 2019): 645
    - DWS data (n=28):

▪ Median	▪ 167
▪ Mean	▪ 210

Impacts for SQR

- Build-up of logs and debris at the bridge, causing overtopping during high flow with downstream bank scouring
- Increased reed (Phragmites) growth.
- Invasive aquatic plant growth
- Invasive riparian plant increase

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (70.5%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged.	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗	
Possible reasons: • Instream habitat and riparian vegetation reduced.	

RIVER			TRIBUTARY OF	
Assegai			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5ASSE-ZANDB			W51E	W51E-02049
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -27.06465	E 30.97461	1 010	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. Northern Eastern Highlands		4.06	

Figure A-25. Upstream view of the site on the Assegai River, W5ASSE-ZANDB (03 August 2015).

Figure A-26. Downstream view of the site on the Assegai River, W5ASSE-ZANDB (03 August 2015).

Figure A-27. Upstream view of the site on the Assegai River, W5ASSE-ZANDB (08 August 2019).

Figure A-28. Downstream view of the site on the Assegai River, W5ASSE-ZANDB (08 August 2019).

RIVER			TRIBUTARY OF	
Mkhondvo			Lusutfu	
SITE NUMBER		**QUATERNARY SUB-CATCHMENT**		**REACH**
W5MKHO-NHLAN		W51E		W51E-02049
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -27.05378	E 31.11166	908	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highlands		4.06	

Figure A-29. Upstream view of the site on the Mkhondvo River, W5MKHO-NHLAN (20 July 2015).

Figure A-30. Downstream view of the site on the Mkhondvo River, W5MKHO-NHLAN (20 July 2015).

Figure A-31. Upstream view of the site on the Mkhondvo River, W5MKHO-NHLAN (20 July 2015).

Figure A-32. Downstream view of the site on the Mkhondvo River, W5MKHO-NHLAN (20 July 2015).

SQ REACH NUMBER W51F-01986

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51F-01986	W5BLES-WEEHO	Blesbokspruit	S-26.89837 E 30.95267	1 080	4.4	C	C 75.4%	C* 68.8%	C 71.6%	C** 77.5%	C 74.6%	C 70%	2015
							C 63.8%	D 55.1%	CD 59.5%	C 77.5%	C 67.2%		2019

Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51C-02022: Blesbokspruit and Sterkwaterpsruit confluence to its merge with the Ndlozane River

The site is located within the PESEIS Reach Code W51F-01986, which is reported as 4.4 km in length. The length is measured from the confluence of the Sterkwaterspruit and Blesbokspruit (4.4 km upstream from the sampling site) to its confluence with the Ndlozane (from Department of Water and Sanitation 2014). The length of the Blesbokspruit from source to its confluence with the Ndlozane River is 18.1 km (measured on Google Earth Pro). The main river channel originates at an elevation of 1,340 m a.m.s.l. The vegetation types in the catchment is represented by KaNgwane Montane Grassland (from Mucina & Rutherford 2006). The site falls within North Eastern Highlands aquatic ecoregion. Landcover consists of thickets and dense bush (11.9%); woodlands and open bush (11.1%) and open spaces dominated by grasslands (21.5%). Landuse practises include cultivated fileds (18.7%), *Pinus and Eucalyptus* forestry (33.6%) (GEOTERRAIMAGE, 2015) and the town of Piet Retief and surrounding areas. Evaporation ponds and seepage into the Farroloop are noted in the Industrial landuse practices. Several farm dams occur in the catchment.

Instream Habitat Integrity

The IHI for the SQ reach W51F- 01986 was calculated at 84.2% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site is characteristic of an upper foothill stream with a steep gradient and fast flowing river, with extreme low flow conditions at the time of the survey. The fish velocity depth class fast shallow was very shallow and moderately present. Other classes present was slow shallow (abundant) and slow deep (moderate). The fish cover present rated sparse to moderately for overhanging vegetation created by reeds in the riparian zone. The substratum varied from sparse to moderate with bedrock, a few small rocks, cobbles and pebbles. The slow deep habitat was silted up.

Table 28: Fish species expected based on the PESEIS Reach Code (W51F-01986) W5BLES-WEEHO; is listed, and the fish species percentage composition during the different surveys is indicated.

W51F-01986	Expected Species	W5BLES-WEEHO			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	-	-	-	-
Labeobarbus marequensis	X	-	-	1	2.63
Labeobarbus polylepis	X	21	28.00	-	-
Labeobarbus nelspruitensis	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	1	1.33	-	-
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	12	16.00	6	15.79
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	41	54.67	31	81.58
Number of species recorded	14	4		3	
Number of individuals		75		38	
Electro-fishing time (minutes)		27 minutes		20 minutes	
Catch/Unit Effort (CPUE)		2.78		1.90	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 75.4%		**CATEGORY C** 63.8%	

Fish diversity was considerably lower than expected. Of the expected 14 fish species only three species were recorded, one species less than recorded during the 2015 survey (Table 28). The assemblage was dominated by the no flow tolerant species, *Tilapia sparrmanii* with a relative abundance of 81.58% (31 individuals) of all fish collected. The large barb, *Labeobarbus polylepis*, which was the most abundant fish species during the 2015 survey, was not collected during the present survey. A single specimen of another large barb species, *Labeobarbus* marequensis, was however recorded which was not present during the 2015 survey.

The CPUE (catch per unit effort) calculated for this site is 1.90 (38 individuals; 20 minutes) which is lower than the 2015 survey with a CPUE of 2.78 (75 individuals; 27 minutes).

A Fish Ecostatus rating of 63.8% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey.

Invertebrates

Two SASS sampling events are on record for the W5BLES-WEEHO site in this reach on the Blesbokspruit. These sampling events occurred in August 2015 and this survey in August 2019. In total 32 SASS taxa have been recorded during these two sampling events.

Several taxa recorded in 2015 were absent in 2019. These include Porifera, Crabs, Tricorythidae, Aeshnidae, Gomphidae, Naucoridae, one Hydropsychidae species, Elmidae, and Simuliidae. The percentage of SASS-rated sensitive taxa were low during both the 2015 and 2019 surveys, with considerably lower taxa diversity in 2019. During both surveys, taxa tolerant to organic pollution were dominant, with considerable increase in scrapers. Tadpoles especially were extremely abundant in 2019, with high number of gastropods.

Table 29: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51F-01986.

W51F-01986	W5BLES-WEEHO	2015	2019	
	Total SASS Score	166	78	
	No. of SASS Families	31	16	Change
	Average Score Per Taxon	5.4	4.9	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 68.8%	Category D 55.1%	↓

The 2019 SASS5 results (Table 29) indicates deterioration when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately modified (Category C – 68.8%) in August 2015 deteriorating to largely impaired (Category D – 55.1%) in August 2019. The 2019 stream flow was slightly lower than in 2015, while the specific in situ electrical conductivity decreased from 234 µS/cm in August 2015 to 139 µS/cm in 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 76.2% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Water Quality

Biomonitoring results using macroinvertebrates identified two SQR which may be impacted in terms of water quality (Diedericks, 2019), with this being one of those reaches

- W51F-01986, Blesbokspruit, biomonitoring site W5BLES-WEEHO: MIRAI – D category

No water quality data could be accessed for this site, which is located in Swaziland, with the responsible water authority being the eSwatini or (Swaziland) Water Services Corporation. In the absence of data or more detailed information, the low confidence desktop water quality assessment is used and modified, as shown below.

MIRAI Category	Desktop WQ Rating/ Equivalent WQ Category	Identified Impacts
D	3 (D)	Irrigation and cultivation – narrow riparian buffer; wood plant (timber processing?) upstream.

Potential impacts or risks of impact in the W51F quaternary catchment is the Usushwana Iron Complex (South African Mine Water Atlas, 2018), and the Ndhlozane tributary of the Assegaai River into which WWTWs discharge. The extent of current and future mining activities in the upper catchments of the W5 quaternary catchments therefore pose a threat to water quality. The desktop PES/EI/ES study refers to a wood plant upstream; presumably a timber processing plant. Evaporation ponds and seepage into the Farroloop were also recorded in the 2015 EcoStatus Assessment Report (IUCMA, 2016). The Farroloop is a tributary of the Blesbokspruit upstream of Piet Retief. Although urban impacts are expected from Piet Retief town, particularly high nutrient loads from WWTWs, the biomonitoring site is far enough downstream that some amelioration of water quality is expected by the time the site is reached. Water quality data collected during the 2015 survey was not definitive as detection limits were not sensitive enough for many variables measured; subsequently few exceedences of guidelines were noted.

A water quality Category of a C is expected due to noted impacts.

Impacts for SQR

- The riparian marginal, lower and upper zones are dominated by invasive plant species
- Maize crops were established in the riparian zone
- Waste from maize harvesting operations are discharged in the river and riparian zone.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (67.2%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

Discussion:

Although the Recommended Ecological Target is met regular water quality monitoring regime is to be implemented to monitor the water quality for this SQ Reach.

RIVER			TRIBUTARY OF	
Blesbokspruit			Ndlozane	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5BLES-WEEHO			W51F	W51F-01986
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.89837	E 30.95267	1080	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highveld		4.06	

Figure A-33. Upstream view of the site on the Blesbokspruit, W5BLES-WEEHO (09 August 2015).

Figure A-34. Downstream view of the site on the Blesbokspruit, W5BLES-WEEHO (09 August 2015).

Figure A-35. Upstream view of the site on the Blesbokspruit, W5BLES-WEEHO (09 August 2015).

Figure A-36. Downstream view of the site on the Blesbokspruit, W5BLES-WEEHO (09 August 2015).

SQ REACH NUMBER W51F-01973

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51F-01973	W5NDHL-SWAZI	Ndhlazane	S-26.95675 E 31.12299	810	22.0	C	Not sampled					BC 80%	2015
							C 68.9%	B 82.8%	C 75.9%	B 83%	BC 78.9%		2019

General description

Reach W51F-1973: Ndlazane River from the joining at Ngwengwana to the confluence with Mkhondvo

The site is located within the PESEIS Reach Code W51F-01973, on the Ndhlazane River, which is reported as 21.95 km in length (Department of Water and Sanitation 2014). The length is measured from the confluence of the Ngwengwana to the Mkhondvo confluence. Measured on Google Earth Pro the length is 25.3 km, and the W5NDHL-SWAZI site is located 20 km downstream from the Ngwengwana. The Blesbokspruit is one of the main upstream tributaries of the Ndhlozane River. The vegetation types in the catchment is represented by Ithala Quartzite Sourveld (from Mucina & Rutherford 2006). The site falls within North Eastern Highlands aquatic ecoregion. No landuse cover and practises available on GEOTERRAIMAGE, 2015.

Instream Habitat Integrity

The IHI for the SQ reach W51F-01973 was calculated at 90.7% rating this SQ reach as a AB category indicating that the instream habitat integrity is close to natural conditions most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5NDHL-SWAZI (W51F-01973) was not sampled previously and is on the Ndhlazane River, a tributary of the Assegai River. This site provides a diversity of shallow habitat types with slow shallow abundant and fast shallow moderate with riffles and runs making it ideal for flow dependant fish species. Substrate cover was provided by rocks and cobbles with a lot of sedimentation. Cover for the fish was also sparse and only present at the slow shallow habitat.

Table 30: Fish species expected based on the PESEIS Reach Code (W51F-01973) W5NDHL-SWAZI; is listed, and the fish species percentage composition during the different surveys is indicated.

W51F-01973	Expected Species	W5NDHL-SWAZI			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X			-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X			-	-
Enteromius crocodilensis	X			-	-
Labeo cylindricus	X			-	-
Labeo molybdinus	X			-	-
Labeobarbus marequensis	X			62	56.36
Labeobarbus polylepis	X			13	11.82
Labeobarbus nelspruitensis	X			-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X			13	11.82
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X			-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X			22	20.00
Chiloglanis emarginatus	X			-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X			-	-
Tilapia sparrmanii	X			-	-
Number of species recorded	14	Not Sampled		4	
Number of individuals				110	
Electro-fishing time (minutes)				25 minutes	
Catch/Unit Effort (CPUE)				4.40	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 68.9%	

The fish assemblage recorded during the survey consisted of four indigenous fish species of an expected fourteen (14) species indicating the presence of a very low species diversity (Table 30). Two of the *Labeobarbus* species expected to occur was recorded, namely *Labeobarbus marequensis* (56.36%; 62 individuals), the most abundant fish species collected at the site and *Labeobarbus polylepis* (11.82%; 13 individuals). The other two fish species recorded was *Amphilius uranoscopus* and *Chiloglanis anoterus*, both also reophilic and habitat sensitive species.

The CPUE (catch per unit effort) calculated for the site is 4.40 (110 individuals; 25 minutes) indicating a relative high abundance of fish present.

A Fish Ecostatus rating of 68.9% was determined for this reach placing it in an Ecological Category C – moderately impaired with low diversity and abundance of species.

Invertebrates

The W5NDLH-SWAZI site on the Ndhlozane River was added in August 2019, so only one data set is available. 35 SASS taxa were encountered during the 2019 sampling event.

Sensitive taxa are dominant (i.e. Prosopistomatidae), with taxa diversity relatively high. Taxa sensitive to organic pollution dominated, while gathering collectors dominated the functional feeding group.

Table 31: 2019 SASS5 results for SQ reach W51F-01973.

W51F-01973	W5NGHL-SWAZI	2015	2019	
	Total SASS Score		224	
	No. of SASS Families		35	Change
	Average Score Per Taxon		6.4	
	SQ REACH SUMMARY Invertebrate Ecostatus	Not sampled	Category B 82.8%	

MIRAI for the 2019 SASS5 results suggest largely natural conditions (Category B – 82.8%) (Table 31). There is evidence of embeddedness upstream from the sampling site, and bank and bed scouring further downstream. Overall the stream appears to be in good condition.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 76.3% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (83%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Impacts for SQR

- The culverts at the bridge is partially blocked, causing upstream impoundment and deposition.
- Water from the steep approaching road (no road drainage) erodes directly into the stream
- Several weed species were present in the riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78.9%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER		TRIBUTARY OF			
Ndhlozane		Mkhondvo			
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH	
W5NDHL-SWAZI		W51F		W51F-01973	
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone	
	S -26.95675	E 31.12299	810	Mountain stream	
AQUATIC ECOREGION	Level I		Level II		
	North Eastern Highlands		4.06		

Figure A-37. Upstream view of the site on the Ndhlozane River, W5NDLH-SWAZI (11 September 2019).

Figure A-38. Downstream view of the site on the Ndhlozane River, W5NDLH-SWAZI (11 September 2019).

SQ REACH NUMBER W51H-01808

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W51H-01808	W5MKHO-SWAZI	Mkhondvo	S-26.69709 E 31.43789	294	29.1	C	C 78%	C* 65.7%	C 70.9%	C** 77.5%	C 74.2%	C 70%	2015
							C 76.8%	C 77.3%	C 77.1%	C 77.5%	C 77.2%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W51H-01808: Mkhondvo River from confluence with Kukwane River to confluence with Lusutfu River

The site is located within the PESEIS Reach Code W51H-01808, which is reported as 29.1 km in length. The length is measured from the confluence of the Mkhondvo River with the Kukwane River in Swaziland to where the Mkhondvo flows into the Lusutfu River (from Department of Water and Sanitation 2014). The length from the source of the Assegai River to the W5MKHO-SWAZI sampling point measured on Google Earth Pro is 297 km, and the site is located 5 km upstream from its confluence with the Lusutfu. The main river channel originates at an elevation of 2,036 m a.m.s.l., flowing 297 km towards the sampling point at an elevation of 294 m a.m.s.l. The vegetation types in the catchment is represented by the Wakkerstroom Montane Grassland; Paulpietersburg Moist Grassland;Eastern Highveld Grassland; KaNgwane Montane Grassland; Ithala Quartzite Sourveld; Swaziland Sour Bushveld, and Granite Lowveld (from Mucina & Rutherford 2006). The site is located in the Granite Lowveld, and falls within North Eastern Highlands aquatic ecoregion.

Landcover consists mainly of open spaces dominated by grasslands and to a lesser degree sourveld savannah. Landuse practises include agriculture, open cast coal mines, towns of Piet Retief and Nhlango and several farm dams are situated within this catchment (IUCMA, 2016).

Instream Habitat Integrity

The IHI for the SQ reach W51H-01808 was calculated at 82% rating this SQ reach as a B category indicating that the instream habitat integrity is largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This monitoring site, W5MKHO-SWAZI (W51H-01808) was not sampled during the 2010 survey. This multi-channel site's fish velocity depth classes included fast shallow (abundant), slow shallow (moderate) and fast deep (sparse). No slow deep habitat was present. The fish cover observed was mostly sparse with emerging aquatic macrophytes providing some cover as overhanging vegetation. Undercut banks and root wads were also sparse but substrate cover provided abundant fish habitat in the form of rocks cobbles and boulders. Substrate in the form of sandy runs were further observed in the fast-shallow habitats.

Table 32: Fish species expected based on the PESEIS Reach Code (W51H-01808) W5MKHO-SWAZI; is listed, and the fish species percentage composition during the different surveys is indicated.

W51H-01808	Expected Species	W5MKHO-SWAZI			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	2	0.46	2	1.27
Petrocephalus wesselsi	X	-	-	-	-
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	3	1.90
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius trimaculatus	X	9	2.07	9	5.70
Enteromius unitaeniatus	X	6	1.38	-	-
Enteromius viviparus	X	19	4.38	94	59.49
Labeo cylindricus	X	118	27.19	3	1.90
Labeo molybdinus	X	14	3.23	10	6.33
Labeobarbus marequensis	X	6	1.38	4	2.53
Labeobarbus polylepis	X	67	15.44	-	-
Mesobola brevianalis	X	-	-	-	-
Opsaridium peringueyi	X	60	13.83	-	-
Characidae (Characins)					
Micralestes acutidens	X	12	2.77	3	1.90
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	4	0.92	-	-
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	2	0.46	4	2.53
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	29	6.68	-	-
Chiloglanis emarginatus	X	15	3.46	-	-
Chiloglanis paratus	X	37	8.52	5	3.16
Chiloglanis swierstrae	X	11	2.53	2	1.27
Cichlidae (Cichlids)					
Oreochromis mossambicus	X	9	2.07	4	2.53
Pseudocrenilabrus philander	X	14	3.23	15	9.49
Tilapia sparrmanii	X	-	-	-	-
Number of species recorded	22	18		13	
Number of individuals		434		158	
Electro-fishing time (minutes)		56 minutes		34 minutes	
Catch/Unit Effort (CPUE)		7.75		4.65	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 78%		**CATEGORY C** 76.8%	

A total of 13 fish species were collected at this site of the 22 expected indigenous fish species, five species less than recorded for the 2015 survey (Table 32). The limnophilic fish species dominated the fish assemblage. Of the three expected small barb species only two were collected, namely *Enteromius trimaculatus* (24 individuals; 5.7%) and *Enteromius viviparus* (94 individuals; 59.49%) which was the most abundant fish species collected. None of the sensitive reophilic species, *Opsaridium peringueyi*, was recorded. Only two of the four expected *Chiloglanis* species were recorded in low abundance that included the sandy habitat specialist, *Chiloglanis swierstrae* (2 individuals; 1.27%) and *Chiloglanis paratus* (5 individuals; 3.16%).

The CPUE (catch per unit effort) calculated for this site is 4.65 (158 individuals; 34 minutes) which indicate a relative abundance of fish, but a decrease in abundance compared to the 2015 survey when a CPUE of 7.75 was calculated.

A Fish Ecostatus rating of 76.8% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance), indicating consistency to the 2015 survey when a Fish Ecostatus rating of 78%, Category C, was determined.

Invertebrates

Two SASS sampling events are on record for the W5MKHO-SWAZI site in this reach on the Mkhondvo River. These sampling events occurred in August 2015 and this survey in September 2019. In total 34 SASS taxa have been recorded during these two sampling events. One Non-SASS family and specimen, Ephemeroptera: Diceromyzidae were encountered in 2019. Flow conditions were lower in 2019 than during the 2015 survey, with a possible 2019 increase in taxa tolerant to organic pollution and decrease in gathering collectors. Sand with bedrock and boulders dominate the stream substrate. The sand smothers interstitial spaces reducing habitat quality and will influence taxa when mobilised during high flows.

Table 33: Comparison of the 2015 and 2019 SASS5 results for SQ reach W51A-02082.

W51H-01808	W5MKHO-SWAZI	2015	2019	
	Total SASS Score	124	173	
	No. of SASS Families	21	30	Change
	Average Score Per Taxon	5.9	5.8	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 65.7%	Category C 77.3%	→

The 2019 SASS5 results (Table 33) indicates improved conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 65.7%) in August 2015 consistent (Category C – 77.3%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 60.6% rating this reach as a Category CD indicating a close to moderately modified riparian habitat most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- High quantities of sand, indicating high sand inputs between the W5MKHO-NHLAN and W5MKHO-SWAZI sampling sites.
- Evidence of sand mining activities
- High weed infestation in the lower and upper zones of the riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.2%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	
Discussion: Althoug the Recommended Ecological Target is met, this reach is impacted by high sedimentation loads resulting in loss of available habitats to fish and macro-invertebrates. Proper management of sediment depositions from landuse practices requires intervention.	

RIVER			TRIBUTARY OF	
Mkhondvo			Lusutfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5MKHO-SWAZI			W51H	W51H-01808
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.69709	E 31.43789	294	Lower foothill
AQUATIC ECOREGION	Level I		Level II	
	4.North Eastern Highveld		4.06	

Figure A-39. Upstream view of the site on the Mkhondvo River, W5MKHO-SWAZI (21 July 2015).

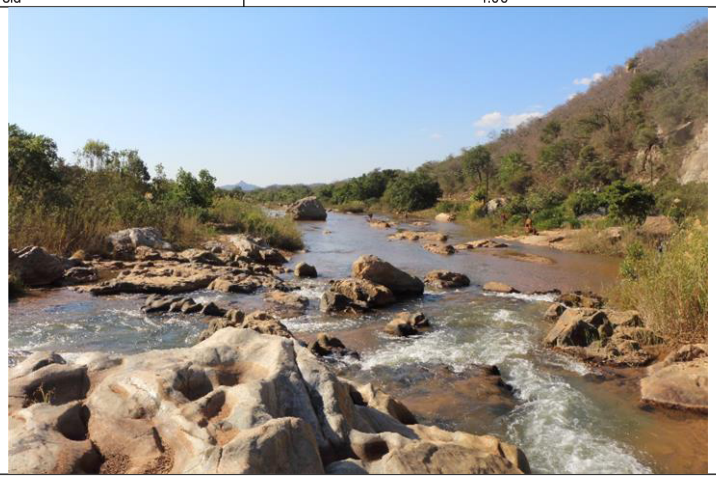


Figure A-40. Downstream view of the site on the Mkhondvo River, W5MKHO-SWAZI (21 July 2015).

Figure A-41. Upstream view of the site on the Mkhondvo River, W5MKHO-SWAZI (10 September 2019).

Figure A-42. Downstream view of the site on the Mkhondvo River, W5MKHO-SWAZI (10 September 2019).

DISCUSSION ASSEGAI-MKHONDVO SUB-CATCHMENT

Fish

A total of 28 indigenous fish species are expected to occur in this sub-catchment of which 22 species were recorded for the present survey, three species less than recorded during the 2015 IUCMA survey. The species recorded during the 2015 survey but not collected during the 2019 survey are *Chiloglanis emarginatus*, *Mesobola brevianalis* and *Petrocephalus wesselsi*. The most abundant fish species collected for the present survey is *Chiloglanis anoterus* with a relative abundance of 28.37% of the total number of fish collected. This species was also the most abundant species found during the 2015 survey. Only *Labeobarbus marequensis*, was recorded throughout the Assegai River at all of the sites in relative abundance. The site where the highest number of fish species were collected is also the furthest downstream site, W5MKHO-SWAZI, where a total of 13 fish species was recorded. The highest abundance of fish was recorded at site W5MKHO-NHLAN where a CPUE of 6.79 fish caught per minute was recorded. During the 2015 survey *Anguilla mossambica* was recorded only on the main stem Assegai at three sites. For the 2019 survey this species was collected at five sites that included two sites on Assegai tributaries. An increase in the number of sites where *Anguilla mossambica* was recorded is noted and that it was also recorded in tributaries of the Assegai, indicates that the river connectivity is largely still in place.

Of concern is the increase in the prevalence of the alien and invasive *Micropterus salmoides*. During the 2015 survey this species was only recorded at one site on the main stem river, but for the 2019 survey it was collected at three sites, all on the main stem river.

Figure 22 summarise the Fish Ecostatus categories for the 10 SQ reaches on the Assegai-Mkhondvo Sub-catcment. The Fish Ecostatus rating for the SQ reach W51C-02109 (W5BOES-ANAL) increased from 71.2% (Category C) calculated in 2015 to 83.3% (Category B). This improvement is mainly due to the presence of the catadromous species *Anguilla mossambica* and the presence of certain reophilic fish species within the fish assemblage. The overall Fish Ecostatus rating for 2019 is 72.8% placing the Assegai-Mkhondvo sub-catchment in a high Category C. This is consistent with the 2015 results of 69.2% also a Category C. Of concern remains flow regulations from the Heyshope Dam as well as the impact of forestry and related impacts on the catchment such as siltatation, sedimentation and abstraction of water directly impacting on the available fish habitat. The present category C (72.8%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

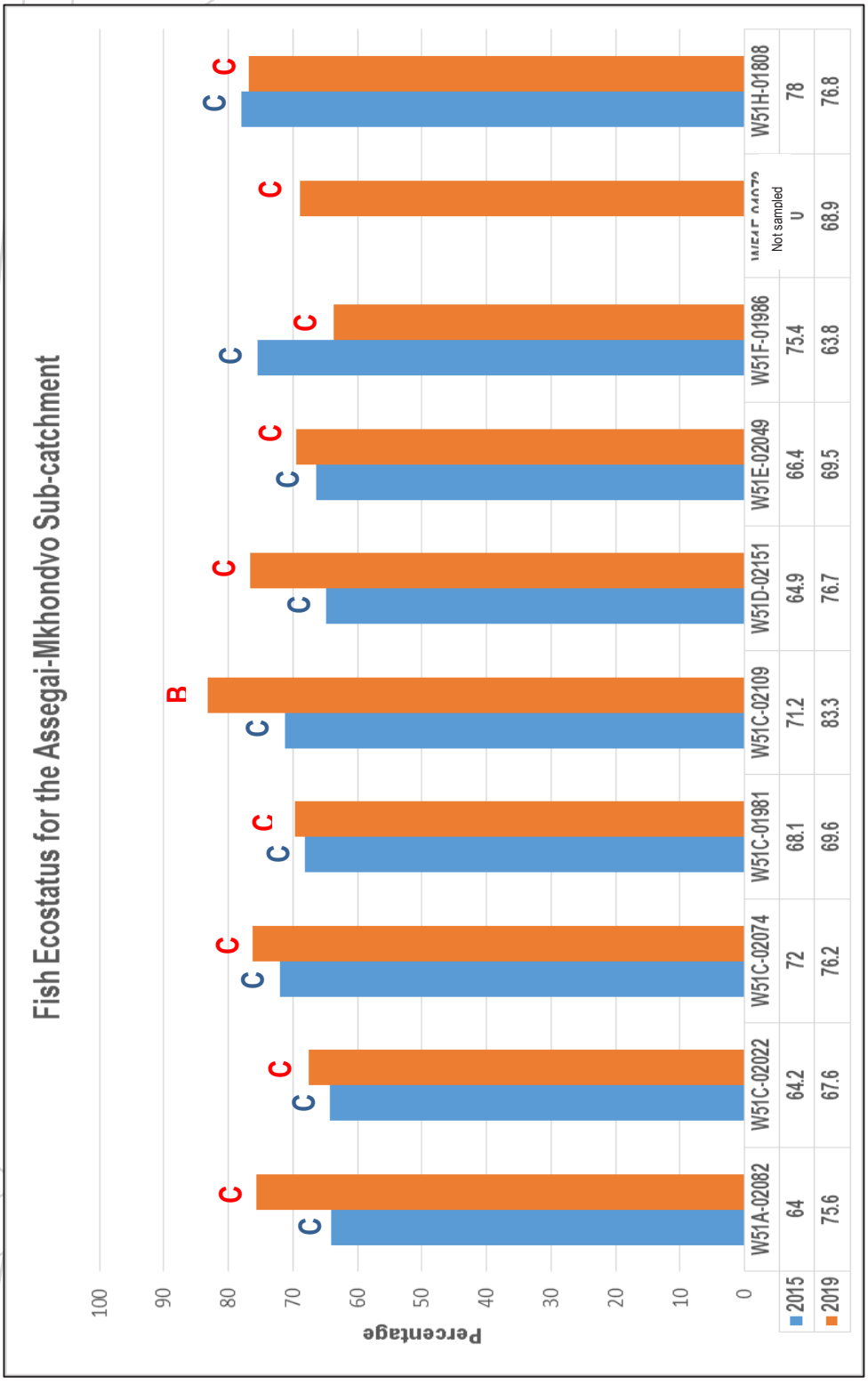


Figure 22: Summary of the Fish Ecostatus for the Assegai-Mkhondvo for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model

Invertebrates

Overall conditions in the main channel remained consistent when compared to the 2015 results (Table 34). Deterioration was recorded in the Boesmanspruit and Blesbokspruit and conditions in the Blesbokspruit are of concern. Historically this system was severely affected by effluent irrigation in one of the systems' headwater tributaries (Farroloop). Detailed chemical analysis (focused on persistent chemicals in the irrigated effluent) should provide insight more clarity on causes for deterioration.

Table 34: Summary of stream conditions per SQ Reach based on MIRAI, comparing 2015 to 2019 results.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	CHANGE
W51	Assegai-Mkhondvo	W51A-02082	76.4	80.8	↑
		W51C-02022	76	77.9	→
		W51C-01981	80.8	80.8	→
		W51E-02049	77.6	76.4	→
		W51H-01808	65.7	77.3	→
	Anysspruit	W51C-02074	75.9	83.1	↑
	Boesmanspruit	W51C-02109	78.1	76.4	↘
	Swartwaterspruit	W51D-02151	81.5	78.5	→
	Blesbokspruit	W51F-01986	68.8	55.1	↓
	Ndhlozane	W51F-01973	Not sampled	82.8	

When comparing the Assegai-Mkhondvo sub-catchment Invertebrate Ecostatus between 2015 and 2019 (Figure 23), conditions improved in general throughout the sub-catchment, deteriorating at PESEIS reach W51C-02109. Several expected sensitive taxa are absent, with decrease in flow dependant taxa diversity. When comparing aquatic invertebrate results between the 2015 and 2019 survey, overall conditions improved. The overall Invertebrate Ecostatus rating for 2019 is 76.9% placing the mainstem in a high Category C. This is consistent with the 2015 results of 75.6% and also a high Category C. The present category C (76.9%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

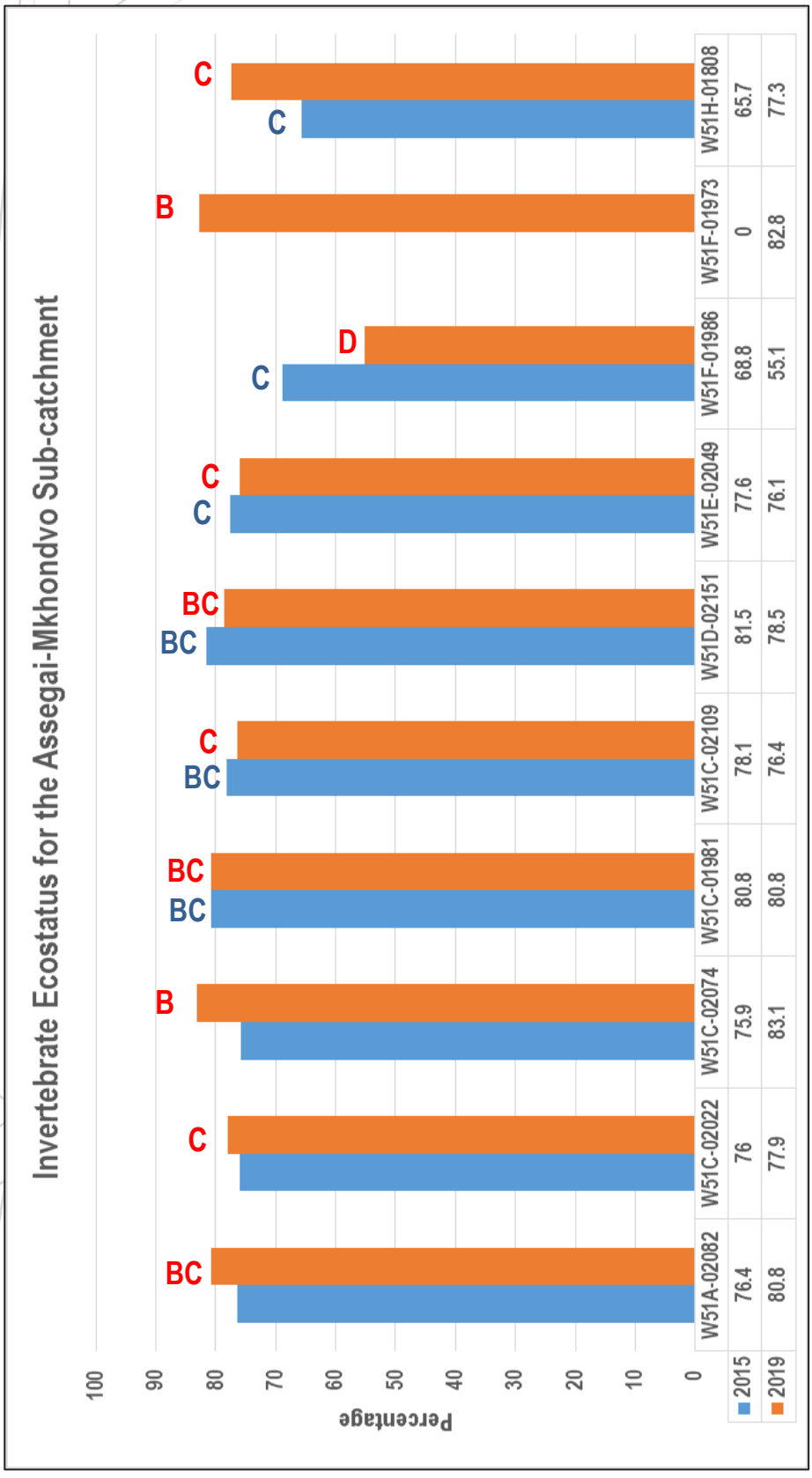


Figure 23: Graphical comparison of the Invertebrate Ecostatus of the Assegai-Mkhondvo Sub-catchment in 2015 and 2019.

Water Quality

The water quality assessment was limited to specific sites, with a discussion of results provided below the results of the data assessment. Water quality state of the Assegaai reach assessed was **Good** to **Moderate** (BC Category), with nutrients (phosphate and nitrogen levels) exceeding EcoSpecs and TPCs set during the Reserve study. Very limited data indicates that coliforms exceed international obligation levels.

Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Assegai-Mkhondvo Sub-catchment.

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity assessment. From Figure 24 it is evident that the Instream Ecostatus improved throughout the Assegai-Mkhondvo ranging from a category CD (59.5%) to a category BC (79.9%) with a mean of 74.9% category C. This remains consistent with the Instream Ecostatus for 2015 surveys at (72.5% Category C). The only site of concern is W51F-01986 (W5BLES-WEEHO) with an Instream Ecostatus of 59.5% (CD Category) where the calculated value of the Invertebrate Ecostatus decreased to a category D (55.1%) – reason being the impact of reduced water quality on the invertebrate community. Water quality is expected to deteriorate as a result of mining activity in the upper reaches as well as non-functioning WWTW from Piet Retief town.

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model. The Integrated Ecostatus for the Assegia-Mkhondvo (Figure 25) also remained consistent throughout the 2015 (77.1%) and 2019 (76%) monitoring with a Category C indicating a moderately impaired habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

When comparing the Integrated Ecostatus with the Recommended Ecological Category within the various SQ reaches and EWR site, it is evident that the set targets are met for all the reaches except for W51E-02049 and W51C-01981. Factors contributing to this can be related to inefficient catchment management in the upper reaches of the river negatively affecting instream habitat. The IHI as well as riparian vegetation deteriorated as a result of upstream forestry and forestry related activities that include, siltation, sedimantation, reduced flow and spreading of alien and invasive plant species.

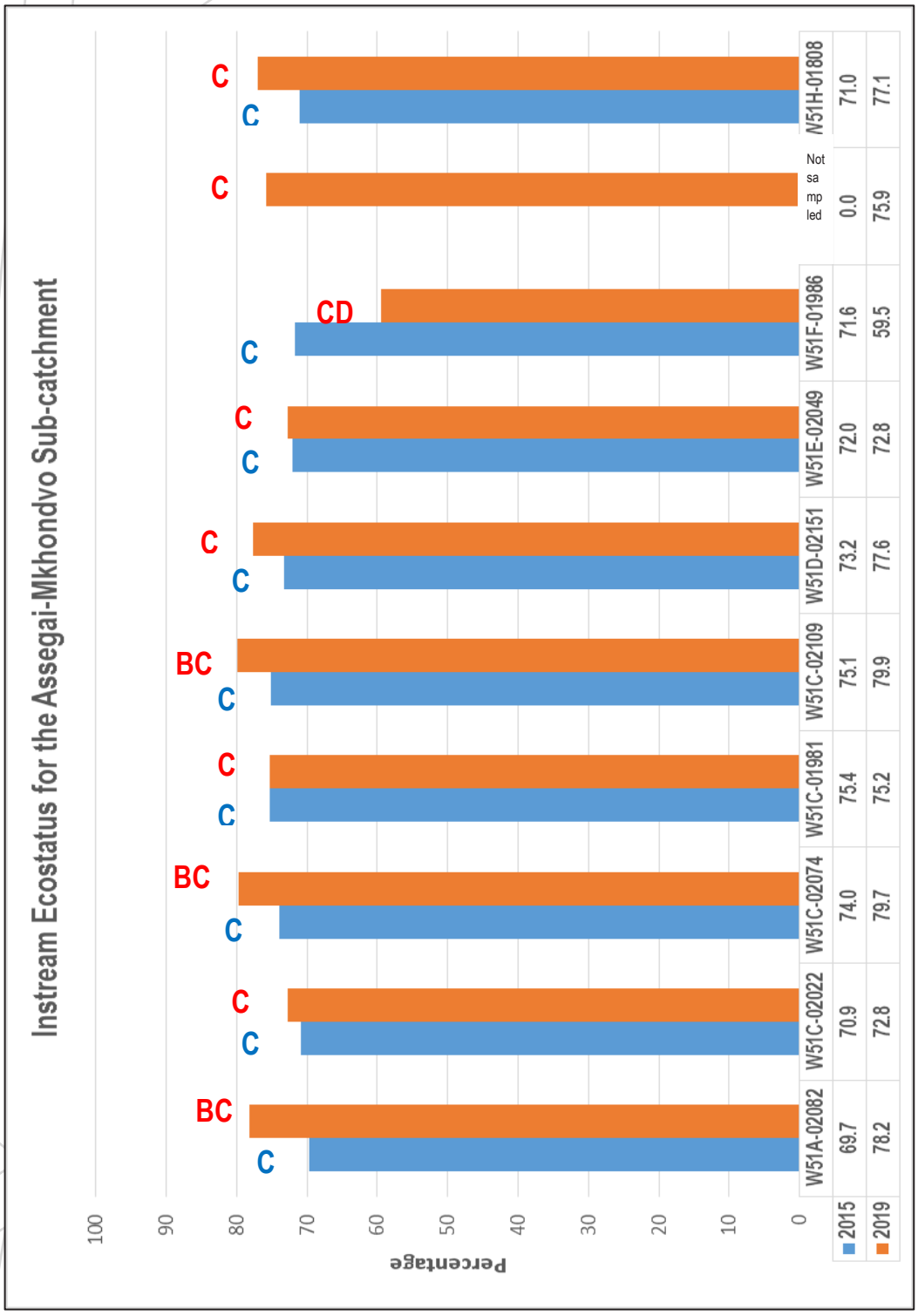


Figure 24: Comparison of the Instream Ecostatus of the Assegai-Mkhondvo in 2015 and 2019.

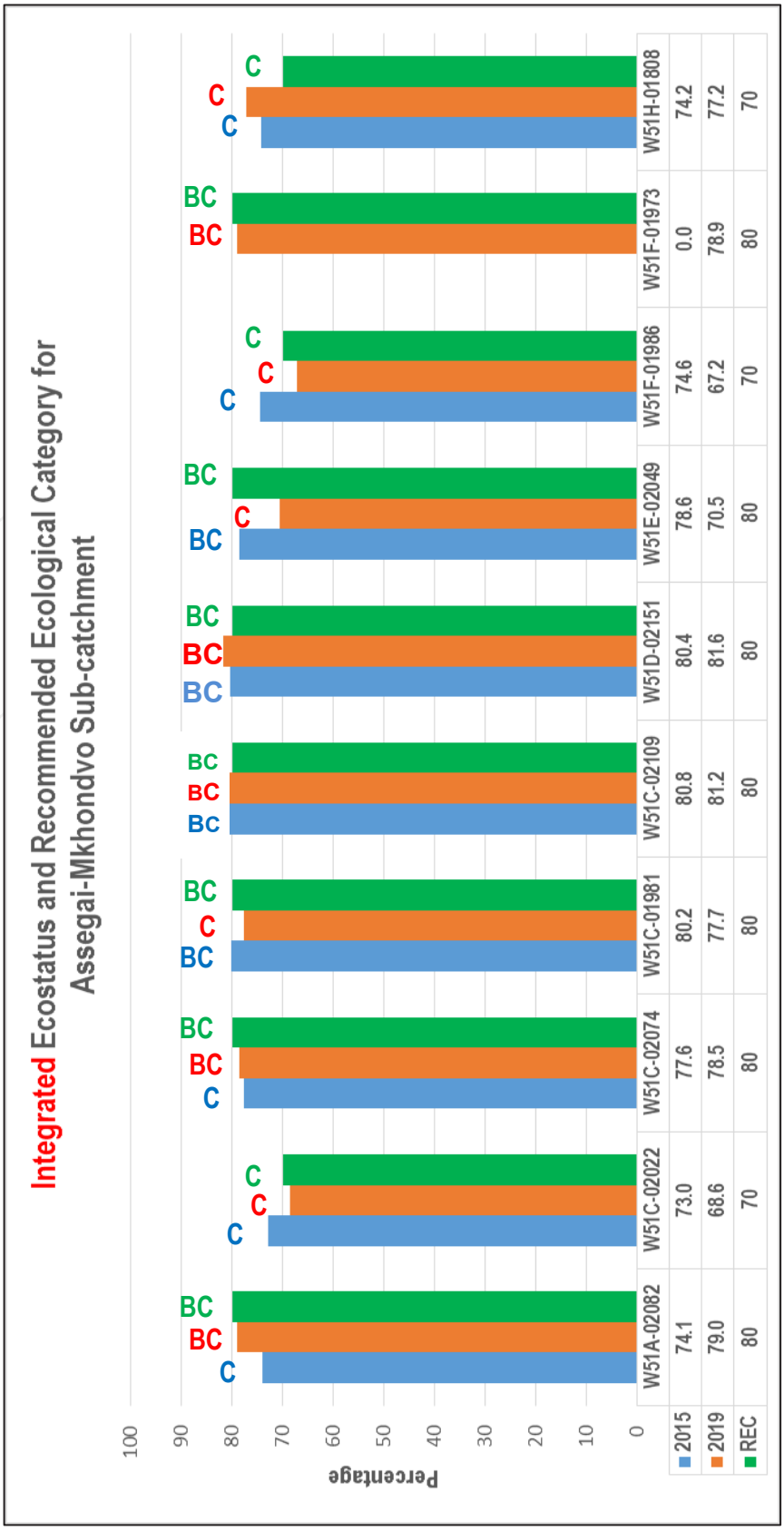


Figure 25: Comparison of the Integrated Ecostatus and Target Ecological Category for the Assegai-Mkhondvo in 2015 and 2019.

Hlelo Sub-catchment Reaches

The Hlelo River catchment originates in the Highveld aquatic ecoregion, and then flows in a direction of east by north to its confluence with the Ngwempisi River in Swaziland. A total of 5 biomonitoring points representing 5 SQ reaches (140.9 km) representing 13.1% of the river monitored on the Usuthu-Lusutfu catchment were sampled during 2019.

SQ REACH NUMBER W52A-01983

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W52A-01983	W5HLEL-WITBA	Hlelo	S-26.97702 E 30.33379	1 394	37.7	C	C 74%	C* 68.9%	C 71.5%	B** 85%	C 77.3%	C 70%	2015
							CD 61.5%	C 77.5%	C 69.5%	B 83%	C 75.3%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa

** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W52A-01983: Hlelo River from its source to confluence with Taaiboschspruit

The PESEIS Reach Code for the Hlelo River at this site is W52A-01983, which incorporates the river from its source to where it merges with the Taaiboschspruit, reach code W52A-01934 (from Department of Water and Sanitation 2014). The length from the source of the Hlelo River to the W5HLEL-WITBA sampling point measured on Google Earth Pro is 21.5 km, and to its confluence with the Taaiboschspruit 42.8 km. The main river channel originates at an elevation of 1,800 m a.m.s.l., flowing in a north-easterly direction towards the sampling point, W5HLEL-WITBA at an elevation of 1,455 m a.m.s.l. The site is located in the Wakkerstroom Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consist of open spaces dominated by grassland (74.9%), thickets and dense bush (4.9%). The Landuse practices include mixed agriculture with cultivated crops (3.2%) and plantations (7.4%) (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W52A-01983 was calculated at 79.8% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The instream habitat of this upper catchment site, W5HLEL-WITBA (W52A-01983), changed a lot since the 2015 survey. The large deep pool upstream from the river crossing is now connected to the downstream habitat and could not be sampled under the bridge. Two channels downstream from the pool and up to the fence, was sampled. No deep habitats were sampled with slow shallow habitat sparse and fast shallow very abundant. Overhanging vegetation was sparse in the fast habitat with moderate undercut banks. Boulders, rocks and cobbles provided the necessary in-stream cover for flow dependant species in the slow shallow habitat.

Table 35: Fish species expected based on the PESEIS Reach Code (W52A-01983) W5HLEL-WITBA; is listed, and the fish species percentage composition during the different surveys is indicated.

W52A-01983	Expected Species	W5HLEL-WITBA			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	0.65	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	10	6.45	-	-
Enteromius brevipinnus	X	1	0.65	-	-
Enteromius crocodilensis	X	8	5.16	-	-
Labeobarbus nelspruitensis	X	-	-	-	-
Labeobarbus polylepis	X	82	52.90	16	26.67
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	23	14.84	24	40.00
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	22	14.19	20	33.33
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	5	3.23	-	-
Tilapia sparrmanii	X	3	1.93	-	-
Number of species recorded	12	9		3	
Number of individuals		155		60	
Electro-fishing time (minutes)		41 minutes		19 minutes	
Catch/Unit Effort (CPUE)		3.78		3.16	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 74%		**CATEGORY CD** 61.5%	

A total of 12 indigenous species of fish are expected to occur in this reach of which only three were collected during the present survey (Table 35), six species less than recorded for the 2015 survey. A possible reason is due to habitat changes and possible concentration of fish during 2015 in the disconnected pool surveyed below the old river crossing. Flow dependant fish species were the only fish species collected with *Amphilius uranoscopus* (24 individuals; 40%) the most abundant species. The other two species recorded were *Chiloglanis anoterus* (20 individuals; 33.33%) and *Labeobarbus polylepis* (16 individuals; 26.67%), collected in the fast and shallow habitat which dominated the site. Based on the absence and low abundance of certain fish species not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered.

The CPUE for the present survey was calculated at 3.16 (60 individuals; 19 minutes) indicating a relative abundance of fish which was also evident for the 2015 survey when a CPUE of 3.78 was calculated but the number of species were notably lower.

A mean Fish Ecostatus rating of 61.5% was calculated for this reach based on all available information, placing this reach in an Ecological Category CD (close to moderately impaired conditions most of the time with low diversity of species and abundance) which indicate a decrease in the Fish Ecostatus rating (Category C – 74%) from the 2015 survey. This decline can be related to certain habitat types being inaccessible and therefore not surveyed.

Invertebrates

Two SASS sampling events are on record for the W5HLEL-WITBA site in this reach in the Hlelo River. These sampling events occurred in August 2015 and this survey in August 2019. In total 34 SASS taxa have been recorded during these two sampling events, with Cladocera (not SASS taxa) during both surveys. SASS taxa diversity for the two surveys are considered relatively low but similar, with a decrease in the percentage SASS-rated sensitive taxa in 2019. Taxa with a preference for fast to moderate flows dominated during both the 2015 and 2019 surveys.

Table 36: Comparison of the 2015 and 2019 SASS5 results for SQ reach W52A-01983.

W52A-01983	W5HLEL-WITBA	2015	2019	
	Total SASS Score	153	155	
	No. of SASS Families	25	28	Change
	Average Score Per Taxon	6.1	5.5	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 68.9%	Category C 77.5%	→

The 2019 SASS5 results (Table 36) indicates similar conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 68.9%) in August and (Category C – 77.5%) in August 2019. The 2019 stream flow was slightly lower than in 2015, and bank scouring created a new side-channel with less stable substrate.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 64.6% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (83%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications. A small change in attributes of natural habitat and biota may have taken place, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Stream bank trampling by domestic livestock
- Culverts at bridge partially blocked, causing upstream impoundment
- Stream bank scouring downstream from the bridge
- Approaching road source of high sediment inputs into the river
- High weed infestation in the riparian zone, dominated by high water using species (*Acacia mearnsii*)

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (75.3%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged

Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✔

RIVER			TRIBUTARY OF	
Hlelo			Ngwempisi	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5HLEL-WITBA			W52A	W52A-01983
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.97702	E 30.33379	1 394	Lower foothills
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.02	

Figure A-43. Upstream view of the site on the Hlelo River, W5HLEL-WITBA (04 August 2015).

Figure A-44. Downstream view of the site on the Hlelo River, W5HLEL-WITBA (04 August 2015).

Figure A-45. Upstream view of the site on the Hlelo River, W5HLEL-WITBA (06 August 2019).

Figure A-46. Downstream view of the site on the Hlelo River, W5HLEL-WITBA (06 August 2019).

SQ REACH NUMBER W52B-01964

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W52B-01964	W5HLEL-TWYFE	Hlelo	S-26.8647 E 30.55205	1 356	31	C	C 68.7%	C* 76.3%	C 72.5%	C** 77.5%	C 74.6%	C 70%	2015
							C 73.6%	C 74.4%	C 74%	C 77.5%	C 75.5 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W52B-01964: Hlelo River confluence with Taaiboschspruit to confluence with Zoar Tributary

The site falls within PESEIS Reach Code W52B-01964, which is indicated as 31 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Hlelo with the Taaiboschspruit (W52A-01934) and ends where the Hlelo meets with the Zoar tributary (W52B-01890). The length from the source of the Hlelo River to the W5HLEL-TWYFE sampling point measured on Google Earth Pro is 72.3 km, and to its confluence with the Ngwempisi River 134 km. The main river channel originates at an elevation of 1,870 m a.m.s.l., flowing in an easterly direction towards the sampling point, W5HLEL-TWYFE which is at an elevation of 1,356 m a.m.s.l. The site is located in the Eastern Highveld Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists of wetlands (6.6%); woodlands open bush (4.0%) and open spaces with grasslands (23.9%). Landuse practises include agriculture with cattle, drylands and cultivated crops (4.2%). Current and historical open cast coal mines is recorded within the catchment. *Pinus and* Eucalyptus forestry (58.8%) dominates the landuse practise in the catchment (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W52B-01964 was calculated at 77.7 rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5HLEL-TWYFE (W52B-01964) is characteristic of a lowland river with a low gradient with long and shallow riffles and runs with some pools present. Fast shallow habitat was the only fish velocity depth class present in abundance with slow shallow habitat moderately abundant. No deep habitat was present. The fish cover rated from sparse to moderately abundant for overhanging vegetation and sparse for undercut banks with no root wads.

The substratum as cover was moderately abundant in the fast habitats and consisted of rocks, cobbles and pebbles, but moderate for the slow habitats with evidence of siltation.

Table 37: Fish species expected based on the PESEIS Reach Code (W52B-01964) W5HLEL-TWYFE; is listed, and the fish species percentage composition during the different surveys is indicated.

W52B-01964	Expected Species	W5HLEL-TWYFE					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	1	0.92	-	-	1	1.30
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius brevipinnis	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus nelspruitensis	X	-	-	-	-	-	-
Labeobarbus polylepis	X	7	6.42	49	32.45	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	43	39.45	9	5.96	8	10.39
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	1	0.92	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	55	50.46	70	46.36	48	62.34
Chiloglanis emarginatus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	-	-	5	6.49
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	7	4.64	6	7.79
Tilapia sparrmanii	X	2	1.83	16	10.59	9	11.69
Number of species recorded	12	6		5		5 + 1	
Number of individuals		109		151		77	
Electro-fishing time (minutes)		38 minutes		53 minutes		37 minutes	
Catch/Unit Effort (CPUE)		3.76		2.38		2.08	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 68.7%		**CATEGORY C** 73.6%	

The fish assemblage recorded at the site consisted of five species of an expected 12 species of indigenous fish as well as one alien and invasive species, *Micropterus salmoides* (Table 37). The most abundant fish species collected was *Chiloglanis anoterus* (48 individuals; 62.34% of fish assemblage) which was also the dominant fish species recorded for both the 2010 and 2015 surveys. This highly sensitive species is flow dependant with a high flow-depth preference for fast deep (4.3) and fast shallow (4.9) fish velocity depth classes. *Chiloglanis anoterus* is also totally intolerant (4.8) to reduced flow conditions and have a very high (4.9) preference to substrate. It is highly intolerant to modified water quality (4.7). The presence of this species would indicate that the flow regime is not disrupted and water quality standards intact. Cichlids prefer lentic habitats and both of the expected Cichlid species, *Pseudocrenilabrus philander* (6 individuals; 7.79% of fish assemblage) and *Tilapia sparrmanii* (9 individuals; 11.69% of fish assemblage) were collected. There are no large dams on the Hlelo River and the presence of *Anguilla mossambica* so high up in the sub-catchment is proof that the river connectivity is still in place. Of great concern is the high number of the alien and invasive species, *Micropterus salmoides* (5 individuals; 6.49%

of fish assemblage) recorded which was not found during the 2010 and 2015 surveys. This predatory alien and invasive species will have a significant impact on the indigenous fish species.

The CPUE for the present survey was calculated at 2.08 (77 individuals; 37 minutes) indicating a low abundance of fish which was consistent when comparing to the 2015 survey CPUE of 2.38. The reasons for the low species diversity and abundance of fish can be related to low flows and unavailability of suitable instream habitat diversity.

A Fish Ecostatus rating of 73.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low abundance and diversity of species) consistent with the results of the 2015 survey (Category C - 69%).

Invertebrates

Nine SASS sampling events are on record for the W5HLEL-TWYFE site on this reach in the Hlelo River. These sampling events occurred in August 1999, 2000, 2001, 2003, 2006, 2009, 2014, 2015 and this survey in August 2019. In total 54 SASS taxa have been recorded during these nine sampling events, of which the highest was recorded in 1999, 2000 and 2003. SASS scores for these sampling periods ranged from 173 – 216 (avg.) - 260. During most of these events SASS-rated sensitive taxa dominated. Sensitive taxa did not dominate in the August 2003 and 2019 samples.

Ephemeroptera's family Tricorythidae was absent for the first time out of nine survey events (B-abundance) since August 1999. Other SASS-rated sensitive taxa absent but previously (less frequent) recorded included Polymitarcidae, and Prosopistomatidae. The flow conditions were low, which reduced the number of taxa associated with marginal vegetation (e.g. Coenagrionidae).

Taxa more tolerant to organic pollution increased in 2015 and 2019 compared to previous surveys, while gathering collectors increased and filtering collectors decreased.

Table 38: Comparison of the 2015 and 2019 SASS5 results for SQ reach W52B-01964.

W52B-01964	W5HLEL-TWYFE	2015	2019	
	Total SASS Score	197	173	
	No. of SASS Families	33	28	Change
	Average Score Per Taxon	6.0	6.2	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76.3%	Category C 74.4%	→

The 2019 MIRAI results (Table 38) indicate that conditions remained consistent compared to 2015. The change is mainly attributed to low flows. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 76.3%) in August 2015 and remainded moderately impaired (Category C – 74.4%) in August 2019. Historical results suggest deterioration (Figure 26), but the exact cause is not clear.

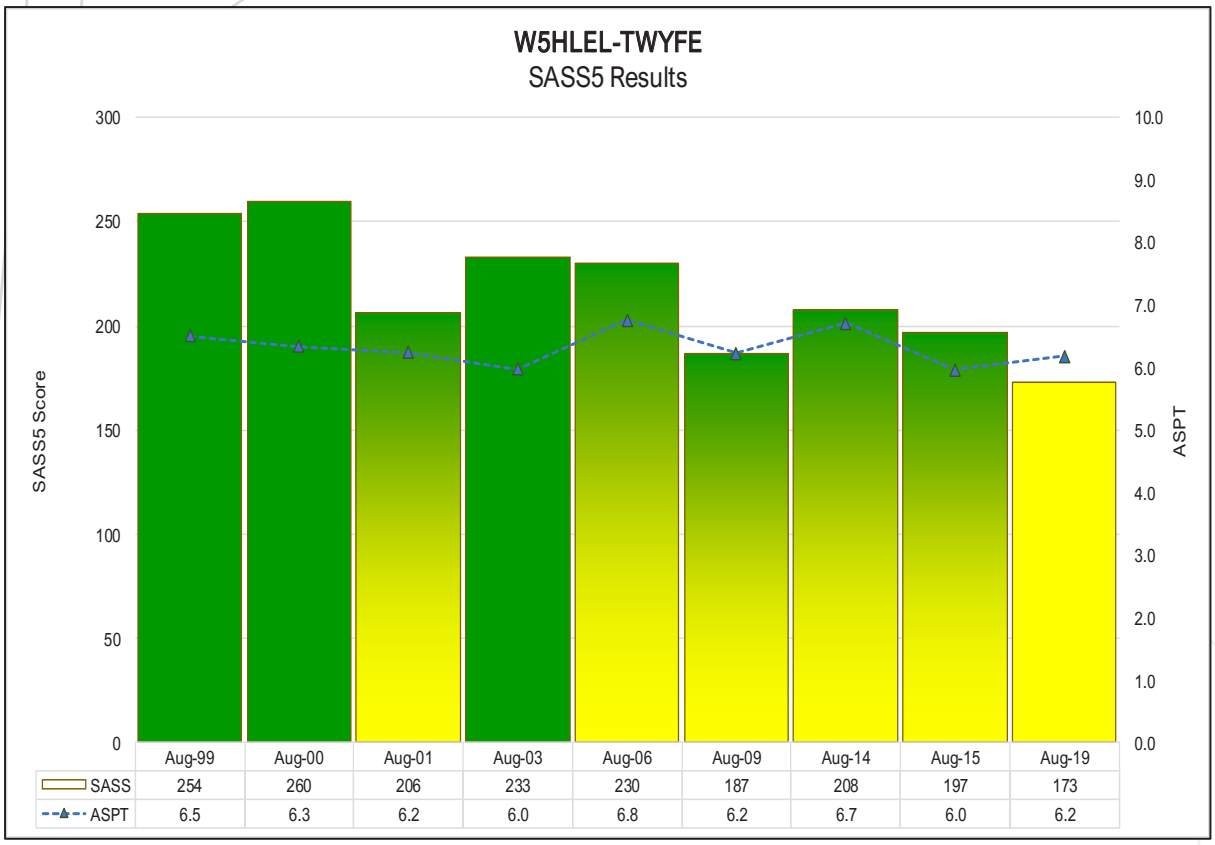


Figure 26. SASS5 Total scores and Average Score Per Taxon illustrated for sampling events carried out since August 1999.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 64.2% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Weed infestation in the riparian zone dominated by high water using species (*Acacia mearnsii*)
- Presence of highly predaceous exotic fish

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (75.5%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged

Integrated Ecostatus remained consistent to recommended Target Ecological Category

RIVER			TRIBUTARY OF	
Hlelo			Ngwempisi	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5HLEL-TWYFE			W52B	W52B-01964
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.89647	E 30.55205	1 356	Lower foothill
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-47. Upstream view of the site on the Hlelo River, W5HLEL-TWYFE (06 August 2015).

Figure A-48. Downstream view of the site on the Hlelo River, W5HLEL-TWYFE (06 August 2015).

Figure A-49. Upstream view of the site on the Hlelo River, W5HLEL-TWYFE (06 August 2019).

Figure A-50. Downstream view of the site on the Hlelo River, W5HLEL-TWYFE (06 August 2019).

SQ REACH NUMBER W52C-01867

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W52C-01867	W5HLEL-HOLDE	Hlelo	S-26.85632 E 30.72652	1 226	33.9	C	C 67.4%	BC* 79.3%	C 73.4%	B** 85%	C 78.3%	BC 80%	2015
							C 70.8%	C 76.3%	C 73.6%	BC 81%	C 76.7%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W52C-01867: Confluence of Hlelo with Zoar tributary to the confluence with the Tweelingspruit

The site falls within PESEIS Reach Code W52C-01867, which is indicated as 33.9 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Hlelo with the Zoar tributary (W52B-01890) and ends where the Hlelo meets with the Tweelingspruit (W52C-01888). The length from the source of the Hlelo River to the W5HLEL-HOLDE sampling point measured on Google Earth Pro is 105 km, and to its confluence with the Ngwempisi River 134 km. The main river channel originates at an elevation of 1,870 m a.m.s.l., flowing in an easterly direction towards the sampling point, W5HLEL-HOLDE which is at an elevation of 1,226 m a.m.s.l. The site is located in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists of wetlands (5.5%), woodlands and open bush (4.5%) and grasslands (16.5%). Landuse practises consist of limited agriculture (>1%), and is dominated by *Pinus and Eucalyptus* plantations (69.6%) (GEOTERRAIMAGE, 2015). Historic and current open cast coal mines are present as well as water abstracted from d/s pump-house to industrial area.

Instream Habitat Integrity

The IHI for the SQ reach W52C-01867 was calculated at 77.7% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The W5HLEL-HOLDE (W52C-01867) site is dominated by riffles and runs providing excellent instream habitat to reophilic fish species. The fish velocity depth classes for this site were fast shallow (abundant), slow shallow (moderately abundant) and slow deep (sparse). The fast deep biotope was absent. The fish cover present was

moderate overhanging vegetation with moderately abundant undercut banks. Rocks and cobbles provided moderate substrate cover for the reophilic fish species. No aquatic macrophytes was present as cover for fish.

Table 39: Fish species expected based on the PESEIS Reach Code (W52C-01867) W5HLEL-HOLDE; is listed, and the fish species percentage composition during the different surveys is indicated.

W52C-01867	Expected Species	W5HLEL-HOLDE			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius brevipinnus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Enteromius trimaculatus	X	-	-	-	-
Enteromius unitaeniatus	X	-	-	-	-
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	-	-	-	-
Labeobarbus marequensis	X	-	-	-	-
Labeobarbus polylepis	X	51	47.66	43	52.44
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	5	4.68	7	8.54
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	37	34.58	24	29.27
Chiloglanis emarginatus	X	-	-	-	-
Centrarchidae (Basses and sunfishes)					
Micropterus salmoides		-	-	1	1.22
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	1	1.22
Tilapia sparrmanii	X	14	13.08	6	7.31
Number of species recorded	16	4		5 + 1	
Number of individuals		107		82	
Electro-fishing time (minutes)		29 minutes		29 minutes	
Catch/Unit Effort (CPUE)		3.69		2.83	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 67.4%		**CATEGORY C** 70.8%	

A total of 16 indigenous species of fish are expected to occur in this reach of which only five was collected, as well as one alien and invasive fish species, *Micropterus* salmoides (Table 39). The indigenous fish species assemblage was very much the same as recorded during the 2015 survey with only one additional cichlid species, *Pseudocrenilabrus philander*, although only one individual was collected. The most abundant species collected was *Labeobarbus polylepis* (43 individuals; 52.44% of fish assemblage). The presence of this yellow fish species is of importance as migration is part of their life history strategy, however these species are impacted on by flow regulation. *Labeobarbus polylepis* is a flow dependant species with a high flow-depth preference for fast deep (3.7) and fast shallow (4.3) as well as slow deep (4.2) fish velocity depth classes. It is moderately intolerant (3.3) to reduced flow conditions, but with a very high requirement and (5) preference to substrate. It is further moderately tolerant to modified water quality (2.9).

The CPUE for the present survey was calculated at 2.83 (82 individuals; 29 minutes) indicating a relative abundance of fish found, a little lower abundance than recorded for the 2015 survey when a CPUE of 3.69 was recorded for this site.

A mean Fish Ecostatus rating of 70.8% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low abundance and diversity of species) consistent with the results of the 2015 survey with a slightly higher Category C Ecostatus rating (Category C – 67.4%).

Invertebrates

Eight SASS sampling events are on record for the W5HLEL-HOLDE site on this reach in the Hlelo River. These sampling events occurred in August 1999, 2000, 2001, 2005, 2008, 2011, 2015 and this survey in August 2019. In total 53 SASS taxa have been recorded during these eight sampling events, of which the highest was recorded in 2000, 2001 and 2008. SASS scores for these sampling periods ranged from 208 – 244 (avg.) - 284. During most of these events SASS-rated sensitive taxa dominated. Sensitive taxa did not dominate in the August 2015 and 2019 samples.

The families Prosopistomatidae and Chlorocyphidae was regularly recorded up to August 2011 but was absent thereafter. SASS-taxa diversity was the lowest in August 2019, with taxa associated with slow flow to stagnant waters dominating.

Table 40: Comparison of the 2015 and 2019 SASS5 results for SQ reach W52C-01867.

W52C-01867	W5HLEL-HOLDE	2015	2019	
	Total SASS Score	232	208	Change
	No. of SASS Families	37	31	
	Average Score Per Taxon	6.3	6.7	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 79.3%	Category C 76.3%	↘

The 2019 MIRAI results (Table 40) indicate slight deterioration when compared to 2015. The change is mainly attributed to low flows. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural with few modifications most of the time (Category BC – 79.3%) in August 2015 and moderately impaired (Category C – 76.3%) in August 2019. Available data suggest long term deterioration since monitoring was initiated in 1999 (Figure 27), but the exact cause is not clear.

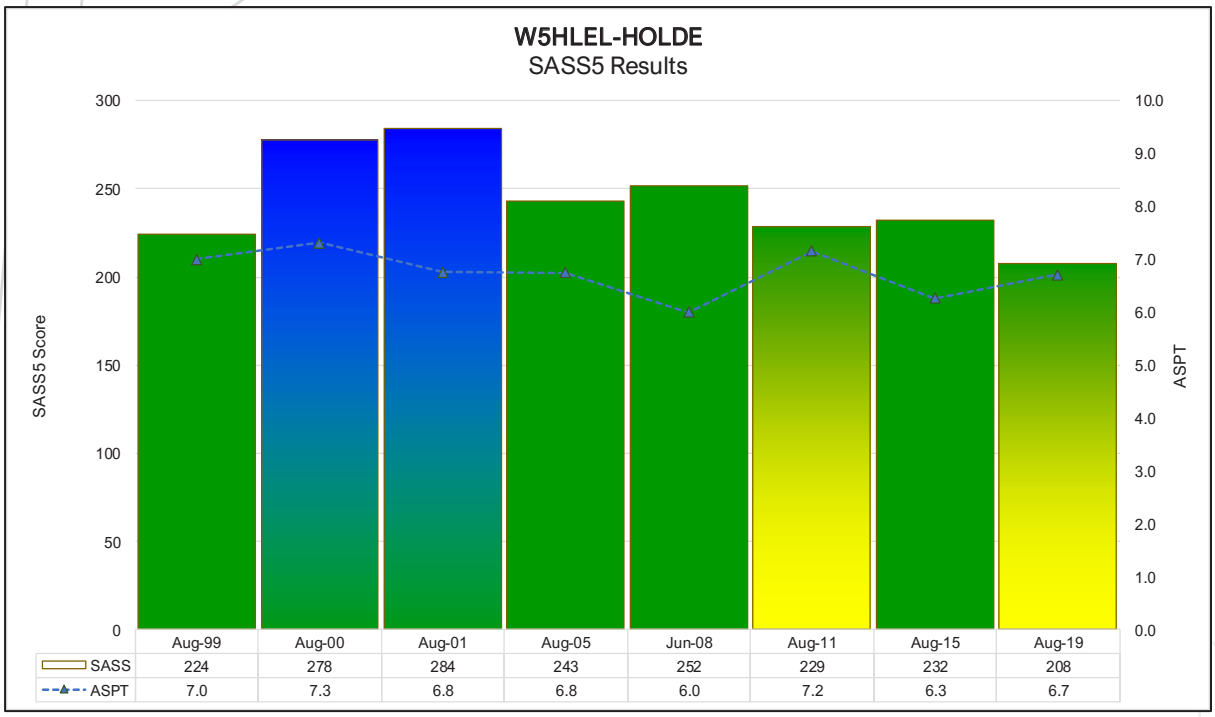


Figure 27. SASS5 Total scores and Average Score Per Taxon illustrated for sampling events carried out since August 1999.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 63.3% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (81%) indicating that the riparian vegetation for this SQ reach is close to largely natural conditions most of the time.

Water Quality

The GE image below (Figure 28) shows the water quality monitoring sites which represent the water quality state of the selected reach of the Hlelo River, i.e. IUCMA monitoring point U-43 and DWS gauging weir W5H005Q01. Data from the DWS gauging weir was assessed, but as data were only collected until 2013, data were not considered acceptable for evaluating present state.

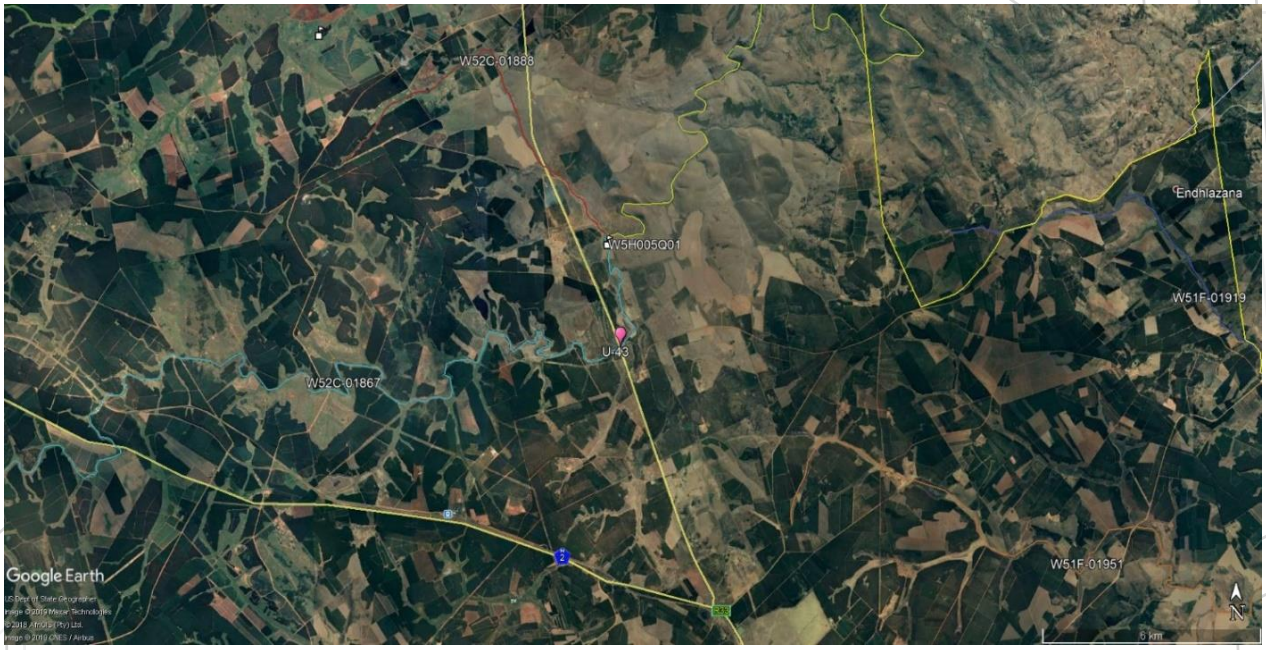


Figure 28: Google Earth image of SQR W52C-01867, Hlelo River, and selected water quality monitoring points.

Table 41 shows the present state assessment according to this study, with Table 42 being the associated PAI table. Land-use activities in the catchment include commercial forestry and limited irrigation. No large impoundments are present in the catchment, but there are several weirs.

Table 41: Water quality PES: SQR W52C-01867, Hlelo River (U-43)

RIVER	Hlelo River	**Water Quality Monitoring Points**	
		RC	Benchmark boundary tables (DWAF, 2008).
IUCMA site code	U-43	**PES**	IUCMA data, U-43: July 2016-Sept 2019; n=39.
Confidence assessment	Confidence in the assessment is **low**, as little DO, temp., turbidity or metal data, and a short data record for PES.		
Water Quality Constituents		**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$	-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	PO_4-P (mg/L)	0.012	B (1)
	TIN-N (mg/L)	0.05	A (0)
Physical variables	pH (5^{th}+95^{th} percentiles)	6.62+7.9	B (1)
	Temperature	-	Few impacts expected; little shading. A/B (0.5)
	Dissolved oxygen	-	Few impacts expected. A/B (0.5)
	Turbidity (NTU)	-	Some impact expected from forestry activities up to stream's edge. B (1)
	Electrical conductivity (mS/m)	16.53	A (0)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category: 70%	C (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	0.10	C (3)
OVERALL SITE CLASSIFICATION (from PAI)		**B (87.3%)**	

- *No data*

Table 42: PAI table for SQR W52C-01867, Hlelo River (U-43)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**2-15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	1.00	N	4.00	60.00		50.00
Salts	0.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	1.00	NONE SPECIFIED	4.00	75.00		65.00
Water Temperature	0.50	N	2.50	55.00		70.00
Water clarity	1.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	0.50	N	2.50	65.00		70.00
Toxics	0.50	N	2.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	0.65	MEAN CONF →	3.07			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	0.65					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	0.63					
FINAL PC MODIFICATION RATING	0.65					
P-C CATEGORY %	P-C CATEGORY					
87.3	B	REVISED % & CATEGORY (2014)				

Table 43 shows the water quality state at this site as compared to the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline. Although sulphate is a variable to be assessed for International Obligations (guideline: 250 mg/L), data were not available for this variable at this site.

Table 43: Comparison to water quality guidelines: SQR W52C-01867, Hlelo River (U-43)

Metric		International Obligations
Physical variables	pH	6.5-8.5
	Electrical Conductivity (mS/m)	150
Nutrients	PO_4 (mg/L P)	2
	NO_2+NO_3 (mg/L N)	50
Toxics	Ammonia (mg/L N)	1
Microbial	Faecal coliforms (cfu/100mL)	2 000 (10, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	10 000 (517, n=1, Sept 2019)

Note the following points regarding analysis:

- Data records are short, with the assessment therefore being of low confidence. Indications are, however, that water quality state for this reach is **Good.**
- Although ammonia levels (as mg/L N) are well within International Obligations, they are elevated for ecological requirements. Further investigation and longer-term monitoring of this variable is recommended.

- There is only one record for *E. coli* for the site, i.e. 12 cfu/100 mL, which is consistent with expectations for this river reach, as all coliform assessments are below the International Obligations and DWS recreational guidelines.

Impacts for SQR

- Weed infestation in the riparian zone, especially on mid-channel islands are dominated by high water using species (*Acacia mearnsii*).
- Presence of exotic highly predaceous fish.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (76.7%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.

Integrated Ecostatus NOT consistent to recommended Target Ecological Category ✗

Possible Reasons:

- Low Invertebrate Category due to low flow conditions
- Instream habitat and riparian vegetation reduced
- Impact of alien and invasive species

RIVER			TRIBUTARY OF	
Hlelo			Ngwempisi	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5HLEL-HOLDE			W52C	W52C-01867
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.85632	E 30.72652	1 226	Lower foothill
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-51. Upstream view of the site on the Hlelo River, W5HLEL-HOLDE (06 August 2015).

Figure A-52. Downstream view of the site on the Hlelo River, W5HLEL-HOLDE (06 August 2015).

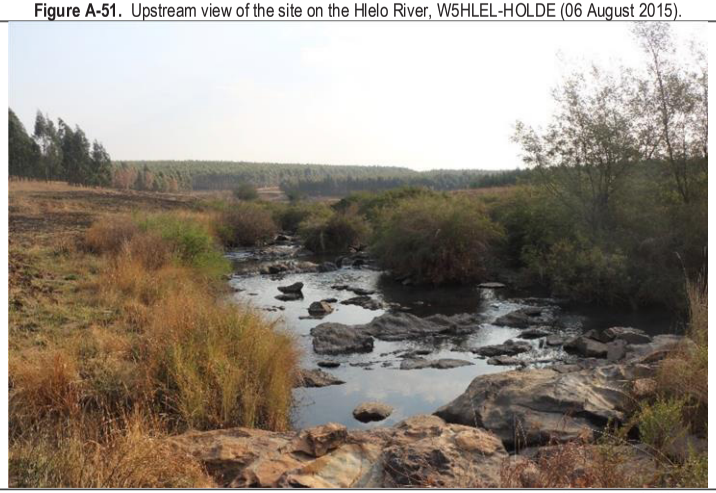


Figure A-53. Upstream view of the site on the Hlelo River, W5HLEL-HOLDE (07 August 2019).

Figure A-54. Downstream view of the site on the Hlelo River, W5HLEL-HOLDE (07 August 2019).

SQ REACH NUMBER W52C-01888

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W52C-01888	W5TWEE-MONDI	Tweelingspruit	S-26.81641 E 30.71804	1 229	11.2	B	Not sampled					C 70%	2015
							C 77.7%	C 75.5%	C 76.6%	BC 79%	C 77.6%		2019

General description

Reach W52C-01888: Tweelingspruit from source to merger with Hlelo RIver

The site on the Tweelingspruit falls within PESEIS Reach Code W52C-01888, which is indicated as 9.4 km in length (from Department of Water and Sanitation 2014). The reach starts at the source of the Tweelingspruit and ends where the stream merges with the Hlelo River. The length from the source of the Tweelingspruit to the W5TWEE-MONDI sampling point measured on Google Earth Pro is 10.5 km, and to its confluence with the Hlelo River 12.2 km. The main river channel originates at an elevation of 1,400 m a.s.l., flowing east before turning in a south-easterly direction towards the sampling point, W5TWEE-MONDI, which is at an elevation of 1,229 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consist of wetlands (6.4%); woodlands open bush (3.9%) and grasslands (20.6%). Landuse practises include cultivated crops (3.6%) and plantations (63.8%) (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W52C-01888 was calculated at 77.7% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The W5TWEE-MONDI (W52C-01888) site was included during the recent biomonitoring, although not monitored during previous surveys. It is a typical high altitude upper foothill stream with cold water indigenous fish species. The fish velocity depth classes present at this site were slow deep moderate, slow shallow moderate and fast shallow moderate, with fast deep absent. Terrestrial grasses in the riparian zone provided moderate cover as overhanging vegetation with moderate undercut banks. Limited rocks, cobbles and pebbles provided substrate cover for the fish in shallow riffles and runs.

Table 44: Fish species expected based on the PESEIS Reach Code (W52C-01888) W5TWEE-MONDI; is listed, and the fish species percentage composition during the different surveys is indicated.

W52C-01888	Expected Species	W5TWEE-MONDI			
		2015		2019	
		Individuals	%	Individuals	%
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	-	-	1	3.85
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	-	-	25	96.15
Number of species recorded	4	Not Sampled		2	
Number of individuals				26	
Electro-fishing time (minutes)				15 minutes	
Catch/Unit Effort (CPUE)				1.73	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 77.7%	

During the survey of this new biomonitoring site two species of an expected four indigenous fish species was collected (Table 44). The limnophilic *Tilapia sparrmanii* (25 individuals; 96.15%) dominated the assemblage with a single reophilic *Amphilius uranoscopus* found. The CPUE for the present survey was calculated at 1.73 (26 individuals; 15 minutes) indicating a relative low abundance of fish found at this site.

A mean Fish Ecostatus rating of 77.7% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately modified with moderate abundance of species and diversity).

Invertebrates

Five SASS sampling events are on record for the W5TWEE-MONDI site on this reach in the Tweelingspruit. These sampling events occurred in August 2000, 2001, June 2008, August 2011 and August 2019. In total 44 SASS taxa have been recorded during these two sampling events, with one taxon, Coleoptera: Lampyridae (non-SASS taxa) encountered June 2008. Total SASS scores for the available SASS data samples ranged from 202 – 152 (avg.) – 106, and taxa diversity from 33 – 25 (avg.) - 16. The lowest SASS-taxa diversity at the W5TWEE-MONDI site were recorded in June 2008 and August 2011 (Figure 29), after the establishment of an impoundment in the upper catchment. Deterioration is therefore attributed to flow regulation and the improvement in 2019 suggests some degree of recovery.

Table 45: Comparison of the 2011 and 2019 SASS5 results for SQ reach W52C-01888.

W52C-01888	W5TWEE-MONDI	2015	2019	
	Total SASS Score		156	
	No. of SASS Families		28	Change
	Average Score Per Taxon		5.6	
	SQ REACH SUMMARY Invertebrate Ecostatus	Not sampled	Category C 75.5%	

Conditions in the PESEIS reach based on MIRAI (Table 45) were rated as moderately impaired (Category C – 75.5%) during the 2019 sampling event.

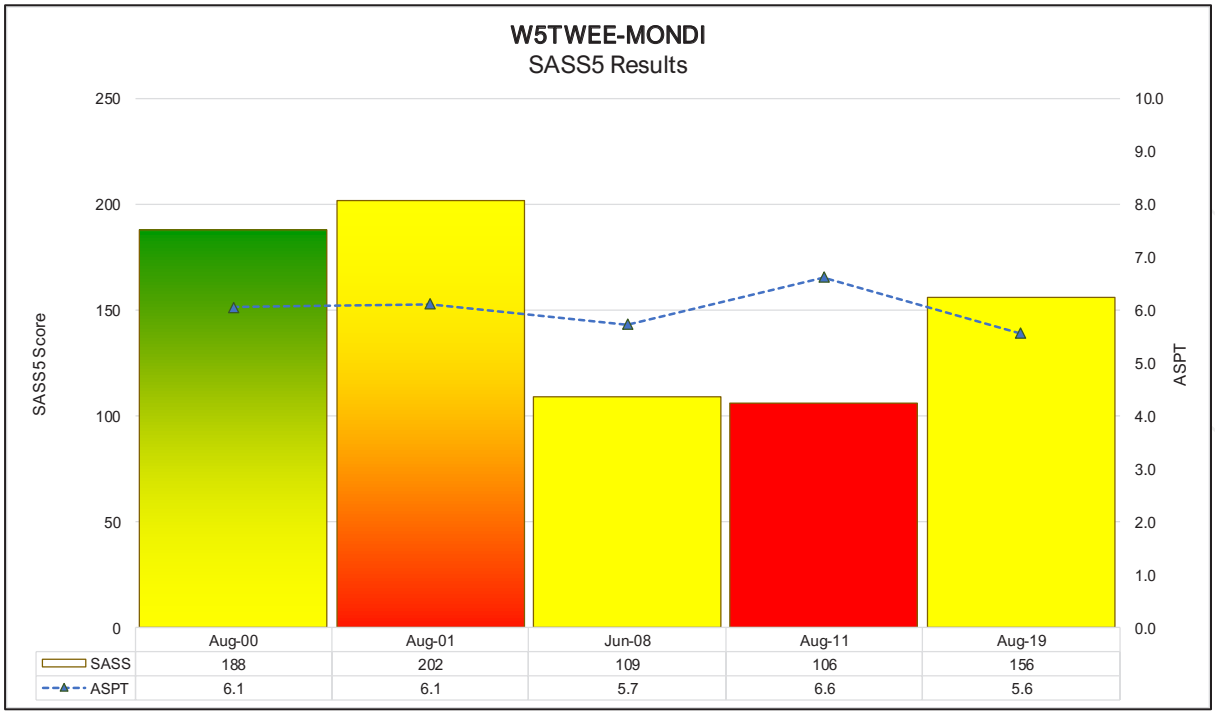


Figure 29. SASS5 Total scores and Average Score Per Taxon illustrated for sampling events carried out since August 2000.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 87.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 63.8% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (79%) indicating that the riparian vegetation for this SQ reach is close to largely natural conditions most of the time.

Impacts for SQR

- The upstream stream crossing impounds the stream above the crossing
- The upstream crossing blocks the free movement of fish during low flow conditions

- The outlet of the crossing creates downstream bank scouring because of the angle of the design.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.6%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category	

RIVER			TRIBUTARY OF	
Tweelingspruit			Hlelo	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5TWEE-MONDI			W52C	W52C-01888
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.81641	E 30.71804	1 229	Upper foothills
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-55. Upstream view of the site on the Tweelingspruit, W5TWEE-MONDI (19 August 2019).

Figure A-56. Downstream view of the site on the Tweelingspruit, W5TWEE-MONDI (19 August 2019).

SQ REACH NUMBER W52D-01862

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W52D-01862	W5HLEL-SWAZI	Hlelo	S-26.76133 E 30.82307	1 009	27.1	BC	B 83%	C* 76.9%	C 79.9%	AB** 90%	B 84.3%	B 85%	2015
							C 76.2%	C 77.1%	C 76.%	B 84%	BC 79.8%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W52D-01862: Confluence of Hlelo with Tweelingspruit to its merge with Ngwempisi

The site falls within PESEIS Reach Code W52D-01862, which is indicated as 27 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Hlelo with the Tweelingspruit (W52C-01888) and ends where the Hlelo merges with the Ngwempisi River. The length from the source of the Hlelo River to the W5HLEL-SWAZI sampling point measured on Google Earth Pro is 133 km, and to its confluence with the Ngwempisi River 134 km. The main river channel originates at an elevation of 1,870 m a.m.s.l., flowing in an easterly direction towards the sampling point, W5HLEL-SWAZI, which is at an elevation of 1,009 m a.m.s.l. The site is located in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within the North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists of wetlands (2.5%); thickets and dense bush (7.7%); woodlands and open bush (5.5%) and open spaces with grasslands (30.9%) (GEOTERRAIMAGE, 2015). Landuse practises include agriculture, open cast coal mines and forestry (12.7%).

Instream Habitat Integrity

The IHI for the SQ reach W52D-01862 was calculated at 79.4% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural conditions with few modifications most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The W5HLEL-SWAZI (W52D-01862) site sampled on this reach is situated the furthest downstream in the Hlelo River just before the confluence with the Ngwempisi River. The aquatic habitat surveyed consisted of mainly riffles, runs and pools. The fish velocity depth classes sampled were slow deep (sparse), slow shallow (moderate) and fast shallow (abundant) with fast deep absent. Overhanging vegetation and undercut banks were mostly observed at the slow shallow habitat. Boulders and rocks provided abundant cover for fish as substrate cover.

Table 46: Fish species expected based on the PESEIS Reach Code (W52D-01862) W5HLEL-SWAZI; is listed, and the fish species percentage composition during the different surveys is indicated.

W52D-01862	Expected Species	W5HLEL-SWAZI			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	-	-	3	3.57
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius crocodilensis	X	15	11.19	13	15.48
Enteromius trimaculatus	X	9	6.72	-	-
Enteromius unitaeniatus	X	6	4.48	-	-
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	-	-	-	-
Labeobarbus marequensis	X	42	31.34	5	5.95
Labeobarbus polylepis	X	12	8.96	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	7	5.22	3	3.57
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	1	1.19
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	34	25.37	49	58.33
Chiloglanis emarginatus	X	3	2.24	-	-
Centrarchidae (Basses and sunfishes)					
Micropterus salmoides		-	-	1	1.19
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	6	4.48	9	10.72
Number of species recorded	15	9		7 + 1	
Number of individuals		134		84	
Electro-fishing time (minutes)		49 minutes		33 minutes	
Catch/Unit Effort (CPUE)		2.73		2.55	
Fish Ecostatus (FRAI Value)		**CATEGORY B** 83%		**CATEGORY C** 76.2%	

Seven indigenous fish species of an expected 19 species were recorded for this reach during the present survey done. The alien and invasive *Micropterus salmoides* was also recorded for the first time at this site and is of a concern (Table 46). The present assemblage comprised of the reophilic species, *Chiloglanis anoterus* (49 individuals; 58.33%) *Amphilius uranoscopus* (3 individuals; 3.57%), *Enteromius crocodilensis* (13 individuals; 15.48%) and *Labeobarbus marequensis* (5 individuals; 5.95%). The limnophilic species composition consisted of *Marcosenius pongolensis* (3 individuals; 3.57%), *Clarias gariepinus* (1 individual; 1.19%) and *Tilapia* sparrmanii (9 individuals; 10.2%). Based on the absence and low abundance of certain fish species not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation and loss of instream habitat.

The CPUE for the present survey was calculated at 2.55 (84 individuals; 33 minutes) indicating a relative abundance of fish which was similar for the 2015 survey with a CPUE of 2.73.

A Fish Ecostatus rating of 76.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low abundance and diversity of species) which is a lower Category for the Fish Ecostatus than for the 2015 survey a Category B – 83%.

Invertebrates

Two SASS sampling events are on record for the W5HLEL-SWAZI site on this reach in the Hlelo River. These sampling events occurred in August 2015 and August 2019. In total 39 SASS taxa have been recorded during these two sampling events. SASS-taxa diversity at the W5HELO-SWAZI site are similar when compared to upstream site (W5HLEL-HOLDE). At the W5HLEL-SWAZI site sensitive taxa are present but not dominant. In 2019, there was a slight increase in the percentage sensitive taxa compared to 2015, and taxa tolerant to organic pollution decreased.

Table 47: Comparison of the 2015 and 2019 SASS5 results for SQ reach W52D-01862.

W52D-01862	W5HLEL-SWAZI	2015	2019	
	Total SASS Score	196	183	
	No. of SASS Families	33	30	Change
	Average Score Per Taxon	5.9	6.1	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76.9%	Category C 77.1%	→

The 2019 MIRAI results (Table 47) indicate similar conditions when compared to 2015, despite lower flow conditions. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 76.9% and C – 77.1%) during the 2015 and 2019 sampling events respectively.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach are calculated at 90% and is consistent with a Category AB – close to natural conditions most of the time. The Riparian IHI was calculated at 76.5% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (84%) indicating that the riparian vegetation for this SQ reach is largely natural conditions with few modifications.

Impacts for SQR

- Quantities of domestic waste increased since 2015.
- Sponsored irrigated agricultural activities at the site (2015) ceased.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (79.8%)	**Category B (85%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions are resilient and are essentially unchanged.

Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗

Possible Reasons:

- Low Fish Ecostatus Category C due to flow regulation and loss of available instream fish habitat
- Riparian vegetation reduced

RIVER			TRIBUTARY OF	
Hlelo			Ngwempisi	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5HLEL-SWAZI			W52D	W52D-01862
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.76133	E 30.82307	1 009	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4.North Eastern Highveld		4.06	

Figure A-57. Upstream view of the site on the Hlelo River, W5HLEL-SWAZI (24 July 2015).

Figure A-58. Downstream view of the site on the Hlelo River, W5HLEL-SWAZI (24 July 2015).

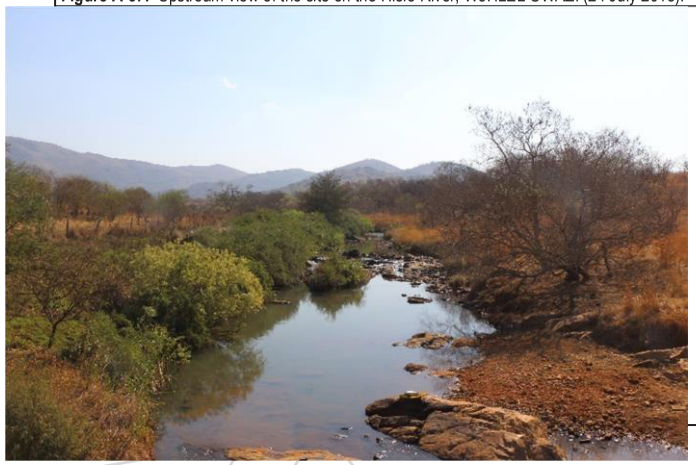


Figure A-59. Upstream view of the site on the Hlelo River, W5HLEL-SWAZI (22 August 2019).

Figure A-60. Downstream view of the site on the Hlelo River, W5HLEL-SWAZI (22 August 2019).

DISCUSSION HLELO SUB-CATCHMENT

Fish

A total of 18 indigenous fish species are expected to occur in this sub-catchment of which 10 species were recorded for the present survey. Two species collected during the present survey were not recorded for the 2015 survey and they are *Clarias gariepinus* and *Marcusenius pongolensis*. The species recorded during the 2015 survey but not found during the 2019 survey are *Chiloglanis emarginatus* and the four small barb species, *Enteromius anoplus, Enteromius brevipinnis, Enteromius trimaculatus* and *Enteromius unitaeniatus*. To date a total of 15 species are recorded of the expected 18 species for this sub-catchment since the IUCMA surveys commenced. The most abundant fish species collected for the present survey is *Chiloglanis anoterus* with a relative abundance of 42.86% of the total number of fish collected. *Labeobarbus polylepis* was the most abundant species found during the 2015 survey and the second most abundant species during the 2019 survey.

Only one species of fish, *Amphilius uranoscopus*, was collected at all of the sites surveyed for this sub-catchment. The site with the highest species diversity and abundance is also the furthest downstream site, W5HLEL-SWAZI, where a total of eight fish species were recorded. The highest abundance of fish was recorded at site W5HLEL-WITBA where a CPUE of 3.16 fish caught per minute.

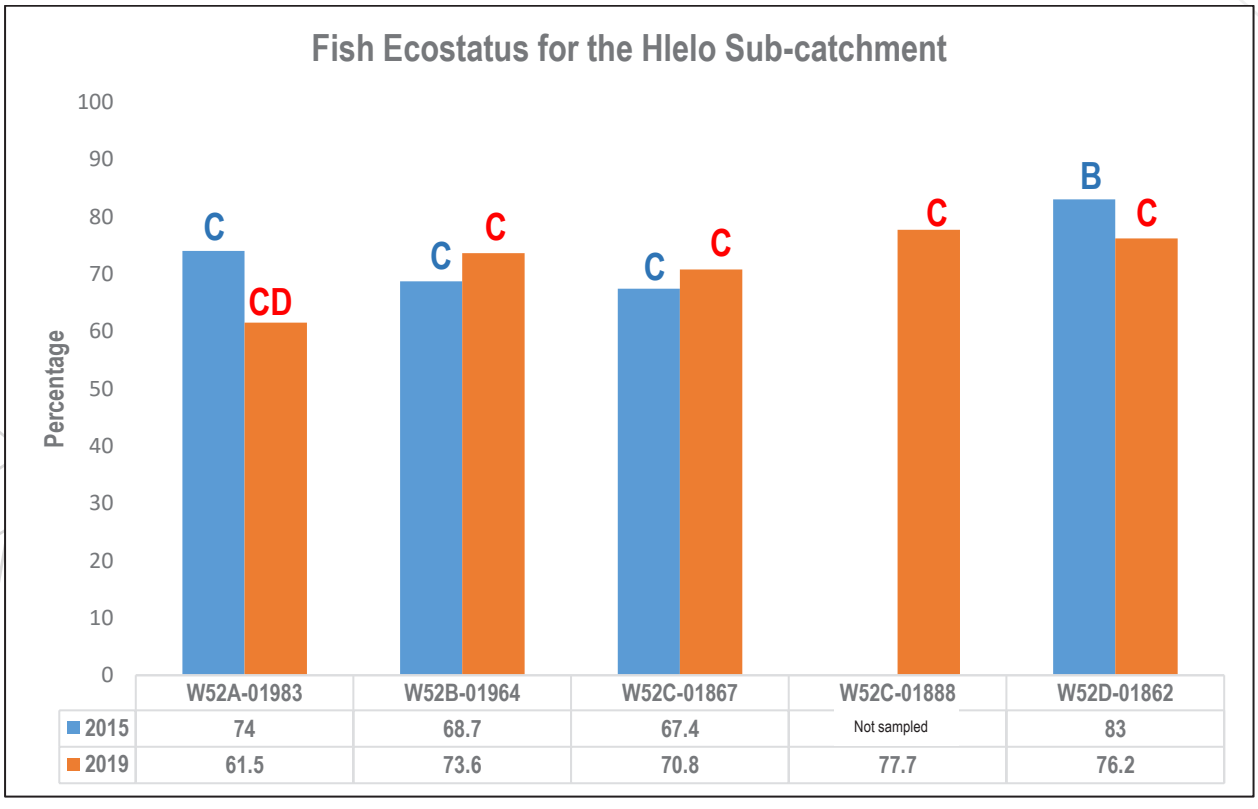


Figure 30: Summary of the Fish Ecostatus for the Hlelo-subcatchment and tributaries for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model.

Figure 30 summarise the Fish Ecostatus categories for the 5 SQ reaches on the Hlelo River sub-catchment. The Fish Ecostatus rating for the SQ reach W52D-01862 (W5HLEL-SWAZI) decreased from 83% (Category B) calculated in 2015 to 76.2% (Category C) and the W52A-01983 (W5HLEL-WITB) from a 74% (Category C) to a 61.5% Category CD. This decline can be related to flow regulation and loss of available instream habitat due to increased agriculture activity in this catchment. The overall Fish Ecostatus rating for 2019 is 71.9% placing the Hlelo Sub-catchment in a high Category C. This is consistent with the 2015 results of 73.3% and also a high Category C. The present category C (71.9%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

Invertebrates

Based on MIRAI, overall conditions in the main channel of the Hlelo remains consistent in a moderately modified Category C condition (Table 48 and Figure 31). Conditions deteriorated slightly at W52C-01867 W5HELL-HOLDE. Deterioration is mainly attributed to reduced flows, which reduced habitat heterogeneity at this site.

Table 48: Summary of stream conditions per SQ Reach based on MIRAI, comparing 2015 to 2019 results.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	CHANGE
W52	Hlelo	W52A-01983	68.9	77.5	→
		W52B-01964	76.3	74.4	→
		W52C-01867	79.3	76.3	↘
		W52D-01862	76.9	77.1	→
	Tweelingspruit	W52C-01888		75.5	

When comparing aquatic invertebrate results between the 2015 and 2019 survey (Figure 31), overall conditions remained consistent. The overall Invertebrate Ecostatus rating for 2019 is 76.2% placing the Hlelo sub-catchment in a high Category C. This compares favourably with the 2015 results of 75.4% also a high Category C. The present category C (76.2%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

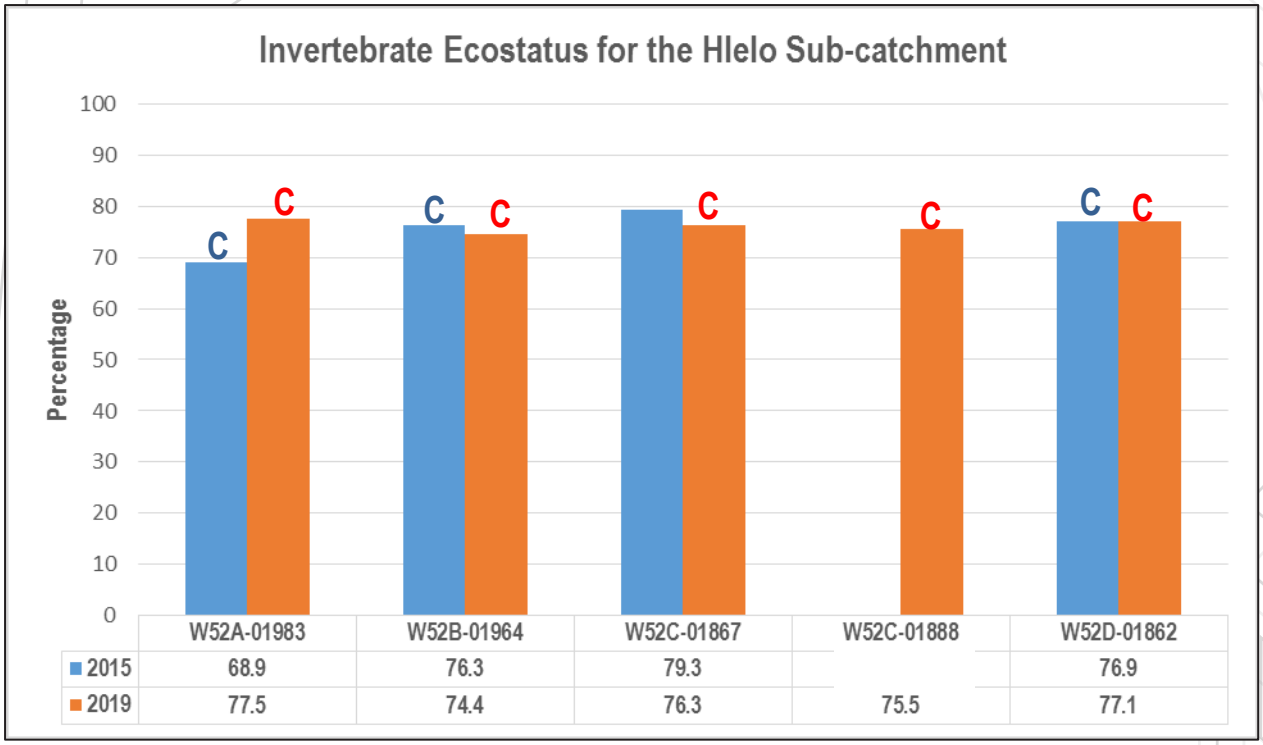


Figure 31: Graphical comparison of the Invertebrate Ecostatus of the Hlelo Sub-catchment in 2015 and 2019.

Water Quality

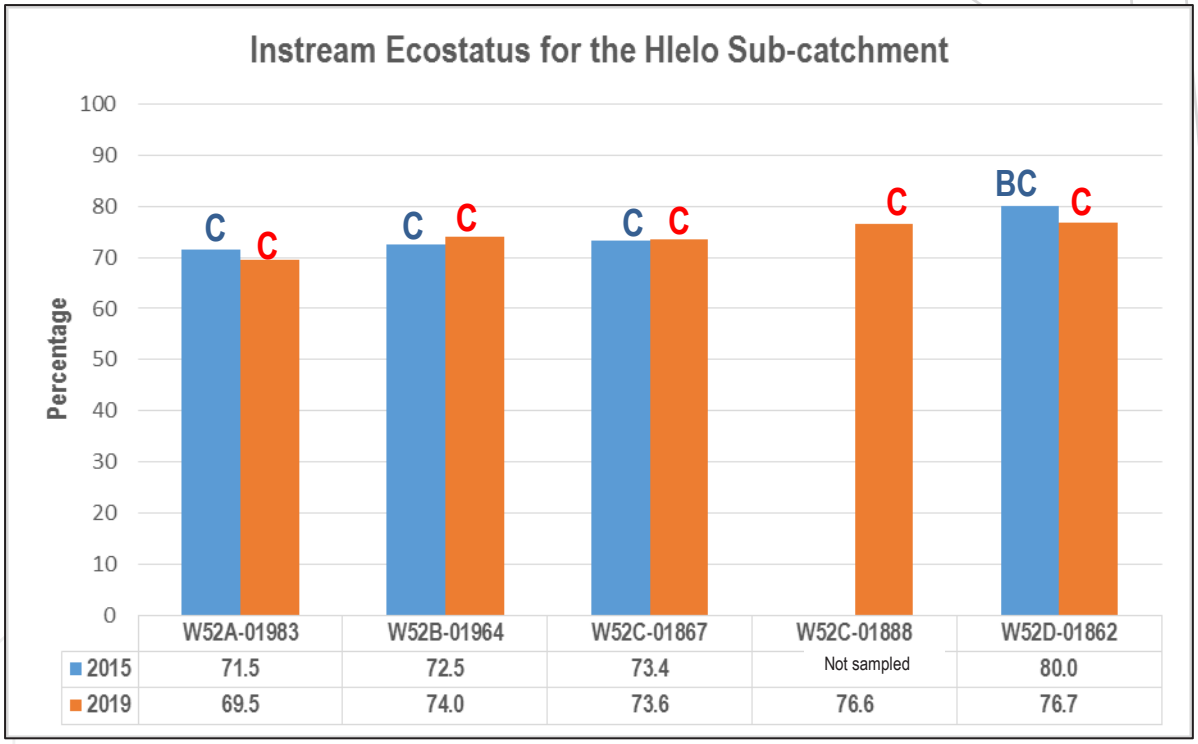
The water quality assessment was limited to specific sites, with a discussion of results provided below the results of the data assessment. Water quality state of the Hlelo reach assessed was **Good** (B category), although data records are too short to make any assessment with confidence.

Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Hlelo River Sub-catchment

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity assessment. From Figure 32 it is evident that the Instream Ecostatus remains consistent throughout the sub-catchment ranging from 69.5% to 76.7% with a mean of 74.1% category C. This remains consistent with the Instream Ecostatus for 2015 surveys at (74.4% Category C).

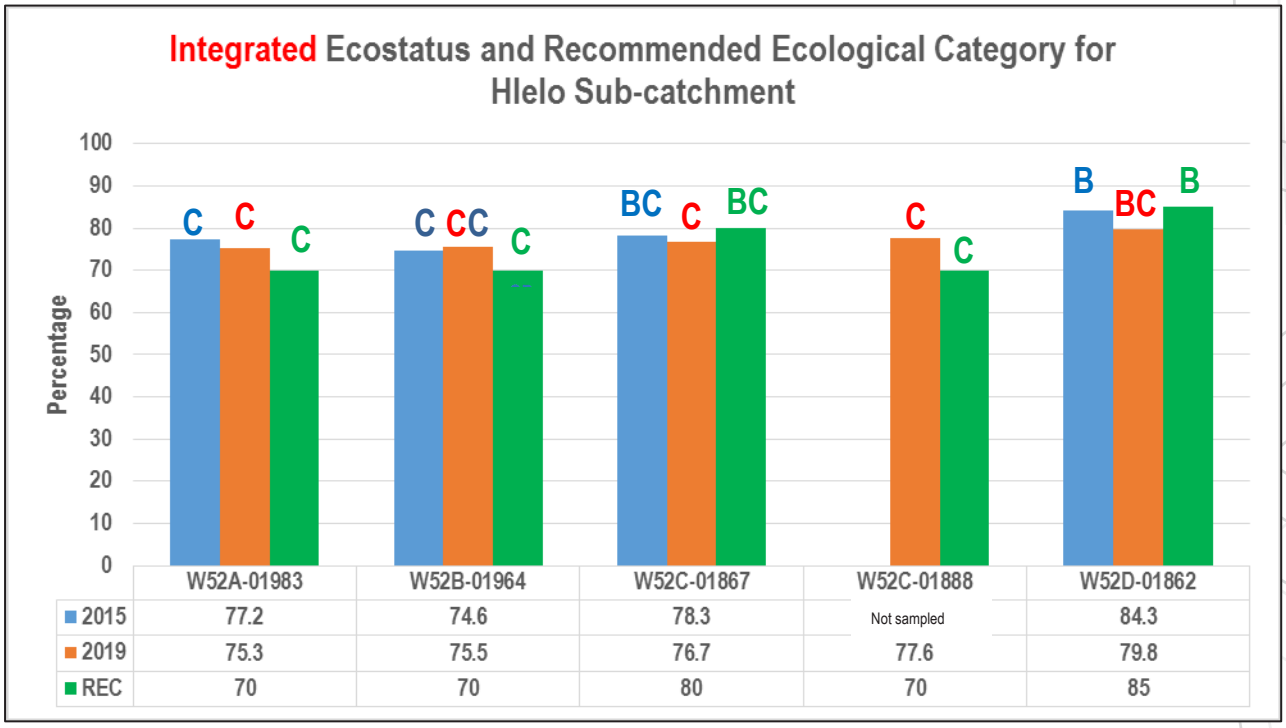
The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model. The Integrated Ecostatus for the Hlelo sub-catchment (Figure 33) also remained consistent throughout the 2015 (78.6%) and 2019 (76.9%) monitoring with a category C indicating a moderately impaired habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

When comparing the Integrated Ecostatus with the Recommended Ecological Category within the various SQ reaches, it is evident that the set targets are met for all the reaches except for W52C-01867 and W52D-01862.



	W52A-01983	W52B-01964	W52C-01867	W52C-01888	W52D-01862
2015	71.5	72.5	73.4	Not sampled	80.0
2019	69.5	74.0	73.6	76.6	76.7

Figure 32: Comparison of the Instream Ecostatus of the Hlelo Sub-catchment in 2015 and 2019.



	W52A-01983	W52B-01964	W52C-01867	W52C-01888	W52D-01862
2015	77.2	74.6	78.3	Not sampled	84.3
2019	75.3	75.5	76.7	77.6	79.8
REC	70	70	80	70	85

Figure 33: Comparison of the Integrated Ecostatusand Target Ecological Category for the Hlelo-subcatchment in 2015 and 2019.

This decline can be related to flow regulation and loss of available instream habitat due the high percentage of landcover consisting of forestry. The direct impact of forestry and related activities such as high density road

networks, incorrect river crossings, and incorrect planting distances from wetlands and river seepages, as well as destruction of riparian zones results in siltation, sedimentation, reduced flow and spreading of alien and invasive plant species.

Ngwempisi Sub-catchment Reaches

The Ngwempisi River catchment originates in the Highveld aquatic ecoregion, and then flows in a general east by southernly direction towards the Lusutfu River in Swaziland. A total of 10 biomonitoring points consisting of 10 SQ reaches (250.8 km) representing 23.4% of the river monitored on the Usuthu-Lusutfu River catchment were sampled during 2019.

SQ REACH NUMBER W53A-01853

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53A-01853	W5NGWE-POMPO	Ngwempisi	S-26.76743 E 30.39716	1 408	26.1	D	C 70%	C* 72%	C 66.3%	BC** 80%	C 74.5 %	C 70%	2015
							C 73.6%	C 76.7%	C 75.2%	BC 80%	C 77.2 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53A-01853: Ngwempisi River from its source to confluence with Sandspruit

The site falls within PESEIS Reach Code W53A-01853, which is indicated as 26.1 km in length (from Department of Water and Sanitation 2014). The reach starts at the origin of the Ngwempisi River and ends where the Ngwempisi meets with the Sandspruit (W53A-01757). The length from the source of the Ngwempisi River to the W5NGWE-POMPO sampling point measured on Google Earth Pro is 28.9 km, and to its confluence with the Lusutfu River 210 km. The main river channel originates at an elevation of 1,767 m a.m.s.l., flowing in an east north eastern direction towards the sampling point, W5NGWE-POMPO, which is at an elevation of 1,408 m a.m.s.l. The site is located in the Eastern Highveld Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (8.8%), thickets and dense bush (2.7%) and dominated by grassland (52.5%). Landuse practices include cultibvated fields (6.8%) and forestry plantations (24.6%) (GEOTERRAIMAGE, 2015). Transfer from Heyshope Dam into Ngwempisi.

Instream Habitat Integrity

The IHI for the SQ reach W53A-01853 was calculated at 79.2% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic habitat sampled at site W5NGWE-POMPO (W53A-01853) is just upstream from Morgenstond Dam at a river crossing. The habitat surveyed downstream from the crossing consisted mainly of very shallow riffles with fast shallow habitat moderate in abundance. The habitat upstream from the crossing consisted of slow shallow habitat in abundance. No deep habitats were present. The substrate cover in the fast shallow habitats were abundant consisting of rocks and cobbles. Green filamentous algae were in abundance in the slow shallow habitat impacting on available fish habitat. Overhanging vegetation provided sparse cover with a few undercut banks at the slow shallow habitat. No aquatic macrophytes was present as cover for fish.

Table 49: Fish species expected based on the PESEIS Reach Code (W53A-01853) W5NGWE-POMPO; is listed, and the fish species percentage composition during the different surveys is indicated.

W53A-02082	Expected Species	W5NGWE-POMPO			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	2	7.40	3	9.37
Enteromius brevipinnus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Enteromius paludinosus		1	3.71	10	31.25
Labeobarbus marequensis	X	1	3.71	-	-
Labeobarbus polylepis	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	1	3.71	5	15.63
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	1	3.13
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	-	-	2	6.25
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	3	11.10	-	-
Tilapia sparrmanii	X	19	70.37	11	34.37
Number of species recorded	12	6		6	
Number of individuals		27		32	
Electro-fishing time (minutes)		41 minutes		27 minutes	
Catch/Unit Effort (CPUE)		0.66		1.19	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 70%		**CATEGORY C** 73.6%	

The fish assemblage collected at this site consisted of six of an expected 12 indigenous fish species, the same number of species recorded for the 2015 survey, but a different assemblage (Table 49). The most abundant species collected was, as with the 2015 survey, the limnophilic cichlid species, *Tilapia sparrmanii,* at 34.37% (11 individuals) which is lower when compared to the 2015 collection of this species at 70.37% (19 individuals) of the total fish assemblage. The small barb, *Enteromius paludinosus*, are not expected to occur in this reach but was collected during both the present and 2015 surveys. It is possible that it may be introduced through the water transfer scheme from Heyshope Dam.

The catch per unit effort (CPUE) was calculated at 1.19 (32 individuals; 27 minutes), a somewhat higher abundance than recorded for the 2015 survey, still indicating a relative low abundance of fish present at the times of the surveys.

A Fish Ecostatus rating of 73.6% was calculated for this SQR based on all available information, placing it in an Ecological Category C (moderately impaired with low diversity and abundance of species) comparing slightly more favourably to the 2015 results, but still an Ecological Category C (70%) for fish.

Invertebrates

Two SASS sampling events are on record for the W5NGWE-POMPO site in this reach on the Ngwempisi River. These sampling events occurred in August 2015 and August 2019. In total 38 SASS taxa have been recorded during these two sampling events, with Cladocera, a non-SASS taxon, encountered during both. Only Chironomidae (tolerant taxa) were recorded during all five sampling events.

SASS-rated sensitive taxa absent in 2015 but encountered in 2019 included Athyidae, Hydracarina, Heptageniidae, and Chlorocyphidae. More tolerant SASS families were present in 2015 than during the 2019 sample. Water was transferred from the Heyshope Dam (Assegai system) during the 2015 sampling event, while stream flow was very low during the 2019 sampling event.

Table 50: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53A-01853.

W53A-01853	W5NGWE-POMPO	2015	2019	
	Total SASS Score	160	185	
	No. of SASS Families	28	30	Change
	Average Score Per Taxon	5.7	6.2	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 72%	Category C 76.7%	→

MIRAI results for 2019 (Table 50) indicates similair conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 72%) in August 2015 remaining consistent (Category C – 76.7%) in August 2019. In 2015, the site was affected by an out-of-season sub-catchment water transfer.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category BC – close to largely natural conditions with few modifications most of the time. The Riparian IHI was calculated at 64.6% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach is close to largely natural conditions with few modifications most of the time.

Impacts for SQR

- Upstream weir blocks the free movement of fish during low flow conditions
- The stream crossing at the site impedes the stream above the crossing, with downstream bank scouring the result.
- High weed infestation in the marginal and lower zones of the riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.2%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF	
Ngwempisi			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5NGWE-POMP			W53A	W53A-01853
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.76743	E 3039716	1 408	Lower foothills
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-61. Upstream view of the site on the Ngwempisi River, W5NGWE-POMPO (07 September 2015).

Figure A-62. Downstream view of the site on the Ngwempisi River, W5NGWE-POMPO (07 September 2015).

Figure A-63. Upstream view of the site on the Ngwempisi River, W5NGWE-POMPO (07 August 2019).

Figure A-64. Downstream view of the site on the Ngwempisi River, W5NGWE-POMPO (07 August 2019).

SQ REACH NUMBER W53A-01757

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53A-01757	W5SAND-ZANDS	Sandspruit	S-26.73906 E 30.35637	1 420	33.1	B	CD 59.5%	C* 71%	C 66.1%	B** 85%	C 74.8%	C 70%	2015
							BC 78.9%	C 69.3%	C 74.1%	B 83%	C 77.9%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53A-01757: Source of the Sandspruit to the confluence with the Ngwempisi River

The site falls within PESEIS Reach Code W53A-01757, which is indicated as 33.1 km in length (from Department of Water and Sanitation 2014). The reach starts close to the source of the Sandspruit and ends where the stream meets with the Ngwempisi River. The length from the source of the Sandspruit to the W5SAND-ZANDS sampling point measured on Google Earth Pro is 31.9 km, and to its confluence with the Ngwempisi River 41.9 km. The main river channel originates at an elevation of 1,808 m a.m.s.l., flowing in a north north-eastern direction towards the sampling point, W5SAND-ZANDS which is at an elevation of 1,420 m a.m.s.l. The site is located in the Eastern Highveld Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consists of wetlands 67%); thickets and dense bush (3.6%); woodlands and open bush (2.5%) and open spaces with grasslands (58.6%). Landuse practises include mixed agriculture with cultivated crops (6.1%) as well as *Pinus and* Eucalyptus forestry (plantations 21.5%) within the catchment (GEOTERRAIMAGE, 2015). Sheepmore and rural villages are situated within the catchment and water is abstracted from d/s pump-house for industrial purposes.

Instream Habitat Integrity

The IHI for the SQ reach W53A-01757 was calculated at 65.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5SAND-ZANDS (W53A-01757) sampled is on the Sandspruit, a tributary of the Ngwempisi River. The fish velocity depth classes present were fast shallow (sparse) and slow shallow (abundant). No deep habitat was present to sample. The substrate cover for fish consisted largely of bedrock with rocks and cobbles. Overhanging vegetation was moderately present at only the slow shallow habitats with undercut banks also moderately present. No aquatic macrophytes were present at the habitats sampled.

Table 51: Fish species expected based on the PESEIS Reach Code (W53A-01757) W5SAND-ZANDS; is listed, and the fish species percentage composition during the different surveys is indicated.

W53A-01757	Expected Species	W5SAND-ZANDS			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	31	46.97
Enteromius brevipinnus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeobarbus polylepis	X	44	86.28	17	25.76
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	-	-	3	4.54
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	-	-	3	4.54
Chiloglanis emarginatus	X	4	7.84	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	1	1.52
Tilapia sparrmanii	X	3	5.88	11	16.67
Number of species recorded	11	3		6	
Number of individuals		51		66	
Electro-fishing time (minutes)		21 minutes		30 minutes	
Catch/Unit Effort (CPUE)		2.43		2.20	
Fish Ecostatus (FRAI Value)		**CATEGORY CD** 59.5%		**CATEGORY BC** 78.9%	

During the present survey a fish assemblage of six indigenous fish species were recorded from an expected 11 species, three species more than recorded for the 2015 survey. (Table 51). The reophilic, flow sensitive species *Chiloglanis anoterus* and *Amphilius uranoscopus* was collected in relative abundance of 4.54% (3 individuas) each indicating that the river flow regime has not been disrupted. The absence of the highly sensitive *Chiloglanis emarginatus* is of concern, as according to literature (Roux & Hoffman, 2018) this species is threatened by water abstraction, river regulation and sedimentation. This highly sensitive species is flow dependant with a high flow-depth preference for fast deep (5) and fast shallow (3.2) fish velocity depth classes. *Chiloglanis emarginatus* is also totally intolerant (5) to reduced flow conditions and have a very high (5) preference to substrate. It is highly intolerant to modified water quality (5). Other species recorded include *Enteromius anoplus, Labeobarbus polylepis, Pseudocrenilabrus philander and Tilapia sparrmanii.*

The CPUE (catch per unit effort) calculated for this site is 2.20 (individuals caught per minute) indicating a similar abundance of fish collected compared to the 2015 survey when a CPUE of 2.43.0 was calculated.

A Fish Ecostatus rating of 78.9% was calculated for this reach based on all available information, placing this reach in an Ecological Category BC (close to largely natural with few modifications most of the time, with moderate diversity and abundance of species) improving from the 2015 survey (Ecological Category CD – 59.5%).

Invertebrates

Eight SASS sampling events are on record for the W5SAND-ZANDS site in this reach on the Sandspruit. These sampling events occurred in August 1999, 2000, 2001, 2005, June 2008, August 2011, 2015 and this survey in August 2019. In total 42 SASS taxa have been recorded during these eight sampling events. In addition, Cladocera were recorded during the 2015 and 2019 surveys. Total SASS scores ranged between 136 – 161 (avg.) – 195, and taxa diversity 23 – 27 (avg.) – 31. Sensitive rated SASS taxa have never been dominant during the different sampling events, with the lowest percentage recorded during the August 2015 and 2019 sampling events. SASS-taxa rated as sensitive frequently recorded during previous surveys but absent in 2019 included Tricorythidae, Chlorocyphidae, Aeshnidae, Naucoridae, and Elmidae.

SASS taxa associated with fast to moderate flows dominated from 1999 to 2008, and those with slow to stagnant waters post 2008. The change is partially attributed to the upstream construction of impoundments and increased water abstraction.

Table 52: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53A-01757.

W53A-01757	W5SAND-ZANDS	2015	2019	
	Total SASS Score	163	162	
	No. of SASS Families	28	25	Change
	Average Score Per Taxon	5.8	6.5	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 71%	Category C 69.3%	→

The 2019 SASS5 results (Table 52) indicates similar conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 71% and 69.3%) in August 2015 and August 2019 respectively. Despite the lower flow conditions and change in riparian vegetation structure (Figure 34 and Figure 35), conditions based on MIRAI remained similar during the different sampling events (Figure 33).

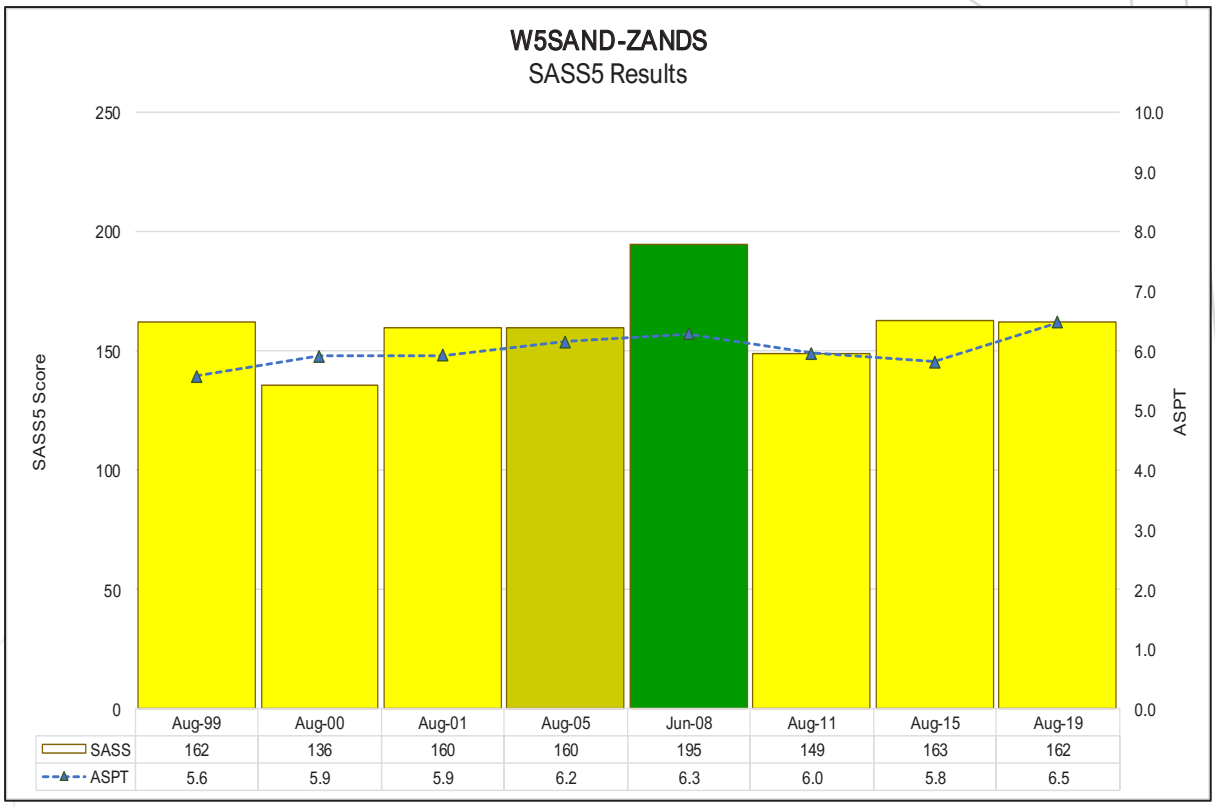


Figure 33. Graphic illustration of historic data, SASS5 Total score and ASPT for sampling events at the W5SAND-ZANDS site. Colour codes represent stream condition categories, e.g. green – B, yellow – C.

Figure 34. Marginal vegetation structure and flow conditions in the Sandspruit during 2015 (31 August 2015, G Diedericks).

Figure 35. Up- and downstream view of the Sandspruit during the August 2019 survey, indicating changes (Figure 34) in vegetation structure, flow volumes, and increased sand deposition (road erosion) (7 August 2019, G Diedericks).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 79.3% rating this reach as a Category BC indicating a riparian habitat close to largely natural with few modifications most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (83%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications. A small change of natural habitat and biota may have taken place, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The stream crossing overtops during high flows, which results in downstream bank scouring
- The road approach is steep, resulting in high sediment inputs below the crossing (see photo on right in Figure 35).
- Increase in woody vegetation in the riparian zone, of which some are invasive (e.g. *Acacia mearnsii*).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.9%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Sandspruit			Ngwempisi	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5SAND-ZANDS			W53A	W53A-01757
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.73906	E 30.35637	1 420	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-65. Upstream view of the site on the Sandspruit, W5SAND-ZANDS (18 August 2015).

Figure A-66. Downstream view of the site on the Sandspruit, W5SAND-ZANDS (18 August 2015).

Figure A-67. Upstream view of the site on the Sandspruit, W5SAND-ZANDS (07 August 2019).

Figure A-68. Downstream view of the site on the Sandspruit, W5SAND-ZANDS (07 August 2019).

SQ REACH NUMBER W53D-01764

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53D-01764	W5MPAM-GLENE	Mpama	S-26.66113 E 30.49137	1 447	15.8	B	CD 59.6%	C* 63.9%	CD 61.9%	B** 82.5%	C 72.2%	C 70%	2015
							C 66.8%	CD 61.8%	C 64.3%	C 77%	C 69.7%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53D-01764: Mpama River to confluence with Ngwempisi

This site on the Mpama River falls within PESEIS Reach Code W53D-01764, which is indicated as 15.8 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Mpama River (W53B-01710) with the Kliprugspruit (W53B-01694) which is in the Jericho Dam, and ends where the Mpama River meets with the Ngwempisi River. The length from the source of the Mpama River to the W5MPAM-GLENE sampling point measured on Google Earth Pro is 24.2 km, and to its confluence with the Ngwempisi River 36 km. The main river channel originates at an elevation of 1,761 m a.s.l., flowing through channelized wetlands for many parts of its catchment before flowing into the Jericho Dam. The sampling point, W5MPAM-GLENE, is at an elevation of 1,447 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (3.9%) and grassland (27%). The land use practises consist of mixed agriculture with cultivated fields (12.1%), pine and eucalyptus forestry (44.2%) (GEOTERRAIMAGE, 2015) as well as water abstraction from catchment towards the Olifanst catchment. Jericho village and surrounding communal lands are present within catchment.

Instream Habitat Integrity

The IHI for the SQ reach W53D-01764 was calculated at 69.7% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The W5MPAM-GLENE (W53D-01764) biomonitoring site is on a tributary of the Ngwempisi River just downstream from Jericho Dam. A diversity of slow habitat types was present with both slow shallow and slow deep moderately abundant. Small riffles and runs present provided little instream habitat to flow dependant species due to low flow

levels. Substrate cover was provided in the form of a few boulders, however most of the habitat was embedded as a result of siltation. Overhanging vegetation was moderate undercut banks sparse, still provided some cover for fish at the slow deep habitat. Aquatic macrophytes was moderately present providing cover for fish.

Table 53: Fish species expected based on the PESEIS Reach Code (W53D-01764) W5MPAM-GLENE; is listed, and the fish species percentage composition during the different surveys is indicated.

W53D-01764	Expected Species	W5MPAM-GLENE					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Mormyridae (Snoutfishes)							
Marcusenius (macrolepidotus) pongolensis		-	-	-	-	1	4.55
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	3	16.67	-	-	2	9.09
Labeobarbus polylepis	X	-	-	-	-	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	-	-	-	-	-	-
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	1	5.55	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	3	100	7	31.82
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	3	16.67	-	-	1	4.55
Tilapia sparrmanii	X	11	61.11	-	-	11	50.00
Number of species recorded	13	4		1		4 + 1	
Number of individuals		18		3		15 + 7	
Electro-fishing time (minutes)		24 minutes		29 minutes		26 minutes	
Catch/Unit Effort (CPUE)		0.75		0.10		0.85	
Fish Ecostatus (FRAI Value)				**CATEGORY CD** 59.6%		**CATEGORY C** 66.8%	

Red – Exotic species

The fish assemblage recorded during the present survey consisted of four indigenous fish species of an expected thirteen (13) species recorded at low abundance, namely; *Marcusenius pongolensis, Enteromius crocodilensis, Pseudocrenilabrus philander and Tilapia sparrmanii* (Table 53). The absence of the flow dependent, reophilic species can be related to the absence of suitable habitat and disrupted flow regime as a result of flow regulation from the upsteam Jericho Dam as well as the presence of the alien and invasive piscivorous *Micropterus salmoides* recorded for this site. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of habitat deterioration due to excessive siltation, sedimentation and flow regulation.

The CPUE (catch per unit effort) calculated for the site is 0.85 (22 individuals; 26 minutes), remaining consistent with the CPUE of 0.10 (3 individuals; 29 minutes) recorded during the 2015 survey and 0.75 for the 2010 survey indicating a very low abundance of fish present.

A Fish Ecostatus rating of 66.8% was determined for this reach placing it in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) which is an improvement from the 2015 survey.

Invertebrates

Eight SASS sampling events are on record for the W5MPAM-GLENE site in this reach on the Mpama River. These sampling events occurred in August 1999, 2000, 2001, 2005, June 2008, August 2011, September 2015 and this survey in August 2019. In total 50 SASS taxa have been recorded during these eight sampling events. Total SASS scores ranged from 109 – 139 (avg.) – 181, and the number of SASS taxa from 20 – 27 (avg.) – 33.

The change in SASS5 results are mainly driven by flow volumes released from the upstream Jericho Dam, with the stream community during all sampling events dominated by taxa considered tolerant slow to stagnant waters. Several flow sensitive taxa expected are absent. These include Perlidae, Prosopistomatidae, Tricorythidae, Philopotamidae, Elmidae, Psephenidae and Athericidae. Since June 2008, taxa tolerant to organic pollution were dominant.

Table 54: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53D-01764.

W53D-01764	W5MPAM-GLENE	2015	2019	
	Total SASS Score	166	128	
	No. of SASS Families	32	23	Change
	Average Score Per Taxon	5.2	5.6	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 63.9%	Category CD 61.8%	↘

The 2019 MIRAI results (Table 54) indicates slight deterioration when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 63.9%) in September 2015 deteriorating to largely to moderately impaired (Category CD – 61.8%) in August 2019. Poor conditions are attributed to regulated flows. Conditions at this site based on MIRAI results range (Figure 36) from largely impaired (D) to moderately impaired (C).

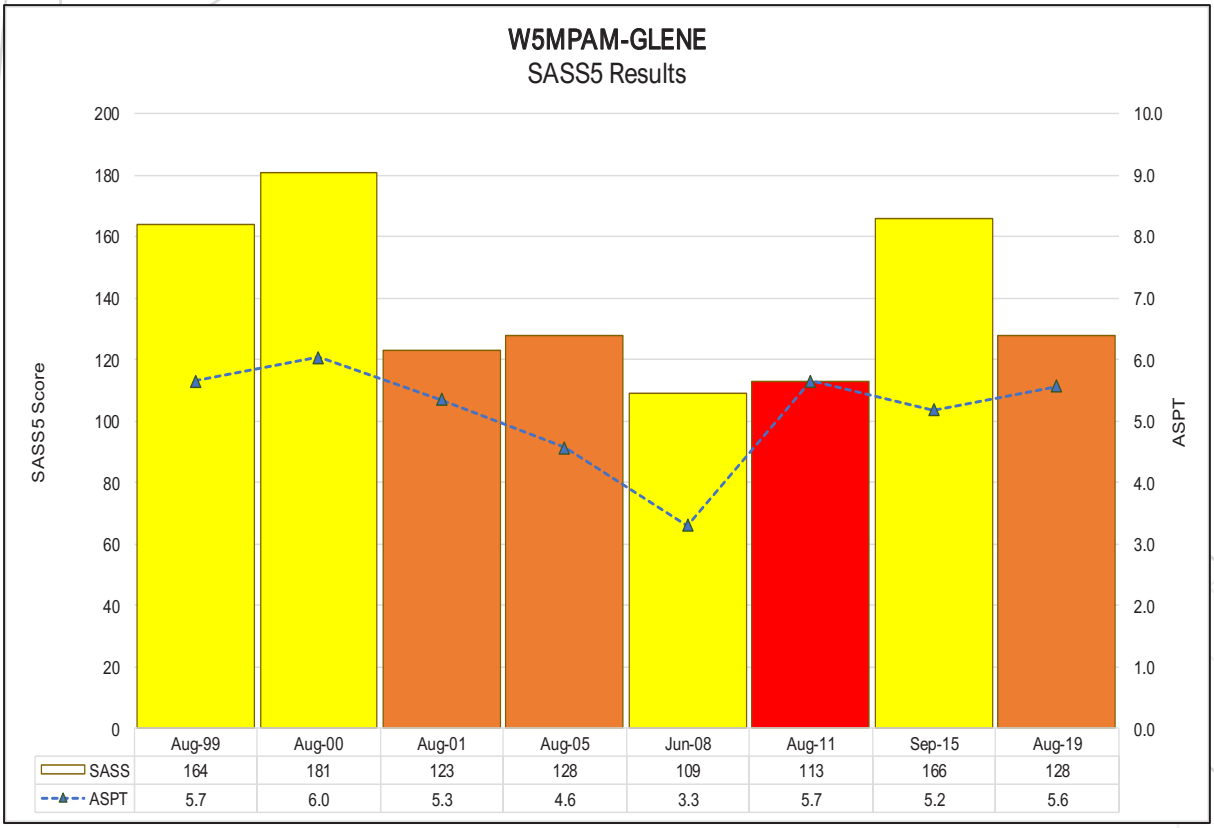


Figure 36. Graphic illustration of historic data, SASS5 Total score and ASPT for sampling events at the W5MPAM-GLENE site. Colour codes represent stream condition categories, e.g. green – B, yellow – C.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 63.1% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Over abstraction and poor flow release management to maintain natural flow regimes.
- High quantities of domestic waste in the stream and riparian zone.
- Weed infestation of the riparian zone.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (69.7%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged

Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔

Discussion:

Although the Recommended Ecological Target has been met, flow regulation and overabstraction is the major impacts on this reach.

RIVER			TRIBUTARY OF	
Mpama			Ngwempisi	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5MPAM-GLENE			W53D	W53D-01764
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.66113	E 30.19437	1 447	Upper foothill
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-69. Upstream view of the site on the Mpama River, W5MPAM-GLENE (07 September 2015).

Figure A-70. Downstream view of the site on the Mpama River, W5MPAM-GLENE (07 September 2015).

Figure A-71. Upstream view of the site on the Mpama River, W5MPAM-GLENE (07 August 2019).

Figure A-72. Downstream view of the site on the Mpama River, W5MPAM-GLENE (07 August 2019).

SQ REACH NUMBER W53D-01773

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53D-01773	W5NGWE-STERK	Ngwempisi	S-26.70081 E 30.64582	1 184	23.9	C	C 75.6%	C* 74.8%	C 75.2%	C** 77.5%	C 76.2%	C 70%	2015
							C 68.6%	BC 80%	C 74.3%	C 76.5%	C 75.2%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53D-01773: Ngwempisi River from its confluence with Sandspruit to confluence of Swartwaterspruit

This site on the Ngwempisi River falls within PESEIS Reach Code W53D-01773, which is indicated as 23.9 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Ngwempisi with the Sandspruit (W53A-01757) and ends at the confluence with the Swartwaterspruit (W53D-01814). The PESEIS Reach length includes the Morgenstond Dam. The length from the source of the Ngwempisi River to the W5NGWE-STERK sampling point measured on Google Earth Pro is 77.9 km, and to its confluence with the Lusutfu River 210 km. The main river channel originates at an elevation of 1,767 m a.s.l., flowing in an east by northerly direction towards the sampling point, W5NGWE-STERK, which is at an elevation of 1,184 m a.s.l. The site is in the KaNgwana Montane Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (6.1%); thickets and dense bush (6.3%); woodlands open bush (8.6%), dominated by grassland (46.9%). The Landuse practices include mixed agriculture (cultivated crops 11.5%) and forestry plantations (19%) of Pine and Eucalyptus (GEOTERRAIMAGE, 2015).Transfer from Morgenstond Dam and Jericho Dam to Vaal and Olifants catchments.

Instream Habitat Integrity

The IHI for the SQ reach W53D-01773 was calculated at 71.2% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5NGWE-STERK (W53D-01773) is just downstream from Morgenstond Dam. This river reach habitat presented similar to previous surveys with mostly fast habitat that could be sampled. Just upstream from the site is a

deep pool stretching up to the river crossing that was inaccessible for sampling. The fish velocity depth classes sampled were fast shallow and slow shallow both abundantly, with the slow habitat the dominant biotope. The fish cover present rated sparse to moderate for overhanging vegetation created by grass and reeds in the riparian zone. The substratum varied from moderate to abundant and consisted of rocks, cobbles and pebbles.

Table 55: Fish species expected based on the PESEIS Reach Code (W53D-01773) W5NGWE-STERK; is listed, and the fish species percentage composition during the different surveys is indicated.

W53D-01773	Expected Species	W5NGWE-STERK					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	-	-
Labeobarbus marequensis	X	-	-	-	-	-	-
Labeobarbus polylepis	X	-	-	-	-	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	8	13.11	9	27.28	2	9.09
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	38	62.30	14	42.42	3	13.64
Chiloglanis emarginatus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	2	6.06	5	22.73
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	7	11.48	2	6.06	2	9.09
Tilapia sparrmanii	X	8	13.11	6	18.18	10	45.45
Number of species recorded	11	4		4 + 1		4 + 1	
Number of individuals		61		31 + 2		17 + 5	
Electro-fishing time (minutes)		20 minutes		42 minutes		39 minutes	
Catch/Unit Effort (CPUE)		3.05		0.79		0.56	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 75.6%		**CATEGORY C** 68.6%	

Red – Exotic species

Of the expected 11 indigenous fish species only four species were recorded for the three surveys done to date (Table 55). The fish assemblage was dominated by flow-tolerant species collected in low-abundance, namely *Tilapia sparrmanii* (45.45%; 10 individuals), Pseudocrenilabrus philander (9.09%; 2 individuals). The reophilic fish component consisted of two species also collected in low abundance, *Chiloglanis anoterus* (13.64%; 3 individuals) and Amphilius uranoscopus (9.09%; 2 individuals). Of concern is the alien and invasive *Micropterus salmoides* which was collected for the second time at this site and in increasing numbers (22.73%; 5 individuals) with some also occupying the fast flowing habitat. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of flow regulation due to the Morgenstond Dam and loss of instream fish habitat.

The CPUE (catch per unit effort) calculated for this site is 0.56 (22 individuals; 39 minutes) which is lower than both the 2010 and 2015 surveys. A steady decrease in abundance is noted which can also be attributed to the presence of alien and invasive predatory species, as well as reduced water quantity and quality.

A Fish Ecostatus rating of 68.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent but with a lower Category C than the 2015 survey Fish Ecostatus rating of Category C (75.6%).

Invertebrates

Two SASS sampling events are on record for the W5NGWE-STERK site in this reach on the Ngwempisi River. These sampling events occurred in August 2015 and August 2019. In total 42 SASS taxa have been recorded during the two sampling events. Cladocera and Ostracoda, non-SASS taxa, were additionally recorded during both the 2015 and 2019 surveys. The site is located downstream from the Morgenstond Dam, and therefore affected by flow regulation. The diversity of SASS5 were similar between the 2015 and 2019 surveys. Sensitive-rated taxa encountered were not dominant during both surveys, but there are families (low abundance) in 2019 not recorded in 2019. These included Perlidae, Polymitarcidae, Chlorocyphidae, Philopotamidae, and Empididae. There was also a decrease in taxa tolerant to organic pollution from 2015 to 2019. Flow volumes were noticeably lower in 2019, as was the specific electrical conductivity in situ measurements.

Table 56: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53D-01773.

W53D-01773	W5NGWE-STERK	2015	2019	
	Total SASS Score	200	232	
	No. of SASS Families	34	35	Change
	Average Score Per Taxon	5.9	6.6	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 74.8%	Category BC 80%	↗

The 2019 SASS5 results (Table 56) indicates a slight improvement in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 74.8%) in August 2015 slightly improving to largely natural to moderately impaired (Category BC – 80%) in August 2019. The site experience flow regulation from the Morgenstond Dam.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 63.1% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the

Vegetation Condition and the Riparian IHI was therefore determined as a Category C (76.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The riparian vegetation has been removed to create an unprotected stream crossing (Figure 37), without the necessary authorisation (Section 21 National Water Act)
- Invasive weeds are present in the riparian zone

Figure 37. Grading of riparian vegetation, pushing loose soil directly into the river (07 August 2019).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (75.2%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	
Discussion: Proper catchment management to reduce desctruction of riparion vegetation recommended	

RIVER			TRIBUTARY OF	
Ngwempisi			Lusutfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5NGWE-STERK			W53D	W53D-01773
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.70081	E 30.64582	1 184	Lower foothills
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-73. Upstream view of the site on the Ngwempisi River, W5NGWE-STERK (07 September 2015).

Figure A-74. Downstream view of the site on the Ngwempisi River, W5NGWE-STERK (07 September 2015).

Figure A-75. Upstream view of the site on the Ngwempisi River, W5NGWE-STERK (20 August 2019).

Figure A-76. Downstream view of the site on the Ngwempisi River, W5NGWE-STERK (20 August 2019).

SQ REACH NUMBER W53D-01814

	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53D-01814	W5SWAR-WOLWE	Swartwaterspruit	S-26.73056 E 30.66792	1 223	21.5	B	C 72.7%	BC* 82.1%	C 77.6%	B** 87.5%	B 82.5%	B 85%	2015
							C 75.1%	C 74%	C 74.6%	C 71%	C 73%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53D-01814: Source of the Sandspruit to the confluence with the Ngwempisi River

This site on the Swarwaterspruit falls within PESEIS Reach Code W53D-01814, which is indicated as 21.5 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Swartwaterspruit and ends at its confluence with the Ngwempisi River downstream from the W5NGWE-STERK sites. The length from the source of the Swartwaterspruit to the W5SWAR-WOLVE sampling point measured on Google Earth Pro is 16.7 km, and to its confluence with the Ngwempisi River 23.2 km. The main river channel originates at an elevation of 1,460 m a.s.l., flowing in an easterly direction towards the sampling point, W5SWAR-WOLVE, which is at an elevation of 1,223 m a.s.l. The site is in the KaNgwana Montane Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists of wetlands (5%), woodlands and open bush (4.5%) and open spaces with grasslands (24.3%). Landuse practises include agriculture with cattle, drylands and cultivated crops (6%) as well as *Pinus and* Eucalyptus forestry (58.5%) dominates within the catchment (GEOTERRAIMAGE, 2015). Small farm damps up and downstream of reach.

Instream Habitat Integrity

The IHI for the SQ reach W53D-01814 was calculated at 74.6% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic site W5SWAR-WOLVE (W53D-01814) in the Swartwaterspruit, a tributary of the Ngwempsi River, is situated at a river crossing. Only the shallow fish velocity depth classes were present at the time of the survey with both the slow shallow and fast shallow rated as abundant. The only cover for fish was substrate cover with a few boulders, rocks and cobbles. No aquatic macrophytes was present as cover for fish.

Table 57: Fish species expected based on the PESEIS Reach Code (W53D-01814) W5SWAR-WOLVE; is listed, and the fish species percentage composition during the different surveys is indicated.

W53D-01814	Expected Species	W5SWAR-WOLVE					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-	3	8.11
Labeobarbus marequensis	X	-	-	-	-	-	-
Labeobarbus polylepis	X	-	-	-	-	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	9	34.62	2	9.53	1	2.70
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	2	7.69	7	33.33	5	13.52
Chiloglanis emarginatus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		13	50.00	-	-	1	2.70
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	-	-
Tilapia sparrmanii	X	2	7.69	12	57.14	27	72.97
Number of species recorded	11	3 + 1		3		4 + 1	
Number of individuals		13 + 13		21		36 + 1	
Electro-fishing time (minutes)		22 minutes		37 minutes		18 minutes	
Catch/Unit Effort (CPUE)		1.18		0.57		2.06	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 72.7%		**CATEGORY C** 75.1%	

Red – Exotic species

A total of four indigenous fish species were recorded during the present surveys from an expected 11 indigenous fish species assemblage (Table 57). The fish assemblage for this biomonitoring reflects low species diversity and abundance in particularly for the reophilic species, with only *Enteromius crocodilensis* (3 indiviuals); *Amphilius uranoscopus* (1 individua) and *Chiloglanis anoterus* (5 individuals) recorded. The less sensitive limnophilic species *Tilapia sparrmanii* were collected in higher abundance (27 individuals; 72.97% of the fish assemblage). The presence of the alien and invasive *Micropterus salmoides* is of concern due to their predatory impacts on indigenous fish. This, together with a loss of available in-stream fish habitat due to river regulation and siltation, result in the low abundance and diversity of species.

The CPUE (catch per unit effort) calculated for this site is 2.06 (37 individuals; 18 minutes), higher compared to the 2015 survey CPUE of 0.57 and 1.18 for the 2010 survey.

A Fish Ecostatus rating of 75.1% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with a low diversity and abundance of species) similar to the 2015 survey (Ecological Category C - 73%).

Invertebrates

Two SASS sampling events are on record for the W5SWAR-WOLVE site in this reach on the Swartwaterspruit. These sampling events occurred in September 2015 and this survey in August 2019. In total 43 SASS taxa have been recorded during these two sampling events.

Several taxa (12) recorded in 2015 were absent in 2019. Some of the more sensitive-rated SASS taxa included Porifera, Athyidae and Chlorocyphidae. There was a considerable increase in gathering collectors from 2015 to 2019. On site disturbance was severe, with large scale wetland drainage and unauthorised dam construction by the landowner (Figure 7), a previous board member of the IUCMA. The issue was reported to the Green Scorpions and the IUCMA for further action. The deterioration in stream conditions from 2015 to 2019 are mostly attributed to onsite disturbances which affected instream habitat conditions for the benthic macro-invertebrate community.

Table 58: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53D-01814.

W53D-01814	W5SWAR-ZWART	2015	2019	
	Total SASS Score	227	175	
	No. of SASS Families	38	28	
	Average Score Per Taxon	6.0	6.3	Change
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 81.2%	Category C 74%	↘

MIRAI results for 2019 (Table 58) indicate a slight deterioration when compared to 2015, mostly in terms of reduced SASS-taxa diversity. Conditions in the PESEIS reach based on MIRAI were rated as largely natural to moderately impaired (Category BC – 81.2%) in August 2015 deteriorating to moderately impaired (Category C – 74%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 87.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 64% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (71%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Wetland drainage (Figure 38).
- Unauthorised impoundment created with pumphouse for water abstraction.

Figure 38. Large scale wetland drainage was carried at up- and downstream from the bridge, and an impoundment was created upstream from the old low-level crossing (07 August 2019, G Diedericks).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (73%)	**Category B (85%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance. Ecosystem functions are resilient and are essentially unchanged.
Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗	

Possible Reasons:

- Wetland drainage and construction of impoundment
- Instream habitat and riparian vegetation reduced
- High sedimentation loads resulting in loss of available habitat to fish and macro-invertebrate
- All these impacts accumulate to create modified conditions

RIVER			TRIBUTARY OF	
Swartwaterspruit			Ngwempisi	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5SWAR-WOLVE			W53D	W53D-01814
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.73056	E 30.66792	1 223	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-77. Upstream view of the site on the Swartwaterspruit River, W5SWAR-WOLVE (07 September 2015).

Figure A-78. Downstream view of the site on the Swartwaterspruit River, W5SWAR-WOLVE (07 September 2015).

Figure A-79. Upstream view of the site on the Swartwaterspruit River, W5SWAR-WOLVE (20 August 2019).

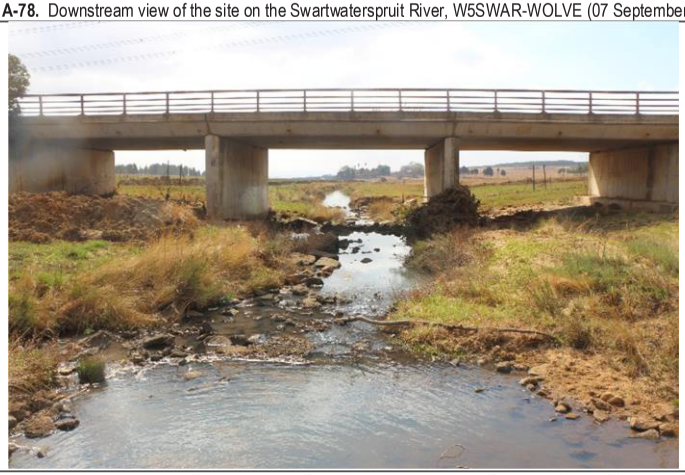


Figure A-80. Downstream view of the site on the Swartwaterspruit River, W5SWAR-WOLVE (20 August 2019).

SQ REACH NUMBER W53C-01679

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53C-01679	W5THOL-ATHOL	Thole	S-26.57401 E 30.57522	1 321	35.1	C	C 67.2%	C* 76.5%	C 71.3%	B** 82.5%	C 75.5%	BC 80%	2015
							C 73.7%	C 75.6%	C 74.7%	B 82.5%	BC 78%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa

** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53D-01764: Source of Thole River to confluence with Ngwempisi

This site on the Thole River falls within PESEIS Reach Code W53C-01679, which is indicated as 35.1 km in length (from Department of Water and Sanitation 2014). The reach starts at the source of the Thole River and ends at its confluence with the Ngwempisi River downstream from the W5NGWE-STERK site and upstream from the W5NGWE-SKURW site. The length from the source of the Thole to the W5THOL-ATHOL sampling point measured on Google Earth Pro is 14.2 km, and to its confluence with the Ngwempisi River 40.7 km. The main river channel originates at an elevation of 1,623 m a.s.l., flowing in a south-east by easterly direction towards the sampling point, W5THOL-ATHOL, which is at an elevation of 1,321 m a.s.l. The site is in the KaNgwana Montane Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (7.1%); thickets and dense bush (6.6%); woodlands and open bush (4.5%) with grassland (47.5%). The land use practises consist of mixed agriculture (cultivated fields 8.4%) and forestry (21.4%) (GEOTERRAIMAGE, 2015) with small farm dams up and down stream of site.

Instream Habitat Integrity

The IHI for the SQ reach W53C-01679 was calculated at 77.4% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The biomonitoring conducted at the W5THOL-ATHOL (W53C-01679) site is on the Thole River, a tributary of the Ngwempisi. This upper foothill stream is characterised by a low gradient stream consisting of multiple pools and riffles with isolated cascades. The habitat remained relatively consistent since the 2015 survey apart from increased levels of siltation resulting from bank instability and wattle encroachment on the riverbanks. A high diversity of fish habitats wes present with slow shallow biotope moderate, slow deep moderate and fast shallow sparse. The fast-deep habitat

was absent. Overhanging vegetation and undercut banks were only present at the slow habitat. Rocks and cobbles provide the necessary in-stream cover for especially the flow dependant fish species, but also provided cover for limnophilic fish in the slow shallow habitat.

Table 59: Fish species expected based on the PESEIS Reach Code (W53C-01679) W5THOL-ATHOL; is listed, and the fish species percentage composition during the different surveys is indicated.

W53C-01679	Expected Species	W5THOL-ATHOL					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	1	3.58	8	4.28	-	-
Enteromius crocodilensis	X	9	32.14	132	70.59	68	77.27
Labeobarbus marequensis	X	-	-	-	-	-	-
Labeobarbus polylepis	X	9	32.14	15	8.02	13	14.77
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	3	10.71	2	1.07	5	5.68
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	6	21.43	30	16.04	2	2.27
Chiloglanis emarginatus	X	-	-	-	-	-	-
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	-	-
Tilapia sparrmanii	X	-	-	-	-	-	-
Number of species recorded	11	5		5		4	
Number of individuals		28		187		88	
Electro-fishing time (minutes)		8 Minutes		30 minutes		25 minutes	
Catch/Unit Effort (CPUE)		3.50		6.23		3.52	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 67.2%		**CATEGORY C** 73.7%	

A total of 11 indigenous species of fish are expected to occur in this reach of which only four were collected during the present survey (Table 59). The small barb, *Enteromius anoplus* was absent during the present survey whilst *Enteromius crocodilensis*, was the most abundant species during the present survey, as well as the 2015 and 2010 surveys at a relative abundance of 77.27%, 70.59% and 32.14% of all fish collected respectively. The reophilic species, *Chiloglanis anoterus* (2 individuals; 2.27%), were recorded in lower abundance than for the 2010 (6 individuals; 21.43%) and 2015 (30 individuals; 16.04%) surveys, the reason being flow related with much lower flow experienced during the present survey. No Cichlids were recorded to date for this site.

The CPUE for the present survey was calculated at 3.52 (88 individuals; 25 minutes) indicating a lower abundance of fish than found during the 2015 survey when a CPUE of 6.23 was calculated but similar to what was calculated for the 2010 survey.

A Fish Ecostatus rating of 73.7% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) which is a slightly higher rating than determined for the 2015 survey, but within the same Ecological Category (Category C – 67.2%).

Invertebrates

Two SASS sampling events are on record for the W5THOL-ATHOL site in this reach on the Thole. These sampling events occurred in August 2015 and this survey in August 2019. In total 38 SASS taxa have been recorded during these two sampling events. Two additional non-SASS taxa were recorded in 2015, namely Nematoda and Cladocera. The shift in community composition between 2015 and 2019 is mostly in terms of those taxa with a preference for marginal vegetation. Bank scouring and increased wattle (*Acacia mearnsii*) growth suppressed and reduced marginal vegetation in 2019, which was reflected in the stream community. Sensitive taxa were present during both sampling events, but at low abundances.

Table 60: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53C-01679.

W53C-01679	W5THOL-ATHOL	2015	2019	
	Total SASS Score	187	181	
	No. of SASS Families	32	30	Change
	Average Score Per Taxon	5.8	6.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 76.5%	Category C 75.6%	→

The MIRAI for 2019 (Table 60) indicates similar conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 76.5%) in August 2015 (Category C – 75.6%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 76.5% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Impacts for SQR

- Stream bank scouring
- Increased degree of weed infestation with mostly *Acacia mearnsii*, an aggressive high water using invader.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF	
THOLE			Ngwempisi	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5THOLE-ATHOL			W53C	W53C-01679
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.57401	E 30.57522	1 321	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-81. Upstream view of the site on the Thole River, W5THOL-ATHOL (19 August 2015).

Figure A-82. Downstream view of the site on the Thole River, W5THOL-ATHOL (19 August 2015).

Figure A-83. Upstream view of the site on the Thole River, W5THOL-ATHOL (20 August 2019).

Figure A-84. Downstream view of the site on the Thole River, W5THOL-ATHOL (20 August 2019).

SQ REACH NUMBER W53E-01790

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53E-01790	W5NGWE-SKURWE	Ngwempisi	S-26.68126 E 30.70271	1 117	23.8	C	B 83.1%	BC* 81.2%	B 82.2%	BC** 80%	BC 81.2%	BC 80%	2015
							C 73%	B 82%	C 77.5%	B 80%	BC 78.6 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53E-01790: Ngwempisi River from its confluence with Merriekloofspruit to confluence of Nwempisi and Hlelo rivers

This site on the Ngwempisi River falls within PESEIS Reach Code W53E-01790, which is indicated as 23.8 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Ngwempisi River with the Merriekloofspruit (W53D-01751) and ends at the confluence of the Ngwempisi and Hlelo rivers. The length from the source of the Ngwempisi River to the W5NGWE-SKURW sampling point measured on Google Earth Pro is 90.6 km, and to its confluence with the Lusutfu River 210 km. The main river channel originates at an elevation of 1,767 m a.s.l., flowing through in an easterly direction towards the sampling point, W5NGWE-SKURW which is at an elevation of 1,117 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (1.3%); thickets and dense bush (12.3%); woodlands and openbush (6.9%) and open spaces with grassland (20.4%) (GEOTERRAIMAGE, 2015). The Landuse practices include mixed agriculture and forestry plantations (42.3%) as well as large dams Morgenstond and Jericho.

Instream Habitat Integrity

The IHI for the SQ reach W53E-01790 was calculated at 77.4% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This biomonitoring site W5NGWE-SKURW (W53E-01790) is situated on the Ngwempisi River and consisted of mainly rapids, riffles and runs under and downstream from a high river crossing. Fish velocity depth classes were in the form of fast shallow and slow shallow habitats with the slow habitat moderately present and fast riffle habitat in abundance. The slow deep and fast deep habitat was sparse. Marginal vegetation formed cover as overhanging vegetation

moderately present with moderate undercut banks and root wads. The substrate in the fast shallow habitats was abundant consisting of large rocks, cobbles and pebbles providing the necessary fish habitat. The substrate as cover in the slow habitat was sparse with a lot of silt, especially in the slow deep habitat. Aquatic macrophytes as cover was moderately present mostly in the fast shallow habitat.

Table 61: Fish species expected based on the PESEIS Reach Code (W53E-01790) W5NGWE-SKURW; is listed, and the fish species percentage composition during the different surveys is indicated.

W53E-01790	Expected Species	W5NGWE-SKURW					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Mormyridae (Snoutfishes)							
Marcusenius (macrolepidotus) pongolensis	X	3	1.41	2	0.51	8	7.48
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	4	1.89	120	30.53	6	5.61
Labeo cylindricus	X	-	-	-	-	-	-
Labeo molibdinus	X	-	-	-	-	-	-
Labeobarbus marequensis	X	17	8.02	7	1.78	9	8.41
Labeobarbus polylepis	X	11	5.19	132	33.59	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	19	8.96	8	2.04	8	7.48
Clariidae (Air-breathing catfishes)							
Clarias gariepinus	X	-	-	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	158	74.53	119	30.28	74	69.16
Chiloglanis emarginatus	X	-	-	-	-	-	-
Centrarchidae (Basses and sunfishes)							
Micropterus salmoides		-	-	-	-	2	1.86
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	-	-
Tilapia sparrmanii	X	-	-	5	1.27	-	-
Number of species recorded	14	6		7		5 + 1	
Number of individuals		212		393		107	
Electro-fishing time (minutes)		21 minutes		37 minutes		45 minutes	
Catch/Unit Effort (CPUE)		10.10		10.62		2.38	
Fish Ecostatus (FRAI Value)				**CATEGORY B** 83.1%		**CATEGORY C** 73.0%	

Red – Exotic species

The fish assemblage recorded for the present survey consisted of only five species of an expected 14 species of indigenous fish for this reach, two species less than recorded during the 2015 survey, but only one species less for the 2010 survey. One exotic species, *Micropterus salmoides*, not expected and previously recorded, was collected for the first time (Table 61). The most abundant fish species collected was the riffle dwelling fish species, *Chiloglanis anoterus* comprising of 69.16% (74 individuals) of the fish assemblage. *Labeobarbus polylepis* was not collected during the present survey, but their absence can be attributed to their migratory behaviour. No Cichlids were collected during the

present survey. In general the Frequency of Occurrence (FROC) of the recorded species is low and could have been altered as a result of flow regulation and loss of instream habitat due to sedimentation.

The CPUE for the present survey was calculated at 2.38 (107 individuals; 45 minutes) indicating a sharp decline in abundance from the 2010 and 2015 surveys when a CPUE of 10.10 and 10.62 respectively was calculated. A possible reason for the lower abundance of fish and species collected, could be related to reduced water quality.

A Fish Ecostatus rating of 73% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance), indicating a decline in the Fish Ecostatus from the Category B (83.1%) –largely natural with few modifications most of the time, during the 2015 survey.

Invertebrates

Nine SASS sampling events are on record for the W5NGWE-SKURW site in this reach on the Ngwempisi River. These sampling events occurred in August 1999, 2000, September 2001, August 2005, June 2018, 2011, March 2015, September 2015 and August 2019. To date 58 SASS taxa have been recorded during the nine sampling events at this site. Total SASS scores ranged from 203 – 245 (avg.) – 278 during these nine sampling events.

The diversity of SASS5 taxa at the site is considered high, increasing between the September 2015 and August 2019 surveys. The percentage sensitive taxa during all surveys were high, indicating sensitive-rated SASS taxa are dominant. Sensitive SASS taxa recorded in August 2019 absent September 2015 included Perlidae, Cordulidae, Ecnomidae, Athericidae, and Dixidae.

Table 62: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53E-01790.

W53E-01790	W5NGWE-SKURW	2015	2019	
	Total SASS Score	206	263	
	No. of SASS Families	33	39	Change
	Average Score Per Taxon	6.2	6.7	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 81.2%	Category B 82%	↗

The 2019 SASS5 results (Table 62) indicates slightly improved conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural most of the time with few modifications (Category BC – 81.2%) in September 2015 slightly improving to largely natural (Category B – 82%) in August 2019. Overall conditions at the W5NGWE-SKURW site ranged from largely natural (B-class) to moderately impaired (C-class), with largely natural conditions dominating result (Figure 39).

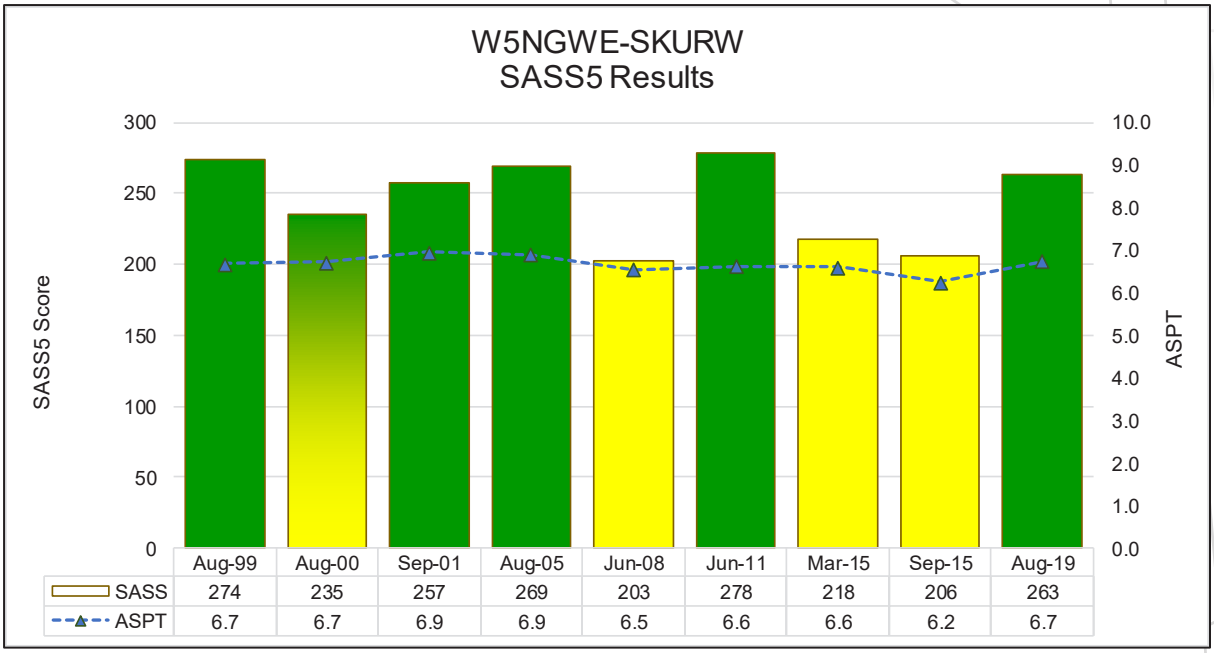


Figure 39. Graphic illustration of historic data, SASS5 Total score and ASPT for sampling events at the W5NGWE-SKURW site. Colour codes represent stream condition categories, e.g. green – B, yellow – C.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 80% and is consistent with a Category BC – close to largely natural conditions with few modifications most of the time. The Riparian IHI was calculated at 66.2% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (80%) indicating that the riparian vegetation for this SQ reach close to largely natural with few modifications most of the time.

Water Quality

The GE image below (Figure 40) shows the water quality monitoring sites which represent the water quality state of the selected reach of the Ngwempisi River, i.e. IUCMA monitoring point U-44 and DWS gauging weir W5H026Q01. Although there is an EWR site on the Lower Ngempisi River (EWR JMB2) and assessed during the Maputo Basin Study, it is situated in W53G, well downstream of the W53E-01790 SQR.

Note that the W5H026Q01 monitoring station was closed between 2009 and 2015. Early data from W5H026Q01 (in the same Level II Ecoregion), and benchmark boundary tables for an A category river from DWAF (2008), were evaluated to represent RC.

Figure 40: Google Earth image of SQR W53E-01790, Ngwempisi River, and selected water quality monitoring points.

Table 63 shows the present state assessment according to this study, with Table 64 being the associated PAI table. SQR W53E-01790 is a fairly long river reach, with dominant land-use activities being forestry and dryland cultivation. Limited irrigation is also present. Although the reach is downstream of Amsterdam town, the Amsterdam WWTW decants into the Thole River, which is well upstream of the river reach containing the U-44 monitoring point. The Jericho and Morgenstond dams are also in the catchment, but are far upstream of the SQR and are not expected to have much of a water quality impact.

Table 63: Water quality PES: SQR W53E-01790, Ngwempisi River (U-44)

RIVER	Ngwempisi River	**Water Quality Monitoring Points**	
		RC	Benchmark boundary tables (DWAF, 2008).
IUCMA site code	U-44	**PES**	IUCMA data, U-44: July 2016-Sept 2019; n=39. W5H026Q01: 2015-2019.
Confidence assessment	Confidence in the assessment is **low-moderate**, as little DO, temp., turbidity or metal data.		
Water Quality Constituents		**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$	-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	PO_4-P (mg/L)	0.02: IUCMA 0.05: DWS (n=44)	C/D (2.5)

	TIN-N (mg/L)	0.43: IUCMA 0.2: DWS (n=10, 2015-2016 only).	B (1)
Physical variables	pH (5th+95th percentiles)	6.62+7.9: IUCMA 6.8+8.1: DWS (n=44)	A/B (0.5)
	Temperature	-	Although both Jerico and Morgenstond dams are upstream of the SQR, little impact is expected due to the distance from the dams to the site. A/B (0.5)
	Dissolved oxygen	-	
	Turbidity (NTU)	-	Some impact expected from forestry activities. B (1)
	Electrical conductivity (mS/m)	13.85: IUCMA 19.15: DWS (n=44)	A (0)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category	B (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	0.1: IUCMA 0.2: DWS (n=34)	D (3)
OVERALL SITE CLASSIFICATION (from PAI)		**B (85.5%)**	

- *No data.*
-

Table 64: PAI table for SQR W53E-01790, Ngwempisi River (U-44)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.50	N	4.00	60.00		50.00
Salts	0.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	2.00	NONE SPECIFIED	4.00	70.00		65.00
Water Temperature	0.50	N	2.50	60.00		70.00
Water clarity	1.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	0.50	N	2.50	65.00		70.00
Toxics	1.00	N	2.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	0.84	MEAN CONF →	3.07			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	0.84					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	0.83					
FINAL PC MODIFICATION RATING	0.84					
P-C CATEGORY %	P-C CATEGORY					
85.5	B	REVISED % & CATEGORY (2014)				

Table 65 shows the water quality state at this site as compared to the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline. Orange shading is used when it is uncertain whether guidelines have been exceeded.

Table 65: Comparison to water quality guidelines: SQR W53E-01790, Ngwempisi River (U-44)

Metric		International Obligations
Physical variables	pH	6.5-8.5
	Electrical Conductivity (mS/m)	150
Nutrients	PO_4 (mg/L P)	2
	NO_2+NO_3 (mg/L N)	50
Toxics	Ammonia (mg/L N)	1
	Sulphate (mg/L)	250 *
Microbial	Faecal coliforms (cfu/100mL)	2 000 (30, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	10 000 (>2 420, n=1, Sept 2019)

**** an indicative evaluation only, as based on 2000-2009 data (n=243; 95th percentile is 10.9 mg/L) from W5H026Q01.***

Note the following points regarding analysis:

- Data records are short, with the assessment therefore being of low confidence.
- Water quality state appears **Good** for this river reach; confirmed by the macroinvertebrate assessment (MIRAI (Macroinvertebrate Response Assessment Index): B category).
- Although ammonia levels (as mg/L N) are well within International Obligations, they are elevated for ecological requirements. Further investigation and longer-term monitoring of this variable is recommended.
- Total coliform data cannot be properly assessed as analytical results are not definitive enough, although available faecal coliform and *E. coli* data seems to suggest faecal coliform data may fall below the 10 000 cfu/100mL guideline.
- *E. coli* data for the river reach were within DWAF's (1996b) guideline for full contact recreational use (0-130 cfu/100mL).
    - IUCMA data (n=1, Sept 2019): 33
    - DWS data (n=23):

▪ Median	▪ 70
▪ Mean	▪ 107

Impacts for SQR

- High quantities of domestic waste in the river and riparian zone, especially below the bridge.
- High number of invasive weed species in the riparian zone.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78.6%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Ngwempisi			Lusutfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5NGWE-SKURWE			W53E	W53E-01790
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.68126	E 30.70271	1 117	Upper foothills
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-85. Upstream view of the site on the Ngwempisi River, W5NGWE-SKURW (18 September 2015).

Figure A-86. Downstream view of the site on the Ngwempisi River, W5NGWE-SKURW (18 September 2015).

Figure A-87. Upstream view of the site on the Ngwempisi River, W5NGWE-SKURW (18 August 2019).

Figure A-88. Downstream view of the site on the Ngwempisi River, W5NGWE-SKURW (18 August 2019).

SQ REACH NUMBER W53E-01841

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53E-01841	W5NGWE-MPONO	Ngwempisi	S-26.72707 E 30.87921	957	10.9	C	C 74.7%	BC* 78.9%	C 76.8%	C** 77.5%	C 77.1%	BC 80%	2015
							C 75.2%	B 86.8%	BC 81%	C 77.5%	BC 79.5%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa

** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53E-01841: Ngwempisi River confluence with Hlelo to confluence with Mpono River

This site on the Ngwempisi River in Swaziland falls within PESEIS Reach Code W53E-01841, which is indicated as 10.9 km in length (from Department of Water and Sanitation 2014). The PESEIS Reach starts at the confluence of the Ngwempis River with the Hlelo and ends where the Ngwempisi meets with the Mpono River. The length from the source of the Ngwempisi River to the W5NGWE-MPONO sampling point (fluvial km) measured on Google Earth Pro is 120 km, and to its confluence with the Lusutfu River 210 km. The main river channel originates at an elevation of 1,767 m a.s.l., flowing in an easterly direction towards the sampling point, W5NGWE-MPONO, which is at an elevation of 957 m a.s.l. The site is located 12 km downstream from the Ngwempisi-Hlelo confluence and 3 km upstream from the Ngwempisi-Mpono confluence. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within the North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists mainly of open spaces with grasslands. Landuse practises include agriculture with cattle, drylands and irrigated crops as well as *Pinus and* Eucalyptus forestry within the catchment. Sheepmore and rural villages are situated within the catchment and water is abstracted from d/s pump-house for industrial purposes. No landcover and landuse practises available on GEOTERRAIMAGE.

Instream Habitat Integrity

The IHI for the SQ reach W53E-01841 was calculated at 79.5% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural conditions with few modifications most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site W5NGWE-MPONO (W53E-01841) is characteristic of an upper foothill stream with a steep gradient and fast flowing river. The fish velocity depth classes present were slow deep (sparse), slow shallow (moderate), fast shallow (abundant) and fast deep (abundant). The fish cover present rated sparse for overhanging vegetation created by some

reeds in the riparian zone. The substratum provided most of the cover available for fish and varied from moderate to abundant with bedrock, boulders, rocks and cobbles. No cover for fish was provided by aquatic macrophytes.

Table 66: Fish species expected based on the PESEIS Reach Code (W53E-01841) W5NGWE-MPONO; is listed, and the fish species percentage composition during the different surveys is indicated.

W53E-01841	Expected Species	W5NGWE-MPONO			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	-	-	1	0.78
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	0.26	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Enteromius trimaculatus	X	-	-	6	4.72
Enteromius unitaeniatus	X	7	1.79	-	-
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	15	3.85	7	5.51
Labeobarbus marequensis	X	143	36.67	17	13.39
Labeobarbus polylepis	X	79	20.26	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	13	3.33	5	3.94
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	3	0.77	2	1.58
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	91	23.33	86	67.72
Chiloglanis emarginatus	X	3	0.77	-	-
Chiloglanis paratus	X	-	-	-	-
Chiloglanis swierstrae	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	35	8.97	3	2.36
Number of species recorded	18	10		8	
Number of individuals		390		127	
Electro-fishing time (minutes)		41 minutes		29 minutes	
Catch/Unit Effort (CPUE)		9.51		4.38	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 74.7%		**CATEGORY C** 75.2%	

Fish diversity was considerably lower than expected. Of the expected 18 fish species only eight species were recorded, two species less than recorded during the 2015 survey (Table 66). The assemblage was dominated by the flow sensitive species, *Chiloglanis anoterus* with a relative abundance of 67.72% (86 individuals) of all fish collected. The large barb, *Labeobarbus marequensis*, which was the most abundant fish species during the 2015 survey, was recorded in a lower abundance during the present survey. *Labeobarbus polylepis*, as well as *Anguilla mossambica*, *Chiloglanis emarginatus* and *Enteromius unitaeniatus* recorded for the 2015 survey, was not collected during the present survey. Fish species recorded during the present survey that was not previously recorded, includes *Marcosenius pongolensis* and *Enteromius trimaculatus*. To date a total of 12 fish species were recorded for this site.

The CPUE (catch per unit effort) calculated for this site is 4.38 (127 individuals; 29 minutes) which is lower than the 2015 survey with a CPUE of 9.51 (390 individuals; 41 minutes).

A Fish Ecostatus rating of 75.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) which is consistent with the 2015 survey.

Invertebrates

Two SASS sampling events are on record for the W5NGWE-MPONO site in this reach on the Ngwempisi River. These sampling events occurred in July 2015 and August 2019. To date 48 SASS taxa have been recorded at this site over two sampling events. Taxa diversity is considered high. Non-SASS taxa, Cladocera and Ostracoda was encountered in 2019. SASS taxa absent from the 2015 survey and present in 2019 included Polymitarcidae, Prosopistomatidae, Aeshnidae, Psephenidae, and Athericidae.

Table 67: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53E-01841.

W53E-01841	W5NGWE-MPONO	2015	2019	
	Total SASS Score	241	273	
	No. of SASS Families	39	40	Change
	Average Score Per Taxon	6.2	6.8	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 78.9%	Category B 86.8%	↗

The SASS5 results for the 2015 and 2019 sampling events were very similar, with more individual SASS-rated sensitive taxa in 2019 than 2015. MIRAI results (Table 67) suggests a slight improvement from 2015 to 2019. Conditions in the PESEIS reach based on MIRAI were rated as close to largely natural (Category BC – 78.9%) in July 2015 and largely natural (Category B – 86.8%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 51.5% rating this reach as a Category D indicating a largely modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- High quantities of domestic waste are dumped in the river and riparian zone at the bridge
- The road approach to the river is steep, with poor drainage allowing water (sediment loaded) from the gravel road to enter the river at the bridge

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (79.5%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Ngwempisi			Lustfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5NGWE-MPONO			W53E	W53E-01841
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.72707	E 30.87921	957	Lower foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highlands		4.06	

Figure A-89. Upstream view of the site on the Ngwempisi River, W5NGWE-MPONO (23 July 2015).

Figure A-90. Downstream view of the site on the Ngwempisi River, W5NGWE-MPONO (23 July 2015).

Figure A-91. Upstream view of the site on the Ngwempisi River, W5NGWE-MPONO (22 August 2019).

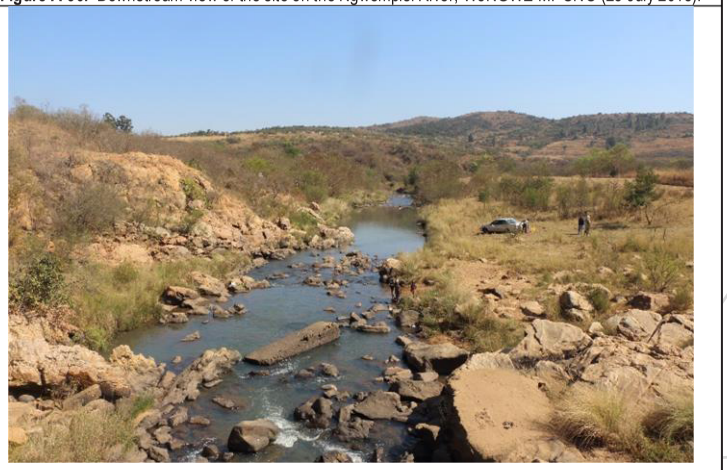


Figure A-92. Downstream view of the site on the Ngwempisi River, W5NGWE-MPONO (22 August 2019).

SQ REACH NUMBER W53E-01785

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53E-01785	W5MPON-SWAZI	Mpono	S-26.71907 E 30.89173	949	5.6	C	Not sampled					C 70%	2015
							BC 78.2%	C 76.7%	C 77.5%	C 66%	C 72.5%		2019

General description

Reach W53D-01764: Mpono River from confluence with Ngwenyama to confluence with Mkhondvo

This site on the Mponono River is located within the PESEIS Reach Code W53E-01785, which is reported as 5.56 km in length (Department of Water and Sanitation 2014). The length is measured from the confluence of the Mlambo to the Ngwempisi River confluence. The vegetation types in the catchment are represented by the Amersfoort Highveld Clay Grassland, Eastern Highveld Grassland, KaNgwane Montane Grassland, and Ithala Quartzite Sourveld (from Mucina & Rutherford 2006). The site falls within North Eastern Highlands aquatic ecoregion. No landcover and land use practice data available on GEOTERRAIMAGE, 2015.

Instream Habitat Integrity

The IHI for the SQ reach W53D-01785 was calculated at 75.8% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic habitat surveyed at the location W5MPON-SWAZI (W53E-01785) is included for the first time for the biomonitoring plan. All of the fish velocity depth classes were present at this site with both slow shallow and fast shallow abundant and both the slow deep and fast deep sparse. The fish cover present was sparse overhanging vegetation provided by terrestrial grasses on the riverbanks with sparse undercut banks and root wads. The substrate rated sparse in the slow and fast deep habitat. Rocks, cobbles and sandy runs provided moderate to abundant cover in the shallow habitat. No aquatic macrophytes provided any cover for fish.

Table 68: Fish species expected based on the PESEIS Reach Code (W53E-01785) W5MPON-SWAZI; is listed, and the fish species percentage composition during the different surveys is indicated.

W53E-01785	Expected Species	W5MPON-SWAZI			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X			-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius crocodilensis	X			-	-
Enteromius trimaculatus	X			24	9.88
Enteromius unitaeniatus	X			-	-
Labeo cylindricus	X			-	-
Labeo molybdinus	X			-	-
Labeobarbus marequensis	X			184	75.72
Labeobarbus polylepis	X			10	4.11
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X			3	1.24
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X			4	1.65
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X			15	6.17
Chiloglanis emarginatus	X			-	-
Chiloglanis swierstrae	X			2	0.82
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X			-	-
Tilapia sparrmanii	X			1	0.41
Number of species recorded	15	Not Sampled		8	
Number of individuals				243	
Electro-fishing time (minutes)				28 minutes	
Catch/Unit Effort (CPUE)				8.68	
Fish Ecostatus (FRAI Value)				**CATEGORY BC** (78.2%)	

At this site eight of the expected 15 fish species were recorded (Table 68). The large barb, *Labeobarbus marequensis* was the most abundant fish species collected at a relative abundance of 75.7% (184 individuals) of all fish collected at the site. The only small barb species found was *Enteromius trimaculatus* at a relative abundance of 9.88% (24 individuals) of all fish collected at the site. Of the three *Chiloglanis* species expected to occur, *Chiloglanis anoterus* and *Chiloglanis swierstrae* were collected. *Chiloglanis* species is a reophilic habitat specialist with *Chiloglanis swierstrae* preferring instream sandy substrates. The limnophilic species recorded was *Tilapia sparrmanii* with only a single specimen found.

The CPUE (catch per unit effort) calculated for this site is 8.68 (243 individuals; 28 minutes) which indicates a high abundance of fish collected. The high abundance recorded for *Labeobarbus marequensis* (184 individuals) may represent a skewed CPUE for the overall fish assemblage.

A Fish Ecostatus rating of 78.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category BC (close to natural conditions with few modifications most of the time with moderate diversity and abundance of species).

Invertebrates

The site on the Mpono River was added in August 2019, so only one data set is available. 27 SASS taxa were encountered during the 2019 sampling event.

Sensitive-rated SASS taxa were present but not dominant. Sensitive taxa expected but absent included Tricorythidae, Psephenidae, Athericidae, and Ancylidae, all associated with the stones biotope. High sediment inputs and deposition (Figure 8) limits the instream habitat and affects the stream community composition. Taxa tolerant to organic pollution were dominant, with gathering collectors dominating the functional feeding groups.

Table 69: 2019 SASS5 results for SQ reach W53E-01785.

W53E-01785	W5MPON-SWAZI	2015	2019	
	Total SASS Score		185	
	No. of SASS Families		27	Change
	Average Score Per Taxon		6.9	
	SQ REACH SUMMARY Invertebrate Ecostatus	Not sampled	**Category C** 76.7%	

MIRAI for the 2019 SASS5 results (Table 69) suggest moderately impaired conditions (Category C – 76.7%). High sand inputs and deposition causes embeddedness, limiting instream habitat quality and diversity.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach are calculated at 77.5% and are consistent with a Category C – moderately modified. The Riparian IHI was calculated at 51.5% rating this reach as a Category D indicating a largely modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (66%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The culverts at the bridge is partially blocked, causing upstream impoundment and deposition (Figure 41).
- Overtopping during high flows cause downstream bed and bank scouring.
- Several weed species were recorded in the riparian zone

Figure 41. Culverts are blocked with organic debris, increasing deposition of sand above the crossing, and causing overtopping and downstream bank scouring during high flows (22 August 2019, G Diedericks).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (72.5%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔	
Discussion: Appropriate management of road crossings and maintenance of culverts recommended through maintenance	

RIVER		TRIBUTARY OF		
Mponono		Ngwempisi		
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH
W5MPON-SWAZI		W53E		W53E-01785
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.71907	E 30.89173	949	Lower foothill
AQUATIC ECOREGION	Level I		Level II	
	4. North Eastern Highlands		4.06	

Figure A-93. Upstream view of the site on the Mponono River, W5MPON-SWAZI (22 August 2019).

Figure A-94. Downstream view of the site on the Mponono River, W5MPON-SWAZI (22 August 2019).

SQ REACH NUMBER W53G-01788

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W53G-01788	W5NGWE-MZIMN	Ngwempsi	S-26.71303 E 31.31287	368	55	C	B 85.1%	C* 62.7%	C 73.9%	C** 77.5%	C 75.4%	C 70%	2015
							C 75.5%	CD 61.7%	C 68.6%	BC 79%	C 73.1%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa

** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W53G-01788: Ngwempisi River confluence with Mpono River to confluence with Lusutfu River

The site falls within PESEIS Reach Code W53G-01788 starting at the confluence of the Ngwempis River with the Mponono River and ends at the Ngwempisi's confluence with the Lusutfu River. The length from the source of the Ngwempisi River to the W5NGWE-MZIMN sampling point (fluvial km) measured on Google Earth Pro is 199 km, and to its confluence with the Lusutfu River 210 km. The main river channel originates at an elevation of 1,767 m a.s.l., flowing in an easterly direction towards the sampling point, W5NGWE-MZIMN, which is at an elevation of 368 m a.s.l. The site falls within the North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005). Landcover consists mainly of open spaces with grasslands and savannah. Landuse practises include agriculture with cattle, drylands and irrigated crops as well as *Pinus and* Eucalyptus forestry within the catchment. No data for landcover or landuse practise available on GEOTERRAIMAGE, 2015.

Instream Habitat Integrity

The IHI for the SQ reach W53G-01788 was calculated at 79.4% rating this SQ reach as a BC category indicating that the instream habitat integrity is close to largely natural with few modifications most of the time. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5NGWE-MZIMN (W53G-01788) is located on the Ngwempisi River just before the confluence with the Lusutfu River. This site provides a high diversity of habitat biotipes with slow deep sparse, slow shallow moderate, fast deep moderate and fast shallow abundant. Rapids, riffles and runs, including long sandy runs, making it ideal for flow dependant fish species. Substrate cover was provided by boulders, rocks and cobbles with excessive siltation and sedimentation. No cover for the fish was provided by overhanging vegetation, undercut banks or aquatic macrophytes.

Table 70: Fish species expected based on the PESEIS Reach Code (W53G-01788) W5NGWE-MZIMN; is listed, and the fish species percentage composition during the different surveys is indicated.

W53G-01788	Expected Species	W5NGWE-MZIMN			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	9	1.42	2	1.35
Petrocephalus wesselsi	X	1	0.16	-	-
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	0.16	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius paludinosus	X	-	-	-	-
Enteromius trimaculatus	X	7	1.10	9	6.08
Enteromius unitaeniatus	X	18	2.83	1	0.68
Enteromius viviparous	X	-	-	-	-
Labeo cylindricus	X	23	3.62	-	-
Labeo molybdinus	X	77	12.13	6	4.05
Labeobarbus marequensis	X	139	21.89	33	22.30
Labeobarbus nelspruitensis	X	13	2.05	-	-
Labeobarbus polylepis	X	15	2.36	-	-
Mesobola brevianalis	X	-	-	-	-
Opsaridium peringueyi	X	8	1.26	15	10.13
Characidae (Characins)					
Micralestes acutidens	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	4	0.63	10	6.76
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	70	11.02	-	-
Chiloglanis emarginatus	X	49	7.72	-	-
Chiloglanis paratus	X	31	4.88	21	14.19
Chiloglanis swierstrae	X	146	22.99	41	27.70
Cichlidae (Cichlids)					
Oreochromis mossambicus	X	21	3.31	10	6.76
Pseudocrenilabrus philander	X	3	0.47	-	-
Tilapia sparrmanii	X	-	-	-	-
Number of species recorded	21	18		10	
Number of individuals		635		148	
Electro-fishing time (minutes)		81 minutes		54 minutes	
Catch/Unit Effort (CPUE)		7.83		2.74	
Fish Ecostatus (FRAI Value)		**CATEGORY B** 85.1%		**CATEGORY C** 75.5%	

The fish assemblage recorded during the survey consisted of ten indigenous fish species of an expected 21 species, eight species less than recorded for the 2015 survey indicating the presence of a low species diversity present at the time of the survey (Table 70). The most abundant fish species found at the site was *Chiloglanis swierstrae* (27.70%) which was also the most abundant species recorded for the 2015 survey at a relative abundance of 22.99% of all fish collected during the survey. This is contributed to the abundance of sandy runs at the site. During the 2015 survey all four of the *Chiloglanis* species were recorded for this site, but only two species, *Chiloglanis paratus* and *Chiloglanis swierstrae* were recorded during the present survey. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded

species has furthermore been altered as a result of habitat alteration due to siltation and sedimentation and changes in thermal regimes.

The CPUE (catch per unit effort) calculated for the site is 2.74 (148 individuals; 54 minutes) which is lower abundance of fish collected than recorded for the 2015 survey when a CPUE of 7.83 was calculated.

A Fish Ecostatus rating of 75.5% was determined for this reach placing it in an Ecological Category C – moderately impaired with low diversity and abundance of species. A higher Ecological Category B (85.1%) was determined for the 2015 survey when a higher fish species diversity and abundance were recorded.

Invertebrates

Two SASS sampling events are on record for the W5NGWE-MZIMN site in this reach on the Ngwempisi River. These sampling events occurred in August 2015 and this survey in September 2019. In total 25 SASS taxa have been recorded during these two sampling events. Sand deposition, movement, and embeddedness of the cobble-boulder substrates are the main cause for the low taxa diversity at this site. The sand smothers interstitial spaces reducing habitat quality and will influence taxa when mobilised during high flows. Sensitive-rated SASS taxa are present but at low abundances. Several taxa expected are absent, including Tricorythidae, Coenagrionidae, Aeshnidae, Naucoridae, >2 Hydropsychidae species, Philopotamidae, and Athericidae. The marginal vegetation is mostly absent because of low flow and high sand deposition.

Table 71: Comparison of the 2015 and 2019 SASS5 results for SQ reach W53G-01788.

W53G-01788	W5NGWE-MZIMN	2015	2019	
	Total SASS Score	119	99	
	No. of SASS Families	18	17	Change
	Average Score Per Taxon	6.6	5.8	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 62.7%	Category CD 61.7%	↘

MIRAI results for 2019 (Table 71) indicates slight deterioration in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 62.7%) in August 2015 deteriorating to close to largely impaired conditions most of the time (Category CD – 61.7%) in September 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 80% rating this reach as a Category BC indicating a close to largely natural riparian habitat most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (79%) indicating that the riparian vegetation for this SQ reach is close to largely natural with few modifications most of the time.

Impacts for SQR

- High quantities of sand, indicating high sand inputs between the W5NGWE-MPONO and W5NGWE-MZIMN sampling sites.
- Evidence of sand mining activities
- High weed infestation in the lower and upper zones of the riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (73.1%)	**Category C (73.1%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category	
Discussion: Although the recommended Ecological Category has been met, increased siltation and sedimentation due to land use practises impact on the reach.	

RIVER			TRIBUTARY OF	
Ngwempisi			Lustfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5NGWE-MZIMN			W53G	W53G-01788
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.71303	E 31.31287	368	Upper foothill
AQUATIC ECOREGION	Level I		Level II	
	4. North Eastern Highlands		4.06	

Figure A-95. Upstream view of the site on the Ngwempisi River, W5NGWE-MZIMN (21 July 2015).

Figure A-96. Downstream view of the site on the Ngwempisi River, W5NGWE-MZIMN (21 July 2015).

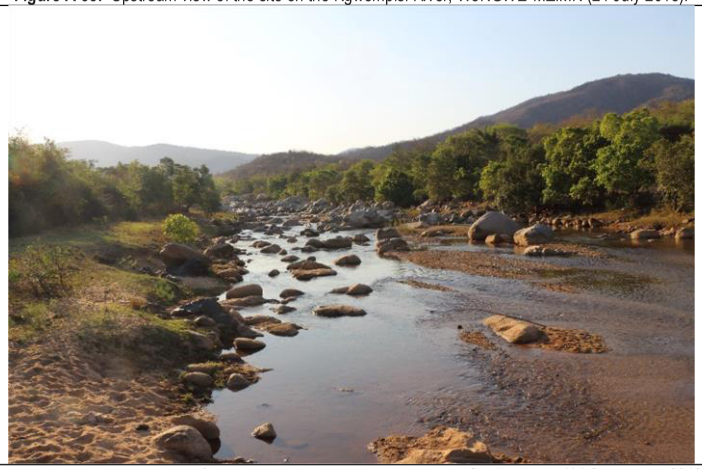


Figure A-97. Upstream view of the site on the Ngwempisi River, W5NGWE-MZIMN (11 September 2019).

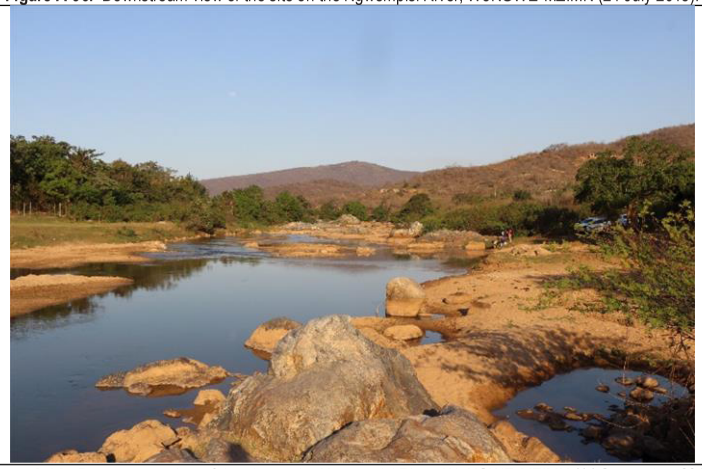


Figure A-98. Downstream view of the site on the Ngwempisi River, W5NGWE-MZIMN (11 September 2019).

DISCUSSION NGWEMPISI SUB-CATCHMENT

Fish

A total of 25 indigenous fish species are expected to occur in this sub-catchment of which 18 species were recorded for the present survey, five species less than recorded during the 2015 IUCMA survey. The species recorded during the 2015 survey but not found during the 2019 survey are *Anguilla mossambica*, *Chiloglanis emarginatus*, *Labeo cylindricus*, *Labeobarbus nelspruitensis* and *Petrocephalus wesselsi*. The most abundant fish species collected for the present survey is *Labeobarbus marequensis* with a relative abundance of 27.24% of the total number of fish collected. This species was the second most abundant species found during the 2015 survey.

The site where the highest number of fish species were found is also the furthest downstream site, W5NGWE-MZIMN, where a total of 10 fish species was recorded. The highest abundance of fish was found, not on the main stem river, but in a tributary at site W5MPON-SWAZI where a CPUE of 8.68 fish caught per minute was recorded.

No *Anguilla mossambica* was found in this sub-catchment during the present survey. During the 2015 survey *A. mossambica* was only found on the main stem Ngwempisi and at two sites.

Of concern is the increase in the prevalence of the alien and invasive *Micropterus salmoides*. During the 2015 survey this species was found at two sites, one on the main stem river and one on a tributary, but for the 2019 survey it was found at four sites, two on the main stem river and two on tributaries.

Figure 42 summarise the Fish Ecostatus categories for 10 SQ reaches on the Ngwempisi River sub-catchment. The Fish Ecostatus rating for the SQ reach W53A-01757 (W5SAND-ZANDS) and W53D-01764 (W5MPAM-GLEN) improved from a Category CD (59.5%) to a Category BC (78.9%) and from a Category CD (59.6) to a Category C (66.8%) respectively from 2015 to 2019 monitoring. Of concern however, is the deterioration of SQ reach W53E-01790 (W5NGWE-SKURW) from a Category B (83.1%) to a Category C (73%) and W53G-01788 (W5NGWE-MZIMN) from a Category B (85.1%) to a Category C (75.5%). This deterioration can be contributed to habitat deterioration due to excessive siltation, sedimentation and flow regulation from forestry related activities and presence of Jericho Dam in the catchment. The Fish Ecological status for all of the Ngwempisi River sub-catchment remains consistent to a Category C (73.9%) indicating a moderately impaired river system with moderate diversity and abundance of fish. These results remain consistent with the 2015 results (71.9%) also a Category C.

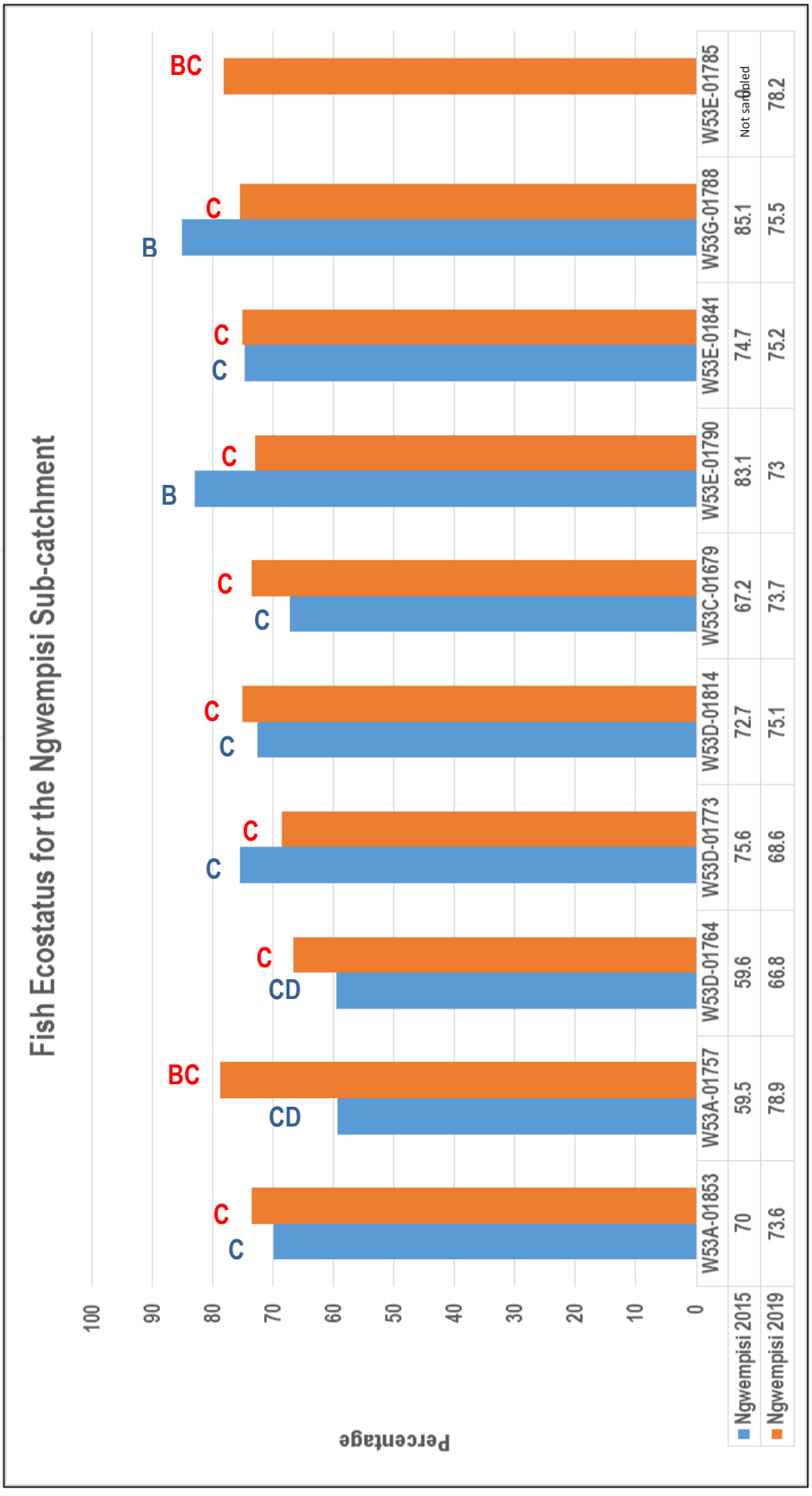


Figure 42: Summary of the Fish Ecostatus for the Ngwempisi Sub-catchment for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model.

Invertebrates

Overall conditions in the main channel improved when compared to the 2015 results (Table 72 Figure 43). Slight deteriorating conditions in the Ngwempisi River was recorded at the W5NGWE-MZIMN site in the SQ Reach W53G-01788. Conditions at this site is affected by excessive sediment input and movement, reducing instream habitat quality and diversity. Conditions of sites in tributaries remained similar for the Sandspruit and Thole, but deteriorated in the Mpama (flow), and Swartwaterspruit (wetland drainage & dam building).

Table 72: Summary of stream conditions per SQ Reach based on MIRAI, comparing 2015 to 2019 results.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	CHANGE
W53	Ngwempisi	W53A-01853	72	76.7	→
		W53D-01773	74.8	80	↗
		W53E-01790	81.2	82	↗
		W53E-01841	78.9	86.8	↗
		W53G-01788	62.7	61.7	↘
	Sandspruit	W53A-01757	71	69.3	→
	Mpama	W53D-01764	63.6	61.8	↘
	Swartwaterspruit	W53D-01814	81.2	74	↘
	Thole	W53C-01679	76.5	75.6	→
	Mponono	W53E-01785		76.7	

The Invertebrate Ecostatus summaries for the Ngwempisi River sub-catchment are summarised in Figure 43. It indicates generally small changes in 2019 when compared to 2015. Overall, MIRAI results suggest similar to improved conditions at 6 of the 9 sites (67%) sampled, and deterioration at 3 of the 9 sites (33%).

The Invertebrate Ecological status for all of the Ngwempisi sub-catchment remains consistent to a high Category C (74.5%) indicating a moderately impaired river system. These results remain consistent with the 2015 results (73.5%) a Category C.

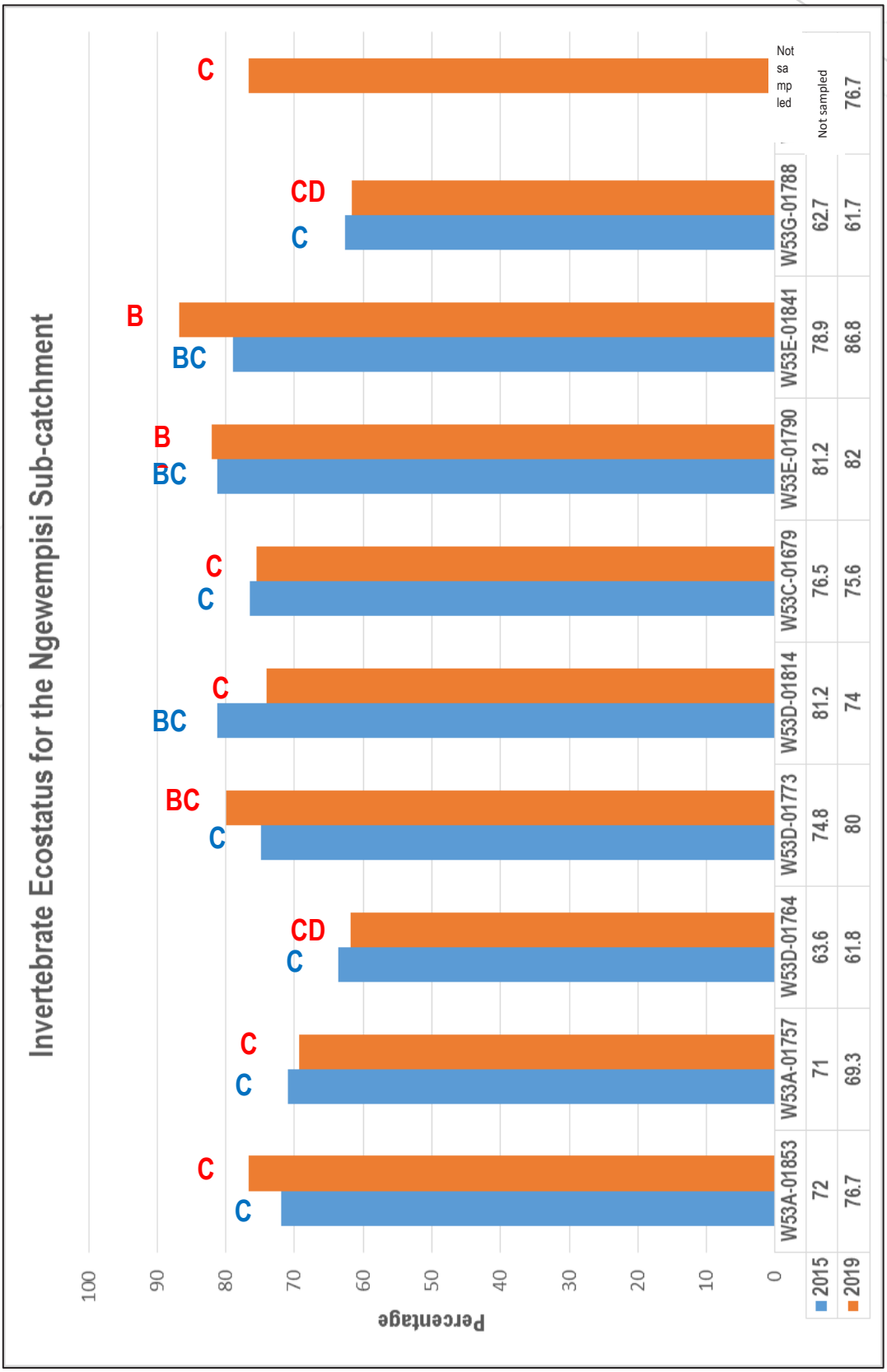


Figure 43: Graphical comparison of the Invertebrate Ecostatus of the Ngwempisi Sub-catchment in 2015 and 2019.

Water Quality

The water quality assessment was limited to specific sites, with a discussion of results provided below the results of the data assessment. Water quality state of the Ngwempisi reach assessed was **Good** (B category), although data records are too short to make any assessment with confidence.

Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Ngwempisi Sub-catchment

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity. From Figure 44 it is evident that the Instream Ecostatus for the 2019 biomonitoring rated an overall Category C (74.7%) and improved overall for the Ngwempisi sub-catchment, ranging from a category BC (81%) to a category C (64.3%). The Instream Ecostatus for 2015 surveys was a consistent C category (72.9%) with recent surveys indicating an improvement at five of the nine sites (56%) and slight decreases at four of the nine sites (44%) as a result of poor land use practices and mismanagement in the upper catchment primarily associated with forestry related activities.

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model (Figure 45). The overall Integrated Ecostatus for the Ngwempisi sub-catchment remained consistent throughout the 2019 (75.4%) and 2015 (76.8%) monitoring placing the sub-catchment in a high Category C. For the 2019 biomonitoring the Integrated Ecostatus ranged from a category C (69.7%) to a category BC (79.5%).

When comparing the Integrated Ecostatus derived from the RIVDINT model with the Recommended Ecological Category within the various SQ reaches not all the set REC's were met at one SQ reaches throughout the system. Factors contributing to this can be related to on site disturbancaes, wetland drainages (see Figure 38 in report). Other factors of concern within the catchment remain the impact of forestry and related activities having a direct impact on available instream habitat and water quality.

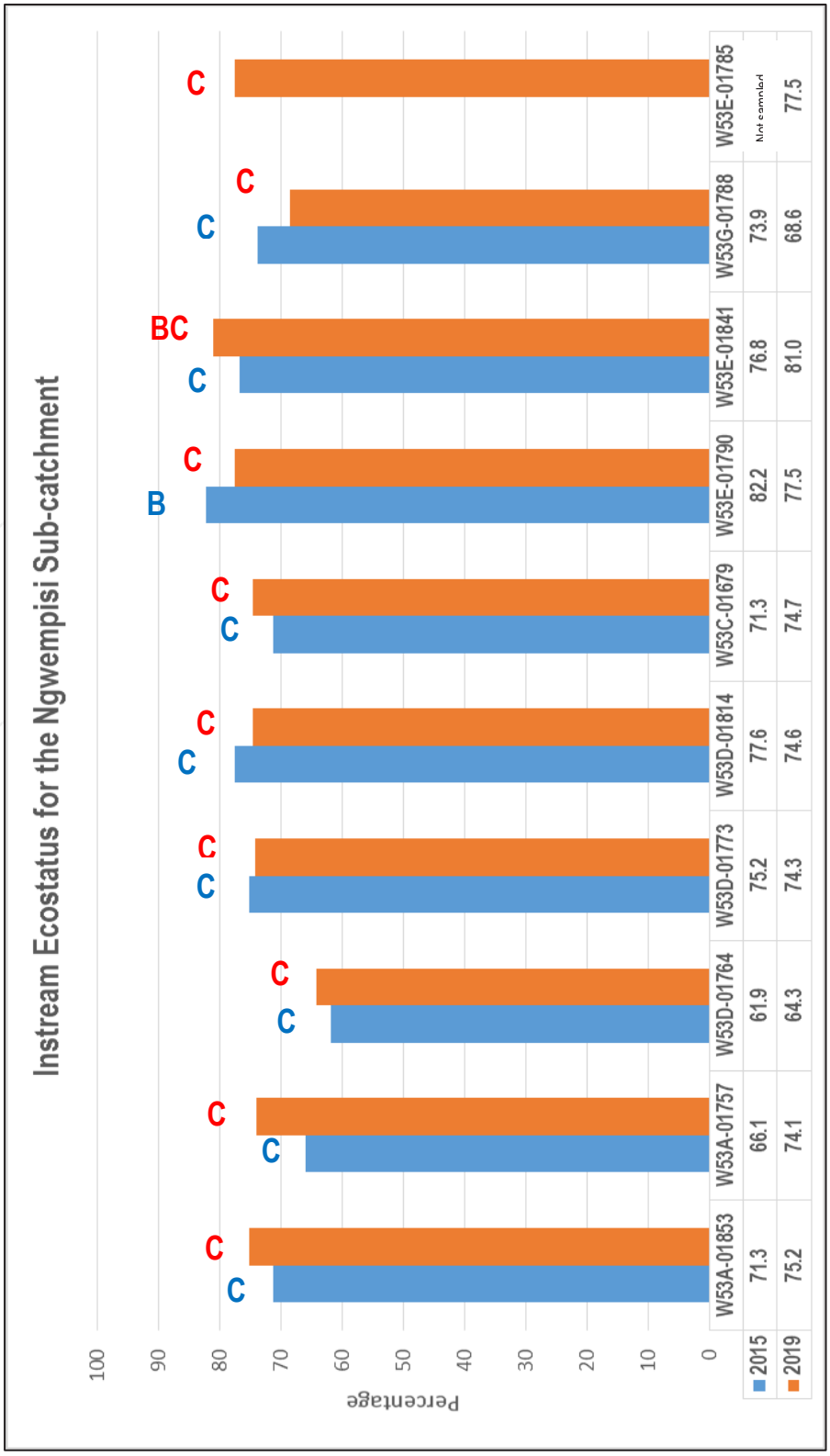


Figure 44: Comparison of the Instream Ecostatus of the Ngwempisi Sub-catchment in 2015 and 2019.

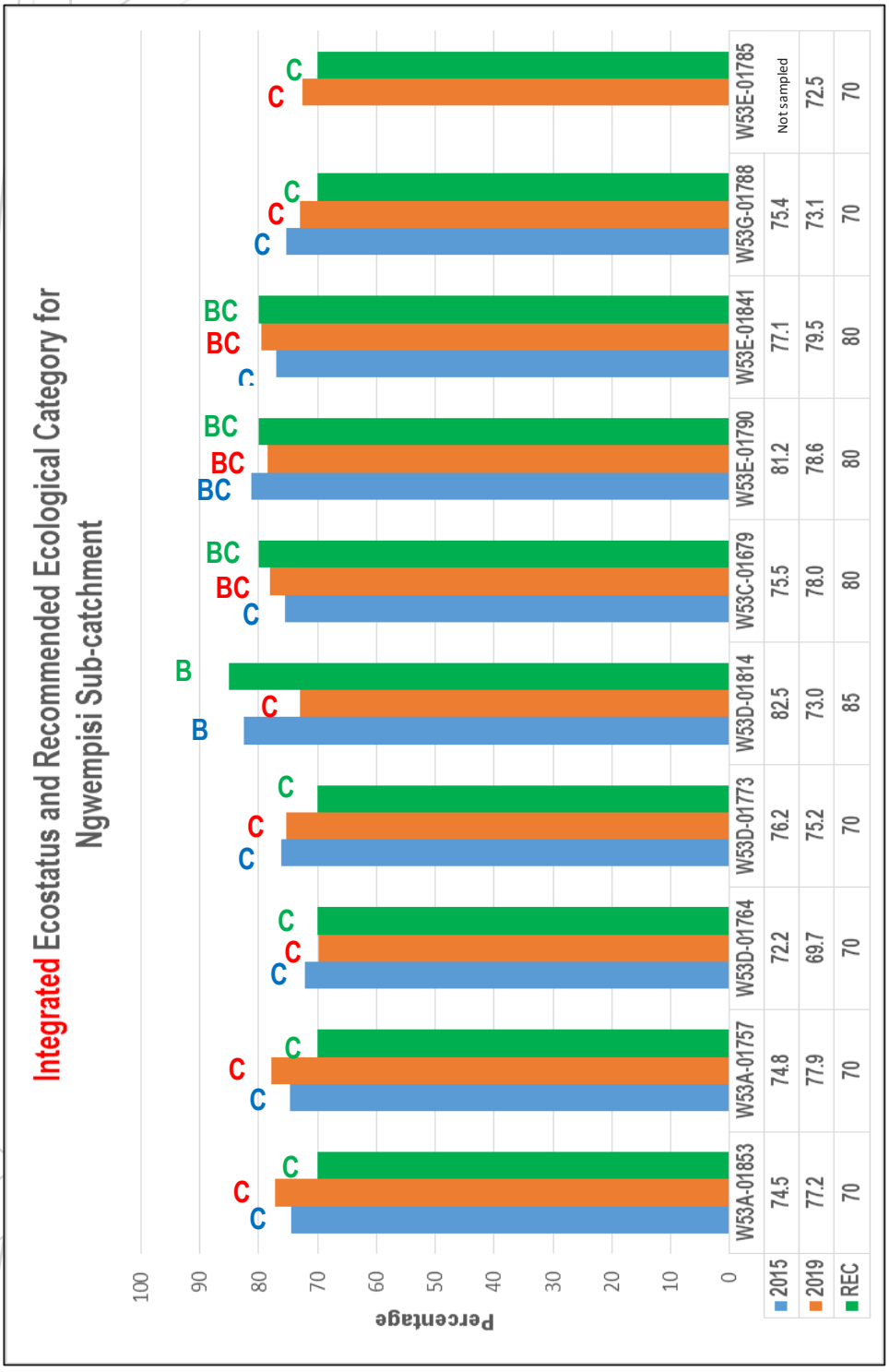


Figure 45: Comparison of the Integrated Ecostatus and Recommended Ecological Category for the Ngwempisi Sub-catchment in 2015 and 2019.

Mpuluzi Sub-catchment Reaches

The Mpuluzi River catchment originates in the Highveld aquatic ecoregion, and then generally flows in a east-south easterly direction towards its confluence with the Lusutfu River in Swaziland. A total of 5 biomonitoring points comprising of 4 SQ reaches (168.8 km) representing 15.7% of the river monitored on the Usuthu-Lusutfu River cachment sampled during 2019.

SQ REACH NUMBER W55C-01395

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W55C-01395	W5MPUL-BUSBY	Mpuluzi	S-26.28034 E 30.59140	1 520	83.4	B	C 65.5%	BC* 80.5%	C 73%	B** 87.5%	BC 79.2%	BC 80%	2015
	W5MPUL-ARDE1		S-26.24958 E 30.75242	1 377			C 68.3%	C 76.8%	C 73.2%	B 83%	C 77.4%		2015

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W55C-01395: Confluence of Mpuluzi River with Blouwaterspruit to confluence with Swartwaterspruit.

This site on the Mpuluzi River falls within PESEIS Reach Code W55C-01395, which is indicated as 83.4 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Mpuluzi River with the Blouwaterspruit (W55A-01423) and ends at the confluence of the Mpuluzi River with the Swartwaterspruit (W55C-01489) just before the river enters Swaziland. The length from the start of the W55C-01395 SQ reach to the W5MPUL-BUSBY sampling point measured on Google Earth Pro is 42.4 km. The W5MPUL-ARDE1 sampling point is 23.9km downstream from previous site measured on Google Earth Pro. The main river channel is 153 km, originating at an elevation of 1,812 m a.s.l., flowing in a south-east by southerly direction towards the two sampling points. Both sites are is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) vegetation type and Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists of wetlands (5.9%) and open spaces with grasslands (42.2%). Landuse practises include agriculture with cattle, drylands and irrigated crops (cultivated crops 8.3%) as well as mostly *Pinus* forestry (plantations - 33.9%) (GEOTERRAIMAGE, 2015) with several small farm dams within the catchment.

Instream Habitat Integrity

The IHI for the SQ reach W55C-01395 was calculated at 68.8% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The SQ Reach W55C-01395 is 83.4km and are therefore represented by two biomonitoring sites namely the W5MPUL-BUSBY and the W5MPUL-ARDE1. This reach is characteristic of an upper foothill steam in the Highveld aquatic ecoregion with moderately steep, cobble-bed or mixed bedrock–cobble bed channel.

The site W5MPUL-BUSBY is the farthest upstream site on the Mpuluzi River and the aquatic habitat is dominated by riffles and runs providing excellent instream habitat to reophilic fish species. The fish velocity depth classes for this site were fast shallow (abundant) and both the slow shallow and slow deep (moderately abundant). No fast-deep habitat was present. The fish cover present was sparse for overhanging vegetation with undercut banks moderately abundant. Boulders, rocks and cobbles provided moderate substrate cover for the reophilic fish species. Aquatic macrophytes were only present as cover for limnophilic fish species at the slow shallow habitat.

The W5MPUL-ARDE1 site was sampled and is situated downstream on the Mpuluzi River from the previous biomonitoring site. All of the fish velocity depth classes were present with fast shallow (abundant), fast deep (moderate), slow shallow (sparse) and slow deep (moderate). The fish cover present consisted largely of substrate with rocks, large boulders and cobbles. Sedimentation was evident with a sandy substrate in the slow deep habitat. Overhanging vegetation was sparsely to moderately present at the shallow habitats and undercut banks were moderately present at both the fast deep and shallow habitat.

At the W5MPUL-BUSBY site a total of 11 indigenous species of fish are expected to occur in this reach of which only four were collected (Table 73). The two most abundant fish species collected was *Chiloglanis anoterus* (24 individuals; 60%) and *Enteromius crocodilensis*, (11 individuals; 27.50%), both rheopilic, flow sensitive fish species. The migratory specialist, *Anguilla mossambica*, was also recorded indicating the river continuity still being intact. This catadromous species breed in the ocean, enters rivers as larvae and migrate upstream as far as they can go where they develop further. Adult eels return to the ocean at some stage to breed. Disruption of the river continuity, especially due to large impoundments, result in the decline of abundance of this species as migration to headwaters following their larval stage in the ocean is obstructed by weirs and impoundments. None of the hardy limnophilic species tolerant to reduced water quality and changes in flow conditions was collected. The CPUE for the present

Table 73: Fish species expected based on the PESEIS Reach Code (W55C-01395) W5MPUL-BUSBY and W5MPUL-ARDE1 is listed, and the fish species percentage composition during the different surveys is indicated.

W55C-01395	Expected Species	W5MPUL-BUSBY					
		2010		2015		2019	
		Individuals	%	Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)							
Anguilla mossambica	X	-	-	-	-	1	2.50
Cyprinidae (Barbs, Yellow-fishes and Labeos)							
Enteromius anoplus	X	-	-	-	-	-	-
Enteromius crocodilensis	X	91	47.39	28	20.00	11	27.50
Labeobarbus marequensis	X	-	-	-	-	-	-
Labeobarbus nelspruitensis	X	-	-	-	-	-	-
Labeobarbus polylepis	X	-	-	-	-	-	-
Amphiliidae (Mountain catfishes)							
Amphilius uranoscopus	X	23	11.98	16	11.43	4	10.00
Mochokidae (Squeakers, suckermouth catlets)							
Chiloglanis anoterus	X	78	40.63	96	68.57	24	60.00
Chiloglanis emarginatus	X	-	-	-	-	-	-
Cichlidae (Cichlids)							
Pseudocrenilabrus philander	X	-	-	-	-	-	-
Tilapia sparrmanii	X	-	-	-	-	-	-
Number of species recorded	11	3		3		4	
Number of individuals		192		140		40	
Electro-fishing time (minutes)		36 minutes		31 minutes		28 minutes	
Catch/Unit Effort (CPUE)		5.33		4.52		1.43	
Fish Ecostatus (FRAI Value) for W5MPUL-BUSBY				**CATEGORY C** 67%		**CATEGORY C** 69.6%	

W55C-01395	Expected Species	W5MPUL-ARDE1			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	0.85	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	32	27.12	21	28.77
Labeobarbus marequensis	X	-	-	-	-
Labeobarbus nelspruitensis	X	-	-		
Labeobarbus polylepis	X	1	0.85	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	6	5.08	4	5.48
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	73	61.86	40	54.79
Chiloglanis emarginatus	X	-	-	-	-
Chiloglanis swierstrae	X	-	-	8	10.96
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	5	4.24	-	-
Number of species recorded	12	6		4	
Number of individuals		118		73	
Electro-fishing time (minutes)		43 minutes		23 minutes	
Catch/Unit Effort (CPUE)		2.74		3.17	
Fish Ecostatus (FRAI Value) for W5MPUL-ARDE1		**CATEGORY C** 64%		**CATEGORY C** 67%	
SQ REACH SUMMARY for Fish Ecostatus (FRAI Value)		**Category C** 65.5%		**Category C** 68.3%	

survey was calculated at 1.43 (40 individuals; 28 minutes) indicating a lower fish abundance of fish collected compared to both the 2010 and 2015 surveys when CPUE's of 4.52 and 5.33 respectively was calculated.

At the W5MPUL-ARDE1 site a fish assemblage of only four species was recorded from an expected 12 species during the present survey, two species less than recorded for the 2015 survey (Table 73). Two of the *Chiloglanis* species were recorded for this site, *Chiloglanis anoterus* (54.79% of fish assemblage; 40 individuals) and the sandy reophilic specialist, *Chiloglanis swierstrae* (10.96% of fish assemblage; 8 individuals) recorded for this site for the first time. The second most abundant fish species collected was *Enteromius crocodilensis* for both the present and 2015 surveys. None of the expected yellowfish species were recorded which can be related to limited available habitat. The CPUE (catch per unit effort) calculated for this site is 3.17 (73 individuals; 23 minutes) indicating a higher abundance of fish collected compared to the 2015 survey with a CPUE of 2.74 (118 individuals; 43 minutes) was calculated.

A Fish Ecostatus rating for the W5MPUL-BUSBY site was calculated at 69.6% based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species), consistent to the 2015 survey. A Fish Ecostatus rating of 67% was calculated for the W5MUPL-ARDE1 based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species) compairing favourably to the 2015 survey. A Fish Ecostatus rating for the W5MPUL-BUSBY of 69.6% was calculated for this site based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species), very much the same than found during the 2015 survey.

The combined Fish Ecostatus rating for this reach W55C-01395 was calculated at 68.3% based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) consistent with the 2015 survey results (Category C – 65.5%).

Invertebrates

Ten SASS sampling events are on record for the W5MPUL-BUSBY site and two for the W5MPUL-ARDE1 site in this reach on the Mpuluzi River. The W5MPUL-BUSBY sampling events occurred in July 1999, August 2000, September 2001, August 2005, July 2008, June 2011, February 2015, August 2015, March 2018, and August 2019. At the W5MPUL-ARDE1 site, monitoring was carried out in August 2015 and August 2019. In total 56 SASS taxa have been recorded at the W5MPUL-BUSBY site during ten sampling events. The diversity of SASS taxa was generally high, with sensitive taxa dominant. Total SASS scores for the ten sampling events ranged from 184 – 231 (avg.) – 270, and SASS-taxa diversity from 30 – 35 (avg.) – 42.

In total 45 SASS taxa have been recorded during the two sampling events at the W5MPUL-ARDE1 site. The diversity of SASS taxa was very high (43) in 2015, decreasing to 31 in 2019. High sediment movement, altering the channel

and instream habitat, occurred between the 2015 and 2019 sampling events. The biggest changes were in the stones and gravel/san/mud biotopes, all with decreased diversity in 2019.

Table 74: Comparison of the 2015 and 2019 SASS5 results for SQ reach W55C-01593.

W55C-01395	W5MPUL-BUSBY	2015	2019	
	Total SASS Score	225	241	
	No. of SASS Families	35	35	Change
	Average Score Per Taxon	6.4	6.9	
	SITE SUMMARY Invertebrate Ecostatus	Category BC 80.5%	Category BC 80.6%	→
	W5MPUL-ARDE1	2015	2019	
	Total SASS Score	266	208	
	No. of SASS Families	43	31	Change
	Average Score Per Taxon	6.2	6.7	
	SITE SUMMARY Invertebrate Ecostatus	Category BC 80.5%	Category C 72.9%	↘
	SQ REACH SUMMARY Invertebrate Ecostatus	Category 80.5%	Category C 76.8%	↘

MIRAI results for 2019 (Table 74) at the W5MPUL-BUSBY site indicates similar conditions when compared to 2015, with both 2015 and 2019 rated as largely natural to moderately impaired (BC-class). At the W5MPUL-ARDE1 site further downstream, conditions deteriorated slightly. In 2015 MIRAI results indicated close to largely natural conditions (Class –BC) to moderately modified (Class – C) in 2019. Instream habitat change as a result of high sediment input and movement was determined to be the main cause. Overall, the reach was rated as close to largely natural in 2015 deteriorating to moderately impaired in 2019.

Historical results for the W5MPUL-BUSBY site indicates stable conditions (Figure 46).

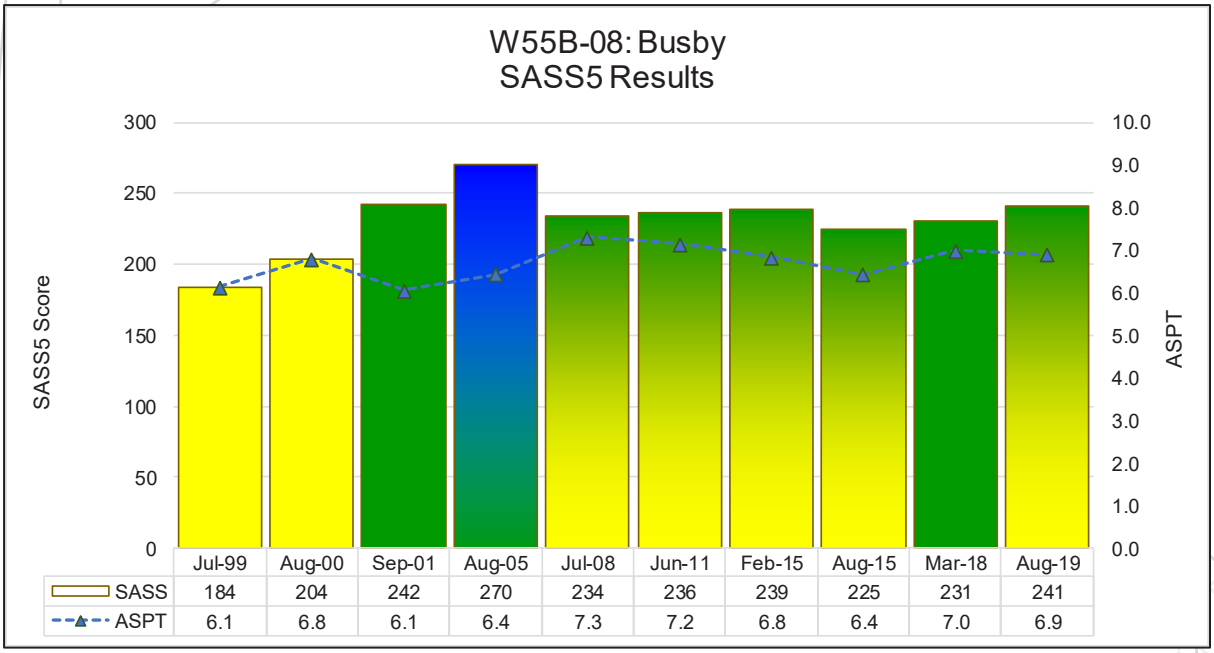


Figure 46. Graphic illustration of historic SASS results for the W5MPUL-BUSBY site.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 87.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 74.3% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (83%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Water Quality

The GE image below (Figure 47) shows water quality monitoring points on the designated reach of the Mpuluzi River, i.e. just downstream of the Mpuluzi Oxidation Ponds and extensive settlements. The Mpuluzi Water Treatment Plant is situated further north of the settlements.

Monitoring point U-57 falls within SQR W55C-01395. The DWS wq monitoring point, W5H024Q01, is on SQR W55E-01477, downstream of the confluence with the Swartwater River (SQR W55C-01489). All points are within the same Level II Ecoregion (11.04). However, data are only available until 2010 and could not be used for a present state assessment.

Figure 47: Google Earth image of the Mpuluzi River, showing the position of U-57 downstream of Empuluzi and Sun City settlements.

Table 75 is a water quality present state assessment for SQR W55C-01395, based on available data. Table 76 is the PAI water quality table produced for the reach.

Table 75: Water quality PES: SQR W55C-01395, Mpuluzi River (U-57)

RIVER		Mpuluzi River	**Water Quality Monitoring Points**	
			RC	Benchmark boundary tables (DWAF, 2008).
IUCMA site code		U-57	**PES**	IUCMA data, U-57: July 2016-Sept 2019; n=39.
Confidence assessment		Confidence in the assessment is **low**, as little DO, temp., turbidity or metal data, and a short data record.		
Water Quality Constituents			**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$		-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4		-	
	$MgCl_2$		-	
	$CaCl_2$		-	
	NaCl		-	
	$CaSO_4$		-	
Nutrients (mg/L)	PO_4-P (mg/L)		0.03	D (3)
	TIN-N (mg/L)		0.17	A (0)
Physical variables	pH (5^{th}+95^{th} percentiles)		6.49+7.7	A/B (0.5)
	Temperature		-	Some impact is expected due to the size of the stream. A/B (0.5).
	Dissolved oxygen		-	

	Turbidity (NTU)	-	Some impact is expected from activities related to the extensive settlements upstream of the site. An increase in instream sand deposition was noted by the macroinvertebrate specialist. C (2)
	Electrical conductivity (mS/m)	32.76	B (1)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category	C (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	8.03	F (5)
OVERALL SITE CLASSIFICATION (from PAI)		**C (75.9%)**	

- No data.

Table 76: PAI table for SQR: W55C-01395, Mpuluzi River (U-57)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**2-15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.50	N	4.00	60.00		50.00
Salts	1.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	2.50	NONE SPECIFIED	4.00	75.00		65.00
Water Temperature	0.50	N	2.50	55.00		70.00
Water clarity	2.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	0.50	N	2.50	65.00		70.00
Toxics	3.00	N	2.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.60	MEAN CONF →	3.07			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.60					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.56					
FINAL PC MODIFICATION RATING	1.60					
P-C CATEGORY %	P-C CATEGORY					
75.9	C	REVISED % & CATEGORY (2014)				

Table 77 shows the water quality state at this site as compared to the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline and pink shading indicates a small exceedance. Orange shading is used when it is uncertain whether guidelines have been exceeded.

Table 77: Comparison to water quality guidelines: SQR W55C-01395, Mpuluzi River (U-57)

Metric		International Obligations
Physical variables	pH	6.5-8.5
	Electrical Conductivity (mS/m)	150
Nutrients	PO_4 (mg/L P)	2
	NO_2+NO_3 (mg/L N)	50
Toxics	Ammonia (mg/L N)	1
	Sulphate (mg/L)	250 *
Microbial	Faecal coliforms (cfu/100mL)	2 000 (760, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	10 000 (>2 420, n=1, Sept 2019)

**** an indicative evaluation only, as based on 2000-2009 data (n=111; 95th percentile is 10.7 mg/L) from W5H024Q01.***

Note the following points regarding analysis:

- Data records are short, with the assessment therefore being of very low confidence.
- Water quality state appears **Moderate-Poor** for this river reach. The ammonia levels are extremely high, presumably related to the Water Treatment Plant upstream of the rural settlements and the oxidation ponds upstream of the monitoring points. One of the purposes of utilizing oxidation ponds is to improve effluent quality by removing suspended solids, lowering ammonia, nitrate and phosphate levels, and reduce the number of pathogens. Ammonia levels seen downstream of the ponds suggest that the efficiency of the ponds should be evaluated.
- It is suggested that a more definitive test is undertaken for total coliforms, as it is unknown whether (for example) >2 420 cfu exceeds the 10 000 cfu guideline.

Impacts for SQR

- Removal of riparian vegetation with a grader at the W5MPUL-BUSBY site.
- High weed infestation in the marginal and lower zones of the riparian zone (W5MPUL-BUSBY and W5MPUL-ARDE1)
- High sand deposition and movement at the W5MPUL-ARDE1 site.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.4%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.

Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗

Possible Reasons:

- High sedimentation loads resulting in loss of available habitat to fish and macro invertebrates
- Insteam habitat and riparian vegetation reduced

RIVER			TRIBUTARY OF	
Mpuluzi			Lusutfu	
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH
W5MPUL-BUSBY		W55C		W55C-01395
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.28034	E 30.59140	1 520	Upper foothill
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-99. Upstream view of the site on the Mpuluzi River, W5MPUL-BUSBY (21 August 2015).

Figure A-100. Downstream view of the site on the Mpuluzi River, W5MPUL-BUSBY (21 August 2015).

Figure A-101. Upstream view of the site on the Mpuluzi River, W5MPUL-BUSBY (05 August 2019).

Figure A-102. Downstream view of the site on the Mpuluzi River, W5MPUL-BUSBY (05 August 2019).

RIVER			TRIBUTARY OF	
Mpuluzi			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5MPUL-ARDE1			W55C	W55C-01395
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.24958	E 30.75242	1 377	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-103. Upstream view of the site on the Mpuluzi River, W5MPUL-ARDE1 09 September 2015).

Figure A-104. Downstream view of the site on the Mpuluzi River,W5MPUL-ARDE1(09 September 2015).

Figure A-105. Upstream view of the site on the Mpuluzi River, W5MPUL-ARDE1 (05 August 2019).

Figure A-106. Downstream view of the site on the Mpuluzi River, W5MPUL-ARDE1 (05 August 2019).

SQ REACH NUMBER W55C-01489

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W55C-01489	W5SWAR-IZIND	Swartwaterspruit	S-26.35762 E 30.78534	1 332	28.6	B	D 57.8%	C* 72.2%	CD 58.2%	B** 85%	C 70.6%	C 70%	2015
							C 65.5%	BC 78.6%	C 72.1%	BC 79.1%	C 75.1%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W55C-01489: Source of Swartwaterspruit to confluence with Mpuluzi River

The site falls within PESEIS Reach Code W55C-01489, which is indicated as 28.6 km in length (from Department of Water and Sanitation 2014). The origin of the Swartwaterspruit starts downstream from the Rinkink Saw-mill in commercial forestry, at an elevation of 1,732 m a.s.l. The reach flows for 33.7 km towards the Izindonga site, W5SWAR-IZIND, at an elevation of 1,332 m a.s.l., and then for another 3.3 km to its confluence of the Mpuluzi River. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (5.7%) and open spaces with grasslands (30.1%) (GEOTERRAIMAGE, 2015). The Landuse practices include mixed agriculture (>1%) and forestry plantations (55.4%) with sawmill. One medium sized farm dam with several small dams as well as small rural settlements are recorded.

Instream Habitat Integrity

The IHI for the SQ reach W55C-01489 was calculated at 72.3% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5SWAR-IZIND (W55C-01489) is on a tributary of the Mpuluzi River. The site is dominated by bedrock with rocks and cobbles and sand sedimentation was evident. The fish velocity depth classes consisted of abundant fast shallow fish habitat, with slow shallow and slow deep habitat moderately present. No fast deep habitat was recorded. The substrate as cover for fish consisted primarily of rocks and cobbles over bedrock. Other fish cover present was overhanging vegetation moderately present in the slow deep habitat, but sparse in both the slow shallow and fast habitat. Undercut banks and root wads as fish cover were sparse.

Table 78: Fish species expected based on the PESEIS Reach Code (W55C-01489) W5SWAR-IZIND; is listed, and the fish species percentage composition during the different surveys is indicated.

W55C-01489	Expected Species	W5SWAR-IZIND			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	7	10.45
Labeobarbus marequensis	X	-	-	-	-
Labeobarbus nelspruitensis	X	-	-	-	-
Labeobarbus polylepis	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	10	20.41	14	20.89
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	39	79.59	46	68.66
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	-	-	-	-
Number of species recorded	10	2		3	
Number of individuals		49		67	
Electro-fishing time (minutes)		41 minutes		31 minutes	
Catch/Unit Effort (CPUE)		1.20		2.16	
Fish Ecostatus (FRAI Value)		**CATEGORY CD** 57.5%		**CATEGORY C** 65.5%	

Ten indigenous fish species are expected (Table 78) to occur in this river reach of which only three reophilic species were collected during the present survey, one species more than recorded for the 2015 survey, namely *Chiloglanis anoterus* (68.66% of fish assemblage; 46 individuals) and *Amphilius uranoscopus* (20.89% of fish assemblage; 14 individuals) and *Enteromius crocodilensis* (10.45% of fish assemblage; 7 individuals). No Cichlids was found during the surveys done. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered due to limited instream fish habitat as a result of siltation and sedimentation. The CPUE (catch per unit effort) was calculated at 2.16 (67 individuals; 31 minutes) which indicates a higher abundance of fish recorded than during the 2015 survey when a CPUE of 1.20 fish found per minute was recorded.

A Fish Ecostatus rating of 65.5% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species), an improvement to the conditions recorded during the 2015 survey when an Ecological Category CD was determined (Fish Ecostatus rating of 58%) close to moderately modified with low diversity and abundance of species.

Invertebrates

Two SASS sampling events are on record for the W5SWAR-IZIND site in this reach on the Swartwaterspruit. These sampling events occurred in September 2015 and this survey in August 2019. In total 35 SASS taxa have been recorded during these two sampling events.

The biggest change in the stream community between the 2015 and 2019 surveys was in the vegetation biotope. Several taxa absent in 2015 were recorded in 2019, of which the most sensitively SASS-rated were Prosopistomatidae, Chlorocyphidae, Philopotamidae, and Scirtidae.

Table 79: Comparison of the 2015 and 2019 SASS5 results for SQ reach W55C-01489

W55C-01489	W5SWAR-IZIND	2015	2019	
	Total SASS Score	181	218	
	No. of SASS Families	31	33	Change
	Average Score Per Taxon	5.8	6.6	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 72.2%	Category BC 78.6%	↗

The 2019 SASS5 results (Table 79) indicates improved conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately modified (Category C – 72.2%) in September 2015 slightly improving to close to largely natural conditions most of the time (Category BC – 78.6%) in August 2019. Marginal vegetation along stream banks re-established after bank scouring exposed stream banks in 2015.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 73.4% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category BC (79.1%) indicating that the riparian vegetation for this SQ reach is close to largely natural conditions with few modifications most of the time.

Impacts for SQR

- High infestation of the stream banks with *Acacia mearnsii*, a high water-using species.
- Evidence of sporadic sand mining.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (75.1%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER	Swartwaterspruit	TRIBUTARY OF	Mpuluzi
SITE NUMBER	W5SWAR-IZIND	QUATERNARY SUB-CATCHMENT	W55C
REACH	W55C-01489		
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude S -26.35762	Longitude E 30.78534	Elevation (m. a.m.s.l.) 1 332
Geomorphological Zone	Upper foothills		
AQUATIC ECOREGION	Level I 11. Highveld		Level II 11.04

Figure A-107. Upstream view of the site on the Swartwaterspruit, W5SWAR-IZIND (09 September 2015).

Figure A-108. Downstream view of the site on the Swartwaterspruit, W5SWAR-IZIND (09 September 2015).

Figure A-109. Upstream view of the site on the Swartwaterspruit, W5SWAR-IZIND (19 August 2019).

Figure A-1110. Downstream view of the site on the Swartwaterspruit, W5SWAR-IZIND (19 August 2019).

SQ REACH NUMBER W55D-01506

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W55D-01506	W5METU-SWAZI	Metula	S-26.46191 E 30.85806	1 187	50.7	C	C 71%	BC* 78.7%	C 75.4%	B** 82.5%	BC 78.7%	BC 80%	2015
							C 67.2%	B 85.4%	C 76.3%	C 76.2%	C 76.3%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W55D-01506: Source of Metula River to confluence with Mpuluzi River

The site falls within PESEIS Reach Code W55D-01506, which is indicated as 50.7 km in length (from Department of Water and Sanitation 2014). The river originates at an elevation of 1,680 m a.s.l. and the reach ends where the Metula River flows into the Mpuluzi River. The length from the source of the Metula River to the W5METU-SWAZI sampling point measured on Google Earth Pro is 54 km. The main river channel is 60.8 km, originating at an elevation of 1,680 m a.s.l., flowing in a south-east by easterly direction towards the sampling point, W5METU-SWAZI, which is at an elevation of 1,187 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) vegetation type and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consist of wetlands (5.6%) and grassland (20.5%). The land use practises consist of mixed agriculture, mostly pine forestry (plantations – 48.9%) as well as rural settlements and several farm dams in the catchment (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W55D-01506 was calculated at 72.6% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This W5METU-SWAZI (W55D-01506) site is also on a tributary of the Mpuluzi River. All of the fish velocity depth classes waspresent with both the slow shallow and slow deep moderately abundant, the fast deep sparse with the fast-shallow habitat in abundance. The fish cover present rated sparse to moderately present for overhanging vegetation created by grass in the riparian zone. The substratum varied from sparse to moderate and cover for fish was provided by large boulders and rocks over bedrock. A sandy substrate provided some habitat for fish but a lot of silt was present.

Table 80: Fish species expected based on the PESEIS Reach Code (W55D-01506) W5METU-SWAZI; is listed, and the fish species percentage composition during the different surveys is indicated.

W55D-01506	Expected Species	W5METU-SWAZI			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromiusanoplus	X	-	-	-	-
Enteromiuscrocodilensis	X	49	35.00	74	66.07
Labeobarbusmarequensis	X	17	12.14	-	-
Labeobarbusnelspruitensis	X	-	-	-	-
Labeobarbuspolylepis	X	9	6.43	-	-
Amphiliidae (Mountain catfishes)					
Amphiliusuranoscopus	X	7	5.00	19	16.97
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanisanoterus	X	36	25.71	18	16.07
Chiloglanisemarginatus	X	3	2.15	-	-
Chiloglanisswierstrae	X	19	13.57	1	0.89
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	-	-
Tilapia sparrmanii	X	-	-	-	-
Number of species recorded	12	7		4	
Number of individuals		140		112	
Electro-fishing time (minutes)		39 minutes		22 minutes	
Catch/Unit Effort (CPUE)		3.59		5.09	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 71%		**CATEGORY C** 67.2%	

Of the expected 12 fish species only four species were recorded, three species less than the 2015 survey (Table 80). The assemblage was dominated by the flow dependant small barb species, *Enteromius crocodilensis* (66.07%; 74 individuals) which was also the case during the 2015 survey when this fish species was recorded at a relative abundance of 35% of all fish collected. None of the yellowfish species was found during the present survey and the reason cannot be explained but may be flow related. Only a single specimen of the sand specialist, *Chiloglanis swierstrae* could be found compared to the 19 found during the 2015 survey. A reason is the siltation of the sandy habitat which is taking place. As with the 2015 survey was no Cichlids found at this site, although suitable habitat was present.

The CPUE (catch per unit effort) calculated for this site is 5.09 (92 individuals; 36 minutes) which is higher than recorded for the 2015 survey when a CPUE of 2.76 (116 individuals; 42 minutes) was calculated. Fewer species but a higher abundance of fish was found during the present survey.

A Fish Ecostatus rating of 67.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey.

Invertebrates

Two SASS sampling events are on record for the W5METU-SWAZI site in this reach on the Metula. These sampling events occurred in July 2015 and this survey in September 2019. In total 38 SASS taxa have been recorded during these two sampling events.

The change in the diversity of SASS5 taxa between 2015 to 2019 was considerable, with an increase in both the stones and vegetation biotopes. Several sensitive absent in 2015 were present in 2019. These include Hydracarina, Prosopistomatidae, Scirtidae, Psephenidae, Athericidae, Dixidae, and Empididae.

Table 81: Comparison of the 2015 and 2019 SASS5 results for SQ reach W55D-01056. .

W55D-01056	W5METU-SWAZI	2015	2019	
	Total SASS Score	174	252	
	No. of SASS Families	28	36	Change
	Average Score Per Taxon	6.2	7.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 78.7%	Category B 85.4%	↗

The 2019 SASS5 results (Table 81) indicates improvement when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as largely natural to moderately impaired (Category BC – 78.7%) in July 2015 improving to largely natural (Category B – 85.4%) in September 2019. The change is attributed to improved instream habitat conditions.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 73.3% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (76.2%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Poor road drainage, increasing sediment inputs into the river during rainfall run-off.
- The stream crossing partially blocks the free movement of fish species, especially during low flows.
- High degree of weed infestation with wattle (*Acacia mearnsii*), a high water-using species.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (78.7%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗	

Possible Reasons:

- Instream habitat and riparian vegetation reduced
- High sedimentation loads resulting in loss of available habitat to fish and macro invertebrates

RIVER			TRIBUTARY OF	
Metula			Mpuluzi	
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH
W5METU-SWAZI		W55D		W55D-01506
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.46191	E 30.85806	1 187	Upper foothill
AQUATIC ECOREGION	Level I		Level II	
	11. Highveld		11.04	

Figure A-111. Upstream view of the site on the Metula River, W5METU-SWAZI (23 July 2015).

Figure A-112. Downstream view of the site on the Metula River, W5METU-SWAZI (23 July 2015).

Figure A-113. Upstream view of the site on the Metula River, W5METU-SWAZI (09 September 2019).

Figure A-114. Downstream view of the site on the Metula River, W5METU-SWAZI (09 September 2019).

SQ REACH NUMBER W55E-01651

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W55E-01651	W5MPUL-VELAB	Mpuluzi	S-26.48943 E 30.89898	1 153	6.1	C	C 71.8%	C* 75.6%	C 73.7%	C** 77.5%	C 75.3%	C 70%	2015
							BC 79.2%	C 72%	C 75.6%	C 73%	C 74.5%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W55E-01651: Confluence of Mpuluzi River with Metula to confluence of Mpuluzi with Mhlangeni River

The site falls within PESEIS Reach Code W55E-01651, which is indicated as 6.1 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Mpuluzi River with the Metula (W55D-01506) and ends at the confluence of the Mpuluzi River with the Mhlangeni (W55E-01590). The length from the source of the Mpuluzi River to the W5MPUL-VELAB sampling point measured on Google Earth Pro is 144 km. The main river channel is 153 km, originating at an elevation of 1,812 m a.s.l., flowing in a south-east by southerly direction towards the sampling point, W5MPUL-VELAB, which is at an elevation of 1,153 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) vegetation type and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consists mainly of open spaces with grasslands. Landuse practises include mixed agriculture with mostly *Pinus* forestry. Several small farm dams and rural settlements within the catchment. No landcoverage and land use practise data available on GEOTERRAIMAGE, 2015 for this SQ reach.

Instream Habitat Integrity

The IHI for the SQ reach W55E-01651 was calculated at 72.3% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5MPUL-VELAB (W55E-01651) sampled is found just before the confluence with the Lusutfu River and was just downstream from a road crossing. The site is characterised by a broad low gradient channel that consist of fast rapids and riffles over bedrock with sandy runs further downstream. All fish velocity depth classes were present except for slow deep habitat at the time of the survey with slow shallow (abundant), fast deep (moderate) and fast shallow (abundant). Aquatic macrophytes provided sparse cover in the slow shallow habitat as overhanging vegetation with undercut banks moderately present at the slow shallow habitat. The only other fish cover present was substrate varying from boulders and rocks over bedrock and sand.

Table 82: Fish species expected based on the PESEIS Reach Code (W55E-01651) W5MPUL-VELAB; is listed, and the fish species percentage composition during the different surveys is indicated.

W55E-01651	Expected Species	W5MPUL-VELAB			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius crocodilensis	X	56	13.96	9	7.83
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	-	-	-	-
Labeobarbus marequensis	X	89	22.19	8	6.95
Labeobarbus nelspruitensis	X	5	1.25	-	-
Labeobarbus polylepis	X	163	40.65	8	6.95
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	7	1.76	5	4.35
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	72	17.95	66	57.39
Chiloglanis emarginatus	X	-	-	-	-
Chiloglanis swierstrae	X	-	-	7	6.09
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	-	-	7	6.09
Tilapia sparrmanii	X	9	2.24	5	4.35
Number of species recorded	14	7		8	
Number of individuals		401		115	
Electro-fishing time (minutes)		41 minutes		32 minutes	
Catch/Unit Effort (CPUE)		9.90		3.59	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 72%		**CATEGORY BC** 79.2%	

The fish assemblage consisted of eight indigenous fish species of an expected 14 species, one species more than recorded for the 2015 survey (Table 82). The most abundant fish species was the flow dependant *Chiloglanis anoterus* (66 individuals; 57.39% of fish found) which was not the case for the 2015 survey. During the previous survey the three expected large yellowfish species dominated the fish assemblage with *Labeobarbus polylepis* the most abundant species (66 individuals; 57.39% of fish found). During the present survey no *Labeobarbus nelspruitensis* was found and the other two large yellowfish species was found at a much lower relative abundance (8 individuals; 6.95% of fish found). The sandy runs provided the ideal habitat for *Chiloglanis swierstrae* which was found for the first time at a relative abundance of 6.09% of all fish found during the present survey.

The CPUE (catch per unit effort) calculated for this site is 3.59 (115 individuals; 32 minutes), much lower when compared to the 2015 survey CPUE of 9.90 (401 individuals; 41 minutes) indicating a decrease in abundance of fish found.

A Fish Ecostatus rating of 79.2% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species) consistent with the previous survey with an Ecological Category C (72%).

Invertebrates

Two SASS sampling events are on record for the W5MPUL-VELAB site in this reach on the Mpuluzi River. These sampling events occurred in August 2015 and September 2019. In total 35 SASS taxa have been recorded, and in addition Cladocera, Copepoda and Machadorythidae (non-SASS taxa). The decrease in taxa diversity between 2015 and 2019 was mainly in the stones and marginal vegetation biotopes. SASS-rated sensitive taxa recorded in 2015 and absent in 2019 included Hydracarina, Cordulidae (Macromidae), Crambidae, one species of Hydropsychidae, Philopotamidae, Scirtidae, and Athericidae. The Ephemerotera family Tricorythidae, was absent during both sampling events. Changes are attributed to increased sediment inputs, movement and deposition.

Table 83: Comparison of the 2015 and 2019 SASS5 results for SQ reach W55E-01651.

W55E-01651	W5MPUL-VELAB	2015	2019	
	Total SASS Score	206	143	
	No. of SASS Families	29	25	Change
	Average Score Per Taxon	7.1	5.7	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 75.6%	Category C 72%	→

The 2019 SASS5 results (Table 83) indicates similar conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 75.6%) in August 2015 and (Category C – 72%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 65.4% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (73%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The bridge impounds the river above the crossing, with downstream bank scouring as a result of overtopping (Figure 48 and Figure 49)
- The bridge serves as a potential barrier to fish movement during low flow conditions (Figure 50)
- High weed infestation with wattle (*Acacia mearnsii*), a high water using species.
- High sediment inputs and deposition (Figure 48).

Figure 48. The photo on the left was taken upstream from the bridge at W5MPUL-VELAB on 23 July 2015, and the one on the right from the same spot 09 September 2019. A blocked culvert designed too small and is impounding the river above the crossing, with increased sediment deposition.

Figure 49. Small culverts at the W5MPUL-VELAB blocked with logs and debris, increased deposition of sand and organic material. The water level overtopping during high flows has effectively been raised, increasing downstream bank and bed scouring (9 September 2019, G Diedericks).

Figure 50. The bridge is an obstruction to the movement of fish during low flow conditions (9 September 2019, G Diedericks).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (74.5%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remains consistent to Recommended Target Ecological Category ✔	

Discussion:

Although the Recommended Ecological Category for this reach has been met, improved management strategies is recommended as

- Road crossings creates obstruction to fish movement
- High sedimentation loads resulting in loss of available habitat to fish and macro invertebrates
- Insteam habitat and riparian vegetation reduced

RIVER			TRIBUTARY OF	
Mpuluzi			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5MPUL-VELAB			W55C	W55C-01651
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.48943	E 30.89898	1 153	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-115. Upstream view of the site on the Mpuluzi River, W5MPUL-VELAB (23 July 2015).

Figure A-116. Downstream view of the site on the Mpuluzi River, W5MPUL-VELAB (23 July 2015).

Figure A-117. Upstream view of the site on the Mpuluzi River, W5MPUL-VELAB (09 September 2019).

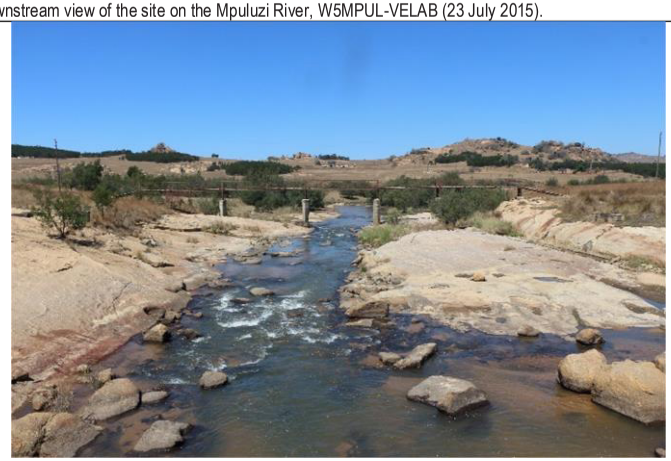


Figure A-118. Downstream view of the site on the Mpuluzi River, W5MPUL-VELAB (09 September 2019).

Discussion Mpuluzi Sub-catchment Reaches

Fish

A total of 17 indigenous fish species are expected to occur in this sub-catchment of which nine species were recorded for the present survey, two species less than recorded during the 2015 IUCMA survey. One species, *Anguilla mossambica*, was found during the present survey but was not recorded for the 2015 survey. The species recorded during the 2015 survey but not found during the 2019 survey are *Chiloglanis emarginatus*, *Enteromius anoplus* and *Labeobarbus nelspruitensis*. The most abundant fish species collected for the present survey is *Chiloglanis anoterus* with a relative abundance of 47.67% of the total number of fish collected. This species was also the most abundant species found during the 2015 survey.

Three species of fish were found at all of the sites done for this sub-catchment during the present survey. They are *Amphilius uranoscopus*, *Chiloglanis anoterus* and *Enteromius crocodilensis*.

The site where the highest number of fish species were found is also the furthest downstream site, W5MPUL-VELAB, where a total of eight fish species was recorded. The highest abundance of fish was found at site W5METU-SWAZI where a CPUE of 5.09 fish caught per minute was recorded.

None of the alien and invasive *Micropterus salmoides* was found during the present survey. It was recorded during the 2015 survey on the main stem river.

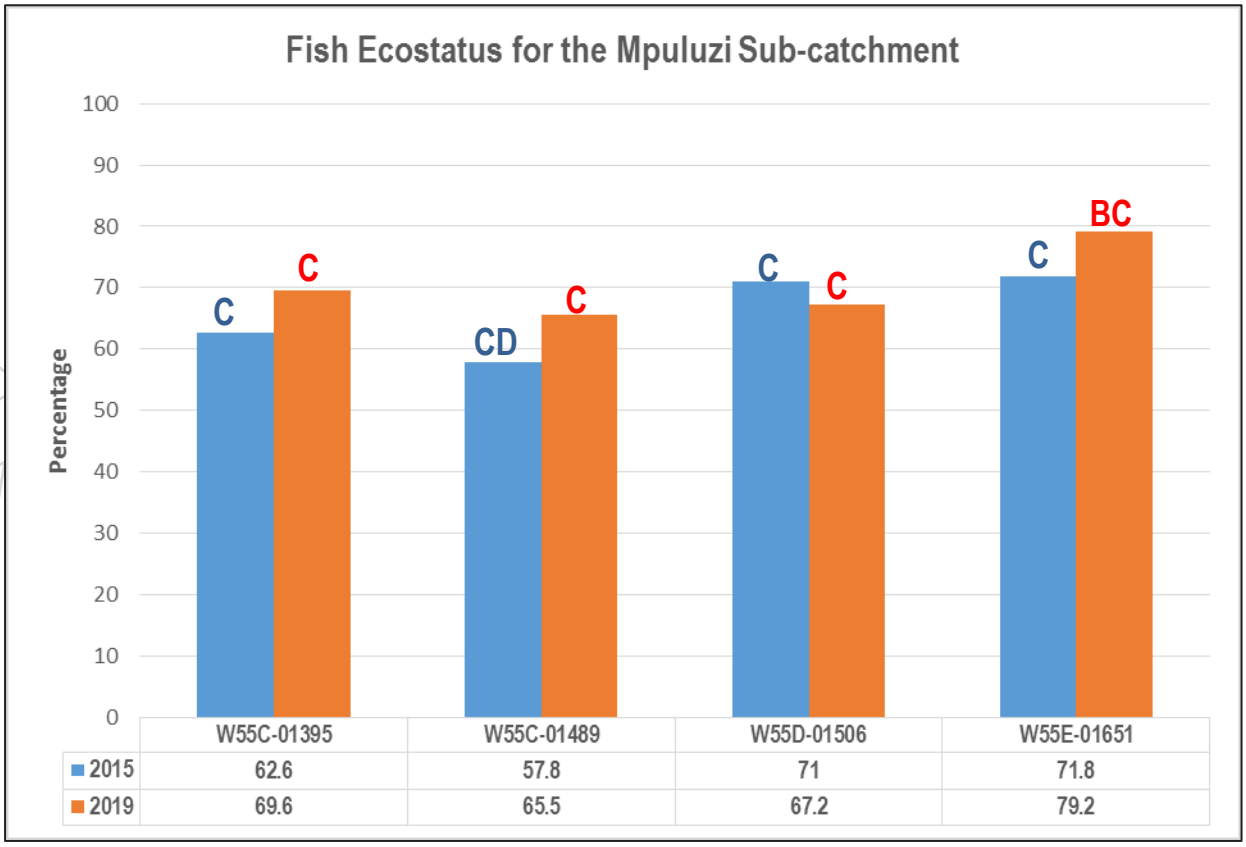


Figure 51: Summary of the Fish Ecostatus for the Mpuluzi Sub-catchment for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model.

Figure 51 summarise the Fish Ecostatus categories for the 4 SQ reaches on the Mpuluzi River sub-catchment. The Fish Ecostatus rating for the SQ reach W55C-01489 (W5SWAR-IZIND) increased from 57.8% (Category CD) calculated in 2015 to 65.5% (Category C) and W55E-01651 (W5MPUL-VELAB) increased from 71.8% (Category C) to a 79.2% (Category BC). The overall Fish Ecostatus rating for 2019 is 70.4% placing the mainstem in a high Category C. This is consistent with the 2015 results of 65.8% a low Category C. The present category C (70.4%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

Invertebrates

Overall conditions in the main channel remain consistent when compared to the 2015 results (Table 84 and Figure 52), with slight deterioration in W55C-01395. The deterioration is attributed to high sediment inputs and movement, with poor bridge design contributing to "trapping" sediments and organic matter, just to "release" large quantities of water, sand, and organic material when these structures eventually fail.

Conditions at sites sampled in the two tributaries improved from 2015 to 2019, with increases in taxa diversity as well as the percentage sensitive taxa.

Table 84: Summary of stream conditions per SQ Reach based on MIRAI, comparing 2015 to 2019 results.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	CHANGE
W55	Mpuluzi	W55C-01395	80.5	76.8	↘
		W55E-01651	75.6	72	→
	Swartwaterspruit	W55C-01489	72.2	78.6	↗
	Metula	W55D-01506	78.7	85.4	↗

When comparing aquatic invertebrate results between the 2015 and 2019 survey, overall conditions improved. The overall Invertebrate Ecostatus rating for 2019 is 78.2% placing the mainstem in a high Category C. This is consistent with the 2015 results of 73.3% a high Category C. The present category C (78.2%) a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

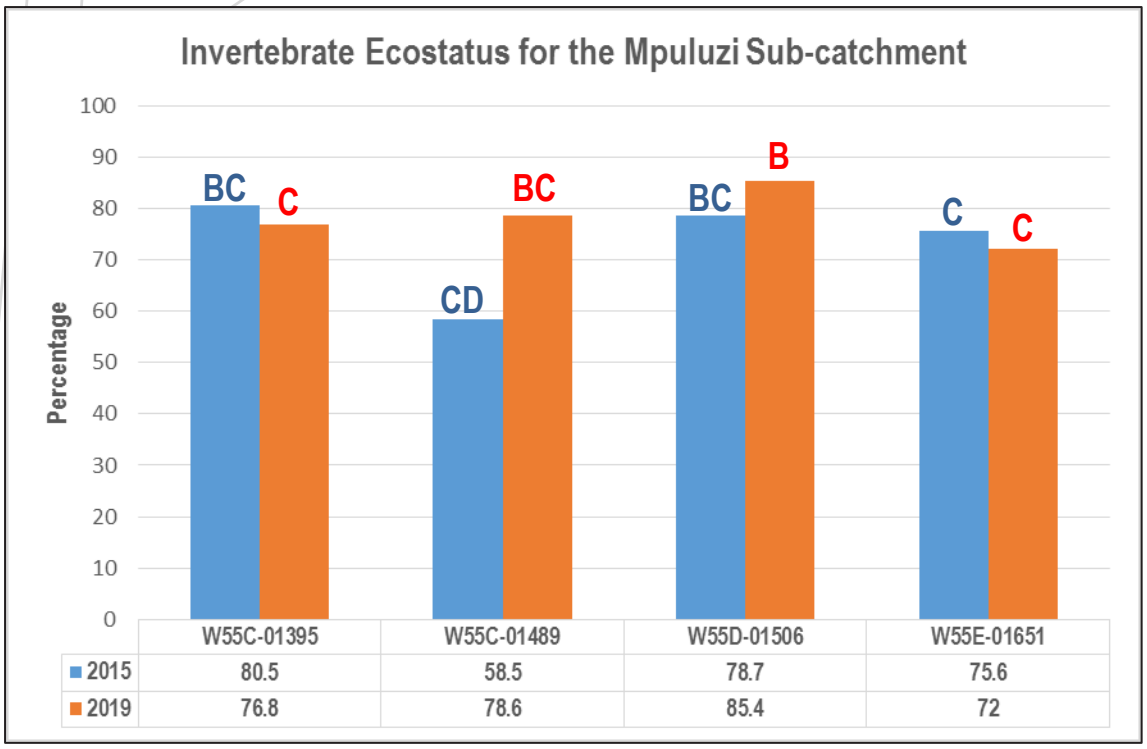


Figure 52: Graphical comparison of the Invertebrate Ecostatus of the Mpuluzi Sub-catchment in 2015 and 2019.

Water Quality

The water quality assessment was limited to a specific site, with a discussion of results provided below the results of the data assessment. Data records are short, with the assessment therefore being of very low confidence. Water quality state appears **Moderate-Poor** for the river reach assessed (W55G-01395). The ammonia levels are extremely high, presumably related to the Water Treatment Plant upstream of the rural settlements and the oxidation ponds upstream of the monitoring points.

Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Mpuluzi Sub-catchment

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity assessment. From Figure 53 it is evident that the Instream Ecostatus improved throughout the sub-catchment ranging from a low category C (58.2%) to a high Category C (75.6%) with a mean of 74.3% category C. This remains consistent with the Instream Ecostatus for 2015 surveys at (67.4% Category C).

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model. The Integrated Ecostatus for the Mpuluzi Sub-catchment (Figure 54) also remained consistent throughout the 2015 (74.4%) and 2019 (75.8%) monitoring

with a category C indicating a moderately impaired habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

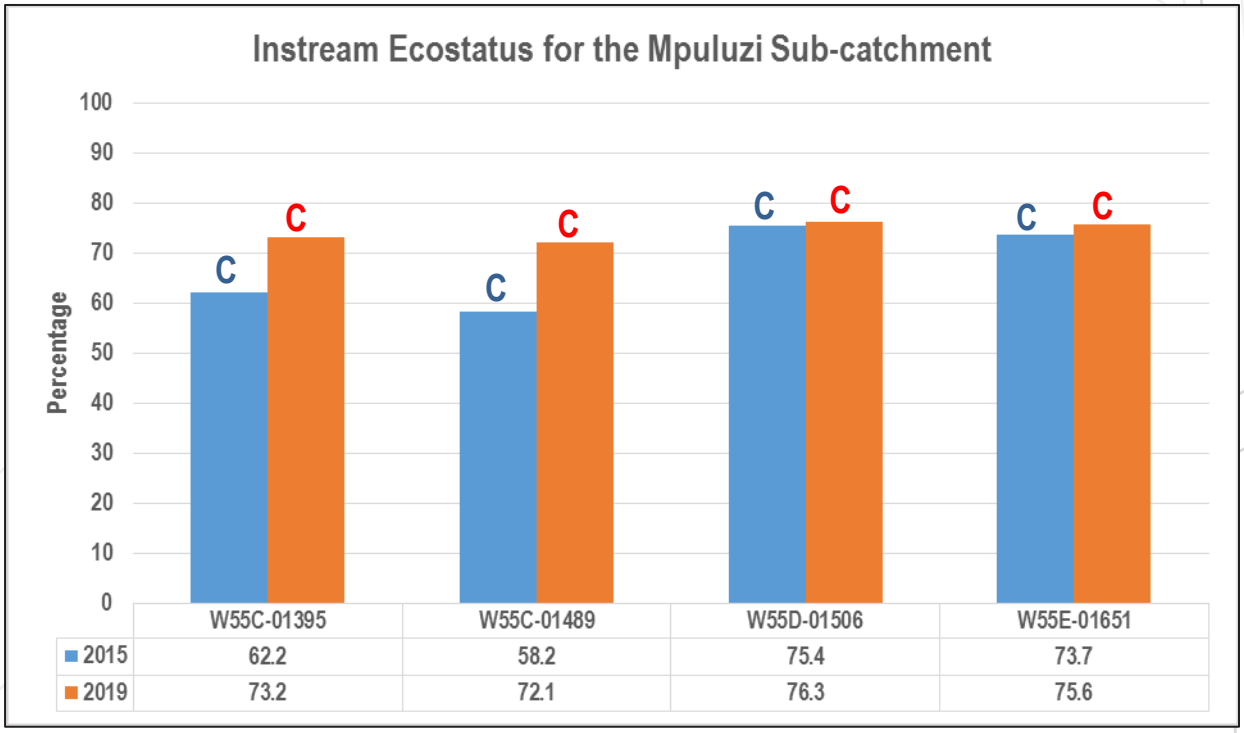


Figure 53: Comparison of the Instream Ecostatus of the Mpuluzi Sub-catchment in 2015 and 2019.

When comparing the Integrated Ecostatus with the Recommended Ecological Category within the various SQ reaches, it is evident that the set targets are met for all the reaches except for W55D-01506. Factors contributing to this can be related to inefficient catchment management in the upper reaches of the river negatively affecting instream habitat and reduced water quality standards. Forestry related impacts further contributed to excessive sedimentation and siltation having a direct impact on the instream habitats.

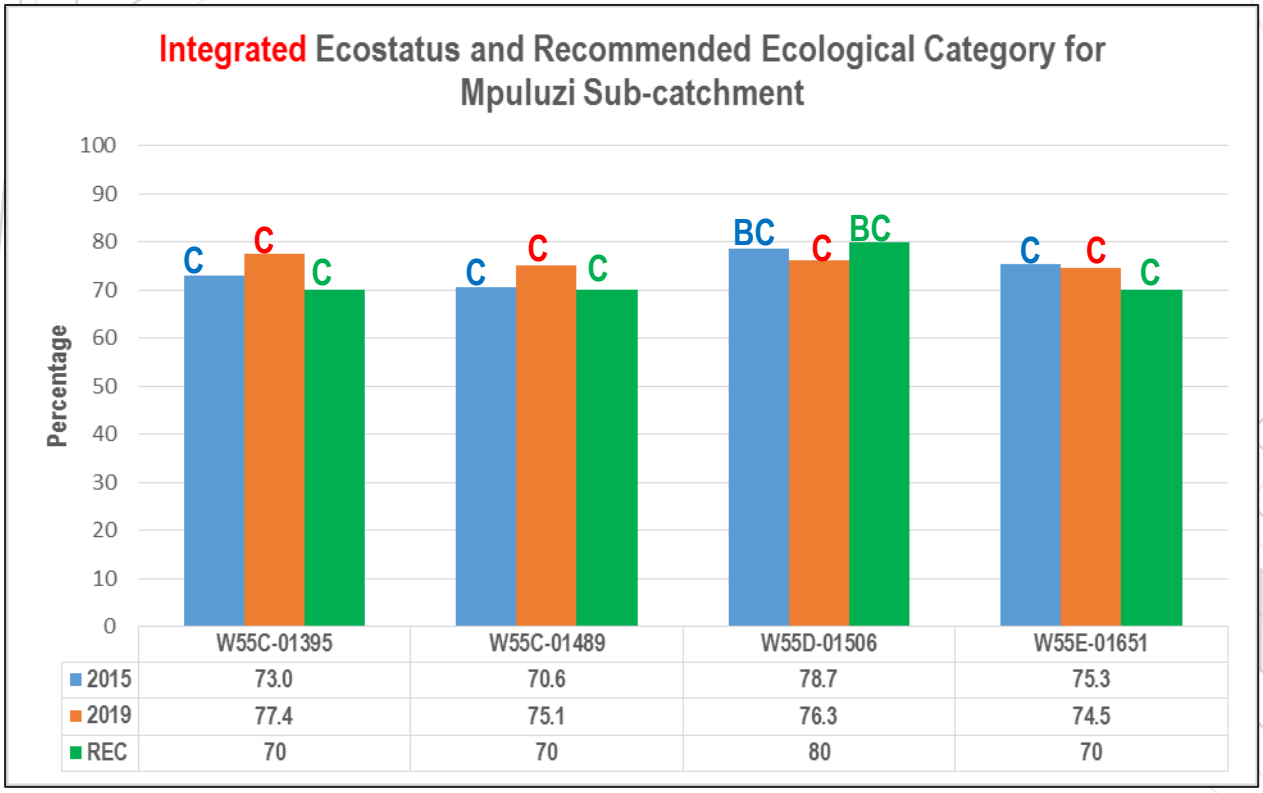


Figure 54: Comparison of the Integrated Ecostatus and Target Ecological Category for the Mpuluzi Sub-catchment in 2015 and 2019.

Lushushwane Sub-catchment Reaches

The Lushushwane River catchment originates in the Highveld aquatic ecoregion, and then flows in a general east-south easterly direction towards its confluence with the Lusutfu River in Swaziland. A total of 3 biomonitoring points consisting of 3 SQ reaches (92.8 km) representing 8.7% of the river monitored on the Usuthu-Lusutfu River catchment sampled during 2019.

SQ REACH NUMBER W56A-01372 (EWR KU1)

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W56A-01372	W5LUSU-IFRSI (EWR LU1)	Lusutfu	S-26.20865 E 30.86326	1 403	58.4	D	C 65.8%	D* 57.1%	CD 60.8%	C** 75%	C 67.9%	BC 80%	2015***
							BC 78%	C 75.6%	C 76.8%	B 83.9%	BC 80.4%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

***2015 Values from RIVDINT model for Reach (although different sites)

General description

Reach W56A-01372: Source of Lushushwane to confluence with Motshane River

The site falls within PESEIS Reach Code W56A-01372, which is indicated as 58.4 km in length (from Department of Water and Sanitation 2014). The reach starts at the origin of the Lusushwane River and ends at its confluence with the Motshane River (W56B-01413) in Swaziland. The length from the source of the Lusushwane River to the W5LUSU-ROBIN sampling point measured on Google Earth Pro is 23.6 km. The main river channel is 145 km, originating at an elevation of 1,740 m a.s.l., flowing first in an east-north easterly direction and then south easterly towards the sampling point, W5LUSU-IFRSI, which is at an elevation of 1,403 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) vegetation type and falls within Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consist of wetlands (3.9%), thickets and dense bush (1.8%) and grasslands (25.6%). Landuse practice consist of plantations (19.8%) (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W56A-01372 was calculated at 71.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The EWR site W5LUSU-IFRS1 (W56A-01372) is included into the biomonitoring programme for the first time.The habitat surveyed consisted of two channels just downstream from a river crossing with mainly shallow riffles and runs with fast shallow habitat in abundance and slow shallow habitat moderate with a pool providing some slow deep habitat. No fast-deep habitats were recorded. The substrate cover in the fast-shallow habitats were abundant consisting of rocks, cobbles and pebbles providing available fish habitat. The slow-deep habitat was silted up with very fine silt impacting on available fish habitat. Overhanging vegetation provided moderate cover with undercut banks. No aquatic macrophytes were present to provide cover for fish in both the slow and deep habitat types present.

Table 85: Fish species expected based on the PESEIS Reach Code (W56A-01372) W5LUSU-IFRS1; is listed, and the fish species percentage composition during the different surveys is indicated.

W56A-01372	Expected Species	W5LUSU-IFRS1			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X			-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X			38	45.24
Enteromius crocodilensis	X			-	-
Enteromius nelspruitensis	X				
Labeobarbus polylepis	X			1	1.19
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X			11	13.09
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X			28	33.33
Chiloglanis emarginatus	X			-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X			-	
Tilapia sparrmanii	X			6	7.14
Number of species recorded	10	Not Sampled		5	
Number of individuals				84	
Electro-fishing time (minutes)				38 minutes	
Catch/Unit Effort (CPUE)				2.21	
Fish Ecostatus (FRAI Value)				**CATEGORY BC** 78.0%	

The fish assemblage collected at this site consisted of five of an expected ten indigenous fish species (Table 85). The most abundant species collected was the small barb species, *Enteromius anoplus* at a relative abundance of 48.8% (38 individuals) of all fish collected. The relative abundance of the other species recorded were *Amphilius uranoscopus* (13.09%; 11 individuals), *Chiloglanis anoterus* (33.33%; 28 inividuals), *Labeobarbus polylepis* (1.19%; 1 individual) and *Tilapia sparrmanii* (7.14%; 6 individuals). The presence of the migratory species *Labeobarbus polylepis*, although only a single individual was found, is significant indicating that this reach is still accessible to larger migratory species.

The catch per unit effort (CPUE) was calculated at 2.21 (84 individuals: 38 minutes) indicating a relative abundance of fish present at this site.

A Fish Ecostatus rating of 78% was calculated for this SQR based on all available information, placing it in an ecological Category BC (slightly impaired with moderate diversity and abundance of species).

Invertebrates

Only one SASS sampling events are on record for the W5LUSU-IFRSI site in this reach on the Lusushwane River. Sampling was carried out in August 2019. In total 29 SASS taxa have been recorded with sensitive taxa and gathering collectors dominant.

The bulk of the taxa (23) were recorded in the stones biotope, while taxa diversity was relatively low in the other two biotopes.

Table 86: Comparison of the 2015 and 2019 SASS5 results for SQ reach W56A-01372.

W56A-01372	W5LUSU-IFRS1	2015	2019	
	Total SASS Score		189	
	No. of SASS Families		29	Change
	Average Score Per Taxon		6.5	
	SQ REACH SUMMARY Invertebrate Ecostatus	Not sampled	Category C 75.6%	

MIRAI results for 2019 (Table 86) at the W5LUSU-IFRS1 site indicates moderately modified (Category C – 75.6%).

Riparian Vegetation

Conditions based on VEGRAI was rated as largely natural (B - 84%). The marginal vegetation was dominated by grass-herbaceous species, with invasive wattle (*Acacia mearnsii*) present. There is an increase in woody species in what is expected to be a grass-herb dominated riparian zone, but the woody species are mainly wattle. The degree of wattle infestation increases in the lower zone but decrease in the upper zone. There is evidence of marginal vegetation disturbance due to trampling by livestock, but it's limited to specific areas. No information could be traced on the Resource Quality Objectives determined for this reach.

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 75% and is consistent with a Category C – moderately modified. The Level III VEGRAI Assessment range for the EWR site assessed in this reach is 83.9% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 52.3% rating this reach as a Category D indicating largely modified riparian vegetation. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition (VEGRAI) and the Riparian IHI was therefore

determined as a Category B (83.9%) indicating that the riparian vegetation for this SQ reach is largely natural conditions with few modifications.

Water Quality

Figure 55 shows SQR W56A-01372 in relation to extensive rural settlements in the area. The only water quality monitoring point in the area is IUCMA point U-61. The upper section of the designated reach is covered by forestry and cultivation. EWR KU1 (Klein Usuthu) is also indicated on the Google Earth image, and is located upstream of U-61. A Rapid III Ecological Reserve was undertaken in 2003 for the Pongola, Lomati and Lusushwane rivers (DWAF, 2003), and the Ecological Category for the site and reach designated a C. The category was checked and approved by DWS again on 19 April 2007. The documentation is however not available and the water quality assessment could not be located.

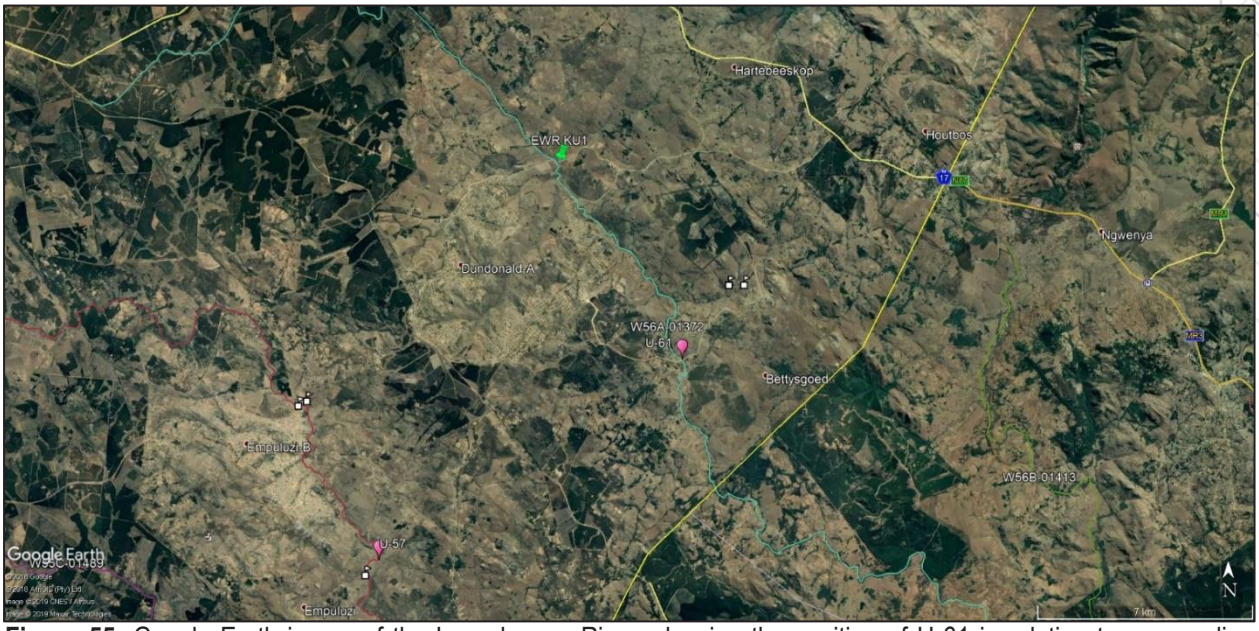


Figure 55: Google Earth image of the Lusushwane River, showing the position of U-61 in relation to surrounding settlements.

Table 87 is a water quality present state assessment for SQR W56A-01372, based on available data. Table 88 is the PAI water quality table produced for the reach.

Table 87: Water quality PES: SQR W56A-01372, Lusushwane River (U-61)

RIVER	Lusushwane River	**Water Quality Monitoring Points**	
		RC	Benchmark boundary tables (DWAF, 2008).
IUCMA site code	U-61	**PES**	IUCMA data, U-61: July 2016-Sept 2019; n=39.
Confidence assessment	Confidence in the assessment is **low**, as little DO, temp., turbidity or metal data, and a short data record for PES.		
Water Quality Constituents		**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$	-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	PO_4-P (mg/L)	0.005	A/B (0.5)
	TIN-N (mg/L)	0.3	B (1)
Physical variables	pH (5^{th}+95^{th} percentiles)	6.6+7.7	A (0)
	Temperature	-	Little impact expected, other than abstraction for upstream cultivation activities. A/B (0.5)
	Dissolved oxygen	-	
	Turbidity (NTU)	-	Some impact is expected from upstream (forestry and cultivation activities. High sand deposition and movement was noted by the invertebrate specialist. C (2)
	Electrical conductivity (mS/m)	11.61	A (0)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category	C (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	0.1	C (3)
OVERALL SITE CLASSIFICATION (from PAI)		**B (85.5%)**	

- No data.

Table 88: PAI table for SQR: W56A-01372, Lusushwane River (U-61)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	4.00	60.00		50.00
Salts	1.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	1.00	NONE SPECIFIED	4.00	70.00		65.00
Water Temperature	0.50	N	2.50	60.00		70.00
Water clarity	2.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	0.50	N	2.50	65.00		70.00
Toxics	1.00	N	2.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	0.84	MEAN CONF →	3.07			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	0.84					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	0.87					
FINAL PC MODIFICATION RATING	0.84					
P-C CATEGORY %	P-C CATEGORY					
85.5	B	REVISED % & CATEGORY (2014)				

Table 89 shows the water quality state at this site as compared to the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline and pink shading indicates a small exceedance. Orange shading is used when it is uncertain whether guidelines have been exceeded.

Table 89: Comparison to water quality guidelines: SQR W56A-01372, Lusushwane River (U-61)

Metric		International Obligations
Physical variables	pH	6.5-8.5
	Electrical Conductivity (mS/m)	150
Nutrients	PO_4 (mg/L P)	2
	NO_2+NO_3 (mg/L N)	50
Toxics	Ammonia (mg/L N)	1
Microbial	Faecal coliforms (cfu/100mL)	2 000 (190, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	10 000 (>2 420, n=1, Sept 2019)

Note the following points regarding analysis:

- Data records are short, with the assessment therefore being of very low confidence.
- Water quality state appears **Good** for this river reach.

- It is suggested that a more definitive test is undertaken for total coliforms, as it is unknown whether (for example) >2 420 cfu exceeds the 10 000 cfu guideline.

Impacts for SQR

- Forestry and forestry related activities
- Alien and invasive plant species in riparian zone
- Excessive siltation and sedimentation

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (80.4%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Lushushwane			Lusutfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5LUSU-IFRSI (EWR KU1)			W56A	W56A-01372
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.20865	E 30.86326	1 403	Upper foothills
AQUATIC ECOREGION	Level I			Level II
	11. Highveld			11.04

Figure A-119. Upstream view of the site on the Lusushwane River, W5LUSU-IFRS1 (05 August 2019).

Figure A-120. Downstream view of the site on the Lusushwane River, W5LUSU-IFRS1 (05 August 2019).

Figure A-121. Upstream view of the site on the Lusushwane River, W5LUSU-IFRS1 (25 September 2019).

Figure A-122. Downstream view of the site on the Lusushwane River, W5LUSU-IFRS1 (25 September 2019).

SQ REACH NUMBER W56C-01514

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W56C-01514	W5LUSU-FORES	Lushushwane	S-26.36328 E 31.05485	1 068	30.4	C	Not sampled					C 70%	2015
							C 72 %	C 76.7%	C 74.4%	BC 81.1%	C 77.2 %		2019

General description

Reach W56C-01514: Lushushwane River from confluence with Motjane to confluence with Mhlambanyatsi River

This site on the Lusushwane River falls within PESEIS Reach Code W56C-01514, which is indicated as 30.4 km in length (from Department of Water and Sanitation 2014). The reach starts at close to the sampling site, downstream from the Motjane-Lusushwane confluence. The reach ends at the Lusushwane's confluence with the Mhlambanyatsi River. The main river channel is 145 km, originating at an elevation of 1,740 m a.s.l., flowing first in an east-north easterly direction and then south easterly towards the sampling point, W5LUSU-FORES, which is at an elevation of 1,068 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) vegetation type and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005). No landcover and landuse practises available on GEOTERRAIMAGE, 2015 for this SQ reach.

Instream Habitat Integrity

The IHI for the SQ reach W56C-01514 was calculated at 71.6% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site W5LUSU-FORES (W56C-01514) was sampled the first time for this river reach. This reach is characterised as a steep gradient river of the upper foothills geomorphological zone. The site is dominated by alluvial rocks and cobbles with large boulders in the rapids, riffles and runs. A small tributary joins the Lusushwane River at this site. The fish velocity depth classes consisted of abundant fast shallow fish habitat, fast deep habitat moderately present, with slow shallow moderately present and slow deep sparse. The substrate consisted primarily of cobbles, rocks and boulders with a high abundance rating providing cover for fish. Other fish cover present was overhanging vegetation sparsely present in the slow habitat types. Undercut banks and root wads were not recorded.

Table 90: Fish species expected based on the PESEIS Reach Code (W56C-01514) W5LUSU-FORES; is listed, and the fish species percentage composition during the different surveys is indicated.

W56C-01514	Expected Species	W5LUSU-FORES			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X			-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X			1	1.41
Labeobarbus marequensis	X			-	-
Labeobarbus nelspruitensis	X			-	-
Labeobarbus polylepis	X			2	2.82
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X			8	11.27
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X			-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X			57	80.28
Chiloglanis emarginatus	X			-	-
Chiloglanis swierstrae	X			-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X			-	-
Tilapia sparrmanii	X			3	4.22
Number of species recorded	12	Not Sampled		5	
Number of individuals				71	
Electro-fishing time (minutes)				32minutes	
Catch/Unit Effort (CPUE)				2.22	
Fish Ecostatus (FRAI Value)				**CATEGORY C** 72%	

Twelve indigenous fish species are expected to occur in this river reach of which only five were collected during the survey (Table 90). The most abundant species was the reophilic, *Chiloglanis anoterus* (80.28% of fish assemblage; 57 individuals). The second most abundant species was *Amphilius uranoscopus* (11.27% of fish assemblage; 8 individuals). Three large yellowfish species are expected to occur in this reach, but only one species, *Labeobarbus polylepis*, was collected at a low abundance (2 individuals; 2.82% of all fish found). The reason for low abundance numbers was high flow conditions limiting access to certain habitats.

The CPUE (catch per unit effort) was calculated at 2.22 (71 individuals; 32 minutes) confirming a relative abundance of fish found at this site.

A Fish Ecostatus rating of 72% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity and abundance of species).

Invertebrates

The W5LUSU-FORES) site on the Lusushwane River was sampled for the first time (on record) in August 2019. In total 27 SASS taxa were encountered, with sensitive rated SASS taxa present but not dominant. Taxa tolerant to organic pollution dominated, with the functional feeding groups dominated by gathering collectors. Conditions in the PESEIS reach based on MIRAI (Table 91) were rated as moderately impaired (Category C – 76.7%) in August 2019

Table 91: Comparison of the 2019 SASS5 results for SQ reach W56C-01514.

W56C-01514	W5LUSU-FORES	2015	2019	
	Total SASS Score		168	Change
	No. of SASS Families		27	
	Average Score Per Taxon		6.2	
	SQ REACH SUMMARY Invertebrate Ecostatus	Not sampled	Category C 76.7%	

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural conditions with few modifications. The Riparian IHI was calculated at 76.48% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (74%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- The marginal and lower riparian zones are characterised by a high infestation with invasive weeds, dominated by the high water-using species *Acacia mearnsii*.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (77.2%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF	
Lushushwane			Lusutfu	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5LUSU-FORES			W56B	W56C-01514
GPS COORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.36328	E 31.05485	1 068	Upper foothills
AQUATIC ECOREGION	Level I			Level II
	4. North Eastern Highlands			4.06

Figure A-123. Upstream view of the site on the Lusushwane River, W5LUSU-FORES (23 August 2019).

SQ REACH NUMBER W56F-01762

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W56F-01762	W5LUSU-MALUN	Lushushwane	S-26.59915 E 31.36973	386	5.7	C	AB 88.3%	C* 73.6%	BC 79.9%	C** 77.5%	BC 78.7%	BC 70%	2015
							B 82.8%	C 64.1%	C 73.5%	C 68%	C 71.1%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W56F-01762: Lushushwane from confluence with Mzimene River to its confluence with Lusutufu River.

The site falls within PESEIS Reach Code W56F-01762, which is indicated as 5.7 km in length (from Department of Water and Sanitation 2014). The reach starts at the Lusushwane River's confluence with the Mzimnene River (W56F-01591) and ends at its confluence with the Lusutfu River. The length from the source of the Lusushwane River to the W5LUSU-MALUN sampling point measured on Google Earth Pro is 140 km. The main river channel is 146 km, originating at an elevation of 1,740 m a.s.l., flowing first in a southeast by easterly direction towards the sampling point, W5LUSU-MALUN, which is at an elevation of 85 m a.s.l. The site is in the Granite Lowveld (from Mucina & Rutherford 2006) vegetation type and falls within North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005)

Landcover consists mainly of open spaces with overgrazed grasslands. Landuse practises include agriculture with commercial forestry mostly *Pinus*. Luphohlo Dam and several small farm dams as well as rural settlements are recorded within the catchment. No data available for landcover or landuse practise on GEOTERRAIMAGE, 2015.

Instream Habitat Integrity

The IHI for the SQ reach W56F-01762 was calculated at 70.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The site W5LUSU-MALUN (W56F-01762) is just downstream from a river crossing which act partly as a barrier for fish movement. All of the fish velocity depth classes are present with fast shallow (abundant), fast deep (sparse) and both of the slow classes moderately abundant. The fish cover present rated sparse to moderately for overhanging vegetation created by grasses in the riparian zone. The substratum varied from sparse to abundant and consisted of rocks, cobbles

and pebbles in the fast shallow habitat and fine silt and sand in the slow habitat. Aquatic macrophytes provided good cover for fish in the deep habitat.

Table 92: Fish species expected based on the PESEIS Reach Code (W56F-01762) W5LUSU-MALUN; is listed, and the fish species percentage composition during the different surveys is indicated.

W56F-01762	Expected Species	W5LUSU-MALUN			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	3	0.50	2	0.78
Petrocephalus wesselsi	X	-	-	-	-
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius paludinosus	X	25	4.12	-	-
Enteromius trimaculatus	X	8	1.32	13	5.04
Enteromius unitaeniatus	X	26	4.29	7	2.71
Enteromius viviparus	X	50	8.25	72	27.91
Labeo cylindricus	X	-	-	-	-
Labeo molybdinus	X	3	0.50	-	-
Labeobarbus marequensis	X	30	4.95	84	32.56
Labeobarbus polylepis	X	30	4.95	-	-
Mesobola brevianalis	X	20	3.30	-	-
Opsaridium peringueyi	X	12	1.98	24	9.30
Characidae (Characins)					
Micralestes acutidens	X	12	1.98	8	3.10
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	-	-	-	-
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	3	0.50	3	1.16
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	100	16.50	13	5.04
Chiloglanis emarginatus	X	50	8.25	5	1.94
Chiloglanis paratus	X	23	3.79	4	1.55
Chiloglanis swierstrae	X	50	8.25	1	0.39
Gobiidae (Gobies)					
Awaous aeneofuscus	X	1	0.17	-	-
Cichlidae (Cichlids)					
Oreochromis mossambicus	X	150	24.75	7	2.71
Pseudocrenilabrus philander	X	10	1.65	7	2.71
Tilapia sparrmanii	X	-	-	8	3.10
Number of species recorded	24	19		15	
Number of individuals		606		258	
Electro-fishing time (minutes)				34 minutes	
Catch/Unit Effort (CPUE)				7.59	
Fish Ecostatus (FRAI Value)		**CATEGORY AB** 88.3%		**CATEGORY B** 82.8%	

A Total of 24 fish species is expected to occur within this reach. Fifteen (15) species were recorded, four species less than for the 2015 survey (Table 92). The assemblage was dominated by the flow dependant species with *Labeobarbus*

marequensis (32.56%; 84 individuals). Other reophilic species include *Enteromius trimaculatus, Enteromius unitaeniatus*, and *Opsaridium peringueyi.* The presence of the four reophilic and habitat specialists, *Chiloglanis anoterus* (5.04%; 13 individuals); *Chiloglanis swierstrae* (0.39%, 1 individual), *Chiloglanis paratus* (1.5%; 4 indiviuals) and *Chiloglanis emarginatus* (1.94%; 5 individuals) is highly significant as this is the only site during this 2019 survey where al four species were recorded at the same time. Cihlid species collected during this survey include *Tilapia sparrmanii* (3.10%; 8 individuals), *Oreochromis mossambicus* (2.7%; 7 individuals) and *Pseudocrenilabrus philander* (27%; 7 individuals). The CPUE (catch per unit effort) calculated for this site is 7.59 (258 individuals; 34 minutes). Although the time was not recorded during the 2015 survey, a high abundance of fish was prevelant (collected 606 individuals).

A Fish Ecostatus rating of 82.8% was calculated for this reach based on all available information, placing this reach in an Ecological Category B (largely natural with moderate diversity and abundance of species) which is a lower Ecological Category than for the 2015 survey (AB).

Invertebrates

Two SASS sampling events are on record for the W5LUSU-MALUN site in this reach on the Lusushwane River. These sampling events occurred in July 2015 and this survey in September 2019. In total 43 SASS taxa have been recorded during these eight sampling events. SASS taxa rated tolerant were dominant during both sampling events, with high taxa diversity in 2015. In both samples, taxa highly tolerant to organic pollution were dominant. The biggest difference between the 2015 and 2019 results were in the stones biotope, with a change in community composition and decrease in taxa diversity. Sensitive taxa absent from the 2019 sample but present in 2015 included Athyidae, Perlidae, Tricorythidae, Chlorocyphidae, Aeshnidae, Cordulidae (Macromiidae), Gomphidae, Ecnomidae, one Hydropsychidae species, Hydroptilidae, Leptoceridae, and Ancylidae.

Table 93: Comparison of the 2019 SASS5 results for SQ reach W56F-01762.

W56F-01762	W5LUSU-MALUN	2015	2019	
	Total SASS Score	208	119	
	No. of SASS Families	35	26	Change
	Average Score Per Taxon	5.9	4.6	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 79.9%	Category C 64.1%	↘

The MIRAI 2019 results (Table 93) indicate similair conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 73.6%) in July 2015 and (Category C – 64.1%) in September 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 59.7% rating this reach as a Category CD indicating a close to largely modified riparian habitat most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (68%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Water Quality

Biomonitoring results using macroinvertebrates identified two SQR which may be impacted in terms of water quality, with this being one of those reaches

- W56F-01762, Lusushwane River, biomonitoring site W5LUSU-MALUN: MIRAI – C/D category

No water quality data could be accessed for this site, which is located in Swaziland, with the responsible water authority being the eSwatini or (Swaziland) Water Services Corporation. In the absence of data or more detailed information, the low confidence desktop water quality assessment is used and modified, as shown below.

MIRAI category	Desktop wq rating / Equivalent wq category	Identified impacts
C/D	2-3 (C/D-D)	Extensive dryland cultivation; roads; two tributaries join immediately upstream of the biomonitoring site. Matsapha town is drained by the Lusushwane in the upstream SQR (W56F-01648), with its associated urban impacts, including a WWTW and Swazi Paper Mills close to the river. The other upstream tributary is the Mzimneni (SQR W56F-01648) which drains the urban and rural area of Manzini, with its associated wq impacts, including a WWTW close to the lower reaches of the river.

Water quality state is expected to be highly impacted due to the upstream urban settlements, although the site is below the confluence of the Lusushwane and Mzimneni rivers, and at least 10 kms downstream of Matsapha and Manzini. Water quality data collected during the 2015 survey was not definitive as detection limits were not sensitive enough for many variables measured; although nutrient and aluminium levels were elevated. Ongoing monitoring is needed to confirm these findings. **A water quality category of a CD is expected due to noted impacts.**

Impacts for SQR

- High quantities of domestic waste in the stream and riparian zone.
- High infestation of the riparian zone with invasive weeds
- High infestation of the river above the bridge with aquatic weeds (e.g. *Eichhornia crassipes, Pistia stratiotes*).

- The bridge causes upstream impoundment, which increase deposition and overtopping during high flows.
- The overtopping causes downstream bank and bed scouring.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (71.1%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗	
Possible Reasons: • Deteriorating water quality – recommended detailed monitoring of water quality on regular basis • Low Invertebrate / Fish Category as a result of loss of available instream habitat due to siltation • Reduced riparian zone	

RIVER			TRIBUTARY OF	
Lushushwane			Lusutfu	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5LUSU-MALUN			W56F	W56F-01762
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.59915	E 31.36973	386	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highlands		4.06	

Figure A-124. Upstream view of the site on the Lusushwane River, W5LUSU-MALUN (20 July 2015).

Figure A-125. Downstream view of the site on the Lusushwane River, W5LUSU-MALUN (20 July 2015).

Figure A-126. Upstream view of the site on the Lusushwane River, W5LUSU-MALUN (10 September 2019).

Figure A-127. Downstream view of the site on the Lusushwane River, W5LUSU-MALUN (10 September 2019).

Discussion Lushushwane Sub-catchment Reaches

Fish

A total of 24 indigenous fish species are expected to occur in this sub-catchment of which 18 species were recorded for the present survey, three species less than recorded during the 2015 IUCMA survey. Two species collected during the present survey were not recorded for the 2015 survey namely *Amphilius uranoscopus* and *Marcusenius pongolensis*. The species recorded during the 2015 survey but not collected during the 2019 survey are *Awaous aeneofuscus, Enteromius paludinosus, Labeo molybdinus, Mesobola brevianalis* and *Petrocephalus wesselsi*. To date a total of 23 species are recorded of the expected 24 species for this sub-catchment since the IUCMA surveys started. The most abundant fish species collected for the present survey is *Chiloglanis anoterus* with a relative abundance of 23.73% of the total number of fish collected. *Oreochromis mossambicus* was the most abundant species found during the 2015 survey with a relative abundance of 22.22% of the total number of fish collected. Two species of fish, *Chiloglanis anoterus* and *Tilapia sparrmanii*, were found at all of the sites done for this sub-catchment. The site where the highest number of fish species were recorded is also the furthest downstream site, W5LUSU-MALUN, where a total of 15 fish species was recorded. The highest abundance of fish was recorded at this site where a CPUE of 6.79 fish caught per minute was recorded. No alien and invasive fish species was recorded to date in this sub-catchment.

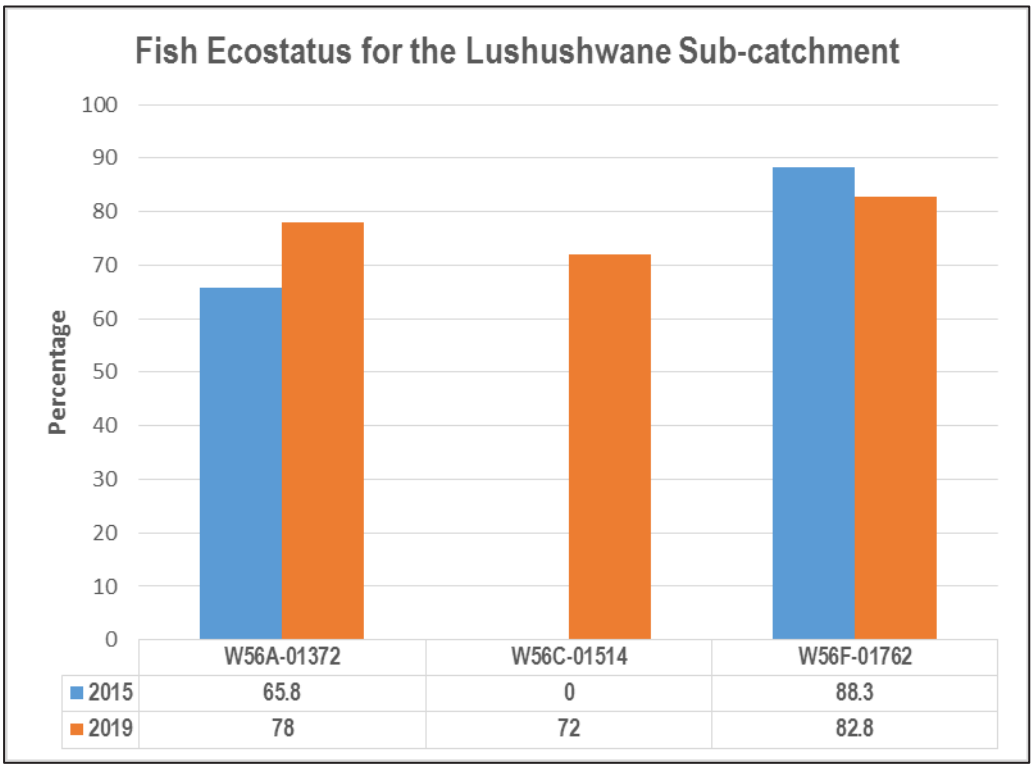


Figure 56: Summary of the Fish Ecostatus for the Lushushwane Sub-catchment for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model.

Figure 12 summarise the Fish Ecostatus categories for the 3 SQ reaches on the Lushushwane Sub-catchment. The Fish Ecostatus rating for the SQ reach W56F-01762 decreased from a Category AB (88.3%) to a category B (82.8%). This can be attributed to decreasing water quality as a result of urban impacts and Swazi Papermill industries within this reach (Water quality Category CD). The overall Fish Ecostatus rating for 2019 is 77.6% placing the Lushushwane sub-catchment in a high Category C. This is consistent with the 2015 results of 77.1% and also a high Category C. The present category C (77.6%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

Invertebrates

Overall conditions in the Lusushwane remains in a moderately impaired Category C (Table 94 and Figure 57).

Table 94: Summary of 2019 stream conditions per SQ Reach based on MIRAI.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	
W56	Lusushwane	W56A-01372		75.6	
		W56C-01514		76.7	
		W56F-01762	73.6	64.1	→

When comparing the Invertebrate Ecostatus between 2015 and 2019 (Figure 57), conditions improved in general. The overall Invertebrate Ecostatus rating for 2019 is 72.1% placing the mainstem in a high Category C. This is consistent with the 2015 results of 65.4% a low Category C. The present category C (72.1%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

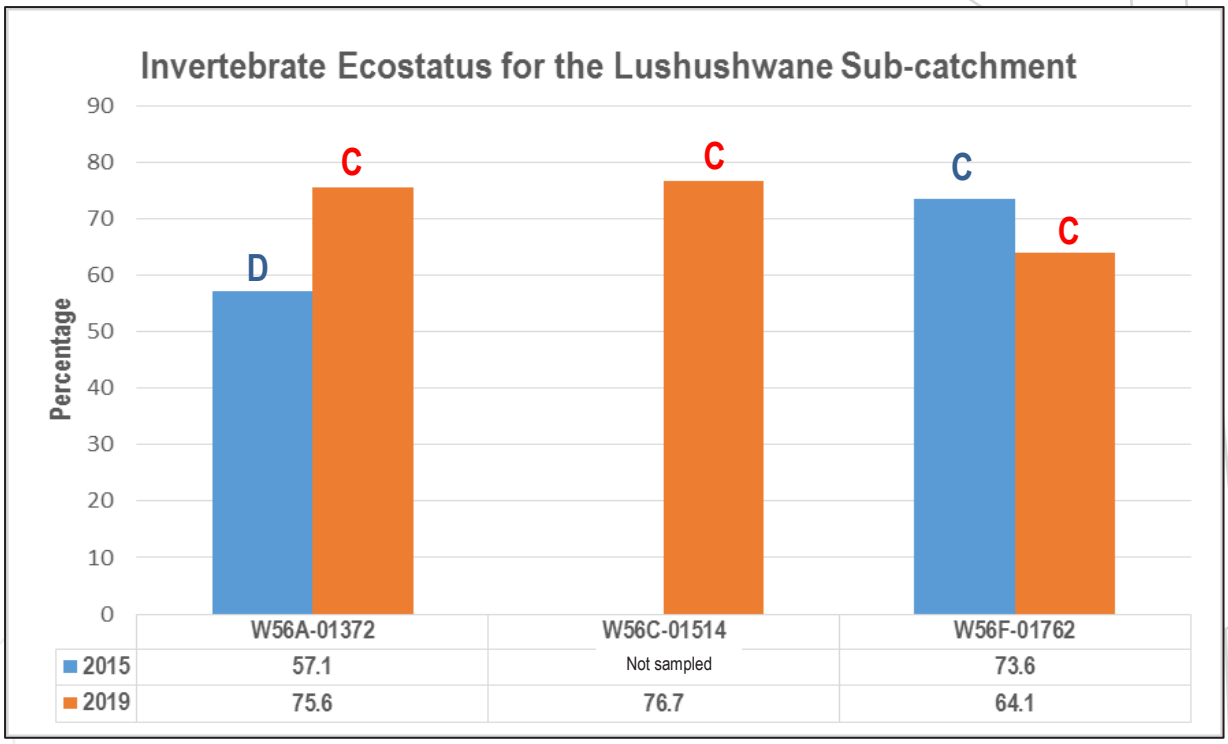


Figure 57: Graphical comparison of the Invertebrate Ecostatus of the Lushuswane Sub-catchment in 2015 and 2019

Water Quality

The water quality assessment was limited to specific sites, with a discussion of results provided below the results of the data assessment. Water quality state of the Lusushwane reach assessed (W56A-01372) was **Good** (B category), although data records are too short to make any assessment with confidence.

The site assessed on a desktop level (W56F-01762) suggested a **highly impacted water quality state** due to upstream urban settlements and associated activities. Ongoing water quality monitoring is needed in this sub-catchment, particularly downstream Matsapha and Manzini.

Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Lushushwane Sub-catchment

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity. From Figure 58 it is evident that the Instream Ecostatus for the 2019 biomonitoring rated an overall Category C (74.9%) ranging from a category C (73.5%) to a category higer Category C (76.8%). The Instream Ecostatus for 2015 surveys was a consistent C category (70.4%).

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model (Figure 59). The overall Integrated Ecostatus for

the Lushushwane sub-catchment remained consistent throughout the 2019 (76.2%) and 2015 (73.3%) monitoring placing it in a high Category C.

When comparing the Integrated Ecostatus derived from the RIVDINT model with the Recommended Ecological Category within the various SQ reaches all the set REC's were met accept SQ reaches W56F-01762 (W5LUSU-MALUN) which is primarily influenced by reduced water quality (Category CD) impacting on the reach.

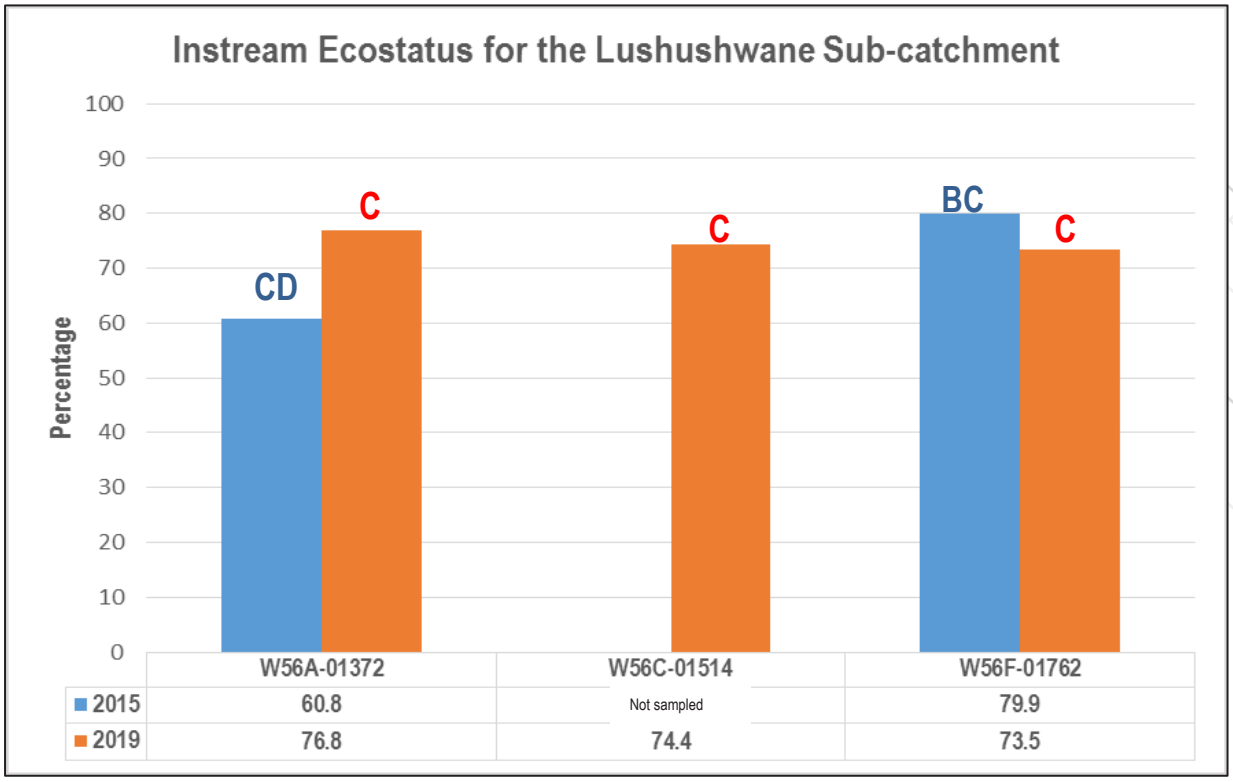


Figure 58: Comparison of the Instream Ecostatus of the Lushushwane Sub-catchment in 2015 and 2019.

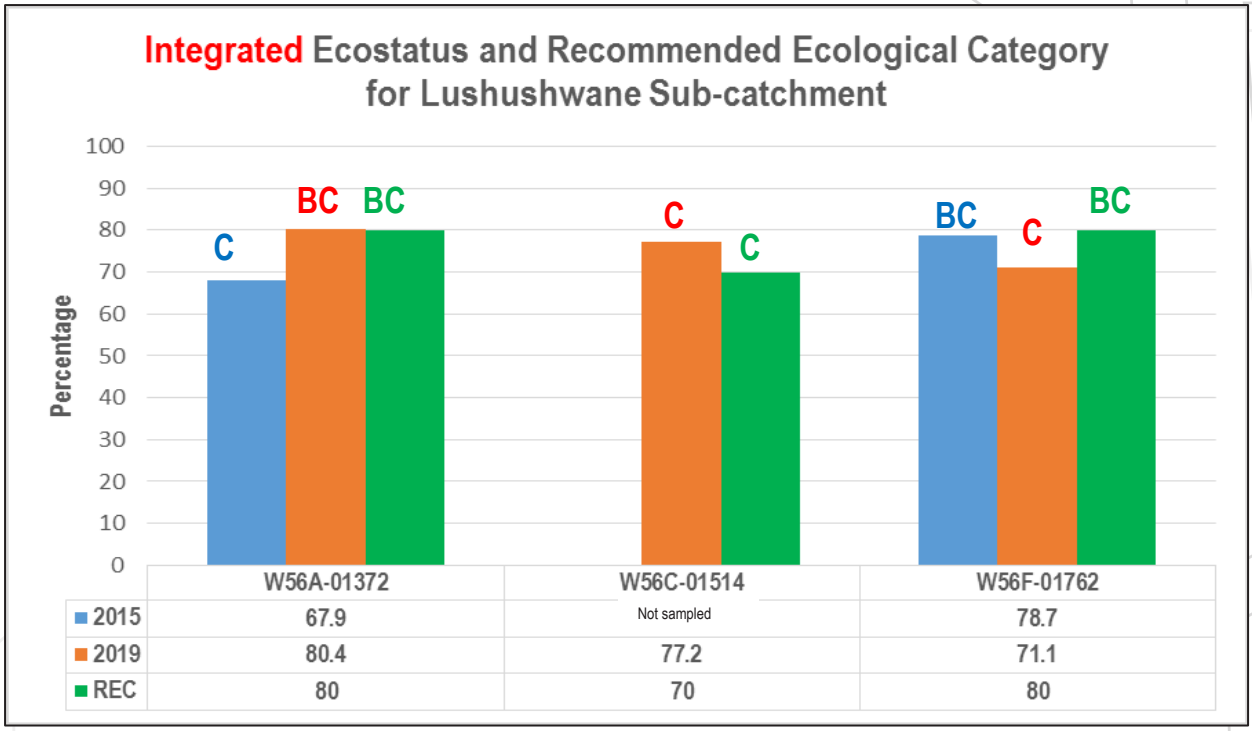


Figure 59: Comparison of the Integrated Ecostatus and Target Ecological Category for the Lushushwane Sub-catchment in 2015 and 2019.

Usuthu-Lusutfu Sub-catchment Reaches

The Usuthu-Lusutfu River catchment originates in the Highveld aquatic ecoregion, and then flows in a general southeast by easterly direction towards its confluence with the Phongoglo River on the vorder between South Africa and Mozambique. A total of 6 biomonitoring points representing 5 SQ reaches (91.1 km) representing 8.5% of the river monitored on the Usuthu-Lusutfu River catchment sampled during 2019.

SQ REACH NUMBER W54C-01556

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W54C-01556	W5BONN-BROAD	Bonnie Brook	S-26.50559 E 30.64736	1 489	21.4	C	C 70.7%	C* 74.9%	C 73.1%	B** 85%	BC 79.1%	BC 80%	2015
							C 64.6%	BC 78.9%	C 71.5%	C 77%	C 74 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W54C-01556: Unnamed tributary confluence with Bonnie Brook to confluence with Usuthu River

The site falls within PESEIS Reach Code W54C-01556, which is indicated as 21.4 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the main Bonnie Brook (W54C-01552) and an un-named tributary (W54C-01512) and ends at the Bonnie Brook's confluence with the Usutu River downstream from Westoe Dam. The length from the source of the Bonnie Brook to the W5BONN-BROAD sampling point measured on Google Earth Pro is 34.5 km, and to its confluence with the Lusutfu River 34.6 km. The main river channel originates at an elevation of 1,720 m a.s.l., flowing in an SSE direction towards the sampling point, W5BONN-BROAD, which is at an elevation of 1,489 m a.s.l. The site is in the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and falls within the Highveld aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of wetlands (7.1%), woodlands open bush (1.4%) and open spaces with grassland (23.8%). The Landuse practices include mixed agriculture (cultivated crops 3.1%) and forestry plantations (62.8%) (GEOTERRAIMAGE, 2015) dominates the catchment. Several small dams and weirs are recorded. Water is transferred to Westoe Doam and sall rural settlements are recorded.

Instream Habitat Integrity

The IHI for the SQ reach W54C-01556 was calculated at 75.8% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This site W5BONN-BROAD (W54D-01556) is on a tributary of the main stem Usuthu River. A diversity of shallow habitat types was present with slow shallow abundant and fast shallow sparse with shallow riffles and runs. The slow shallow habitats recorded were extreme making it unsuitable for flow dependant species. No deep habitat is present at this site. Boulders and large rocks dominated the site and substrate cover was provided by layers of boulders and rocks which was difficult to sample. Overhanging vegetation was sparse and undercut banks were absent. No aquatic macrophytes was present, not even up and downstream from the site.

Table 95: Fish species expected based on the PESEIS Reach Code (W54D-01556) W5BONN-BROAD; is listed, and the fish species percentage composition during the different surveys is indicated.

W54D-01556	Expected Species	W5BONN-BROAD			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeobarbus marequensis	X	-	-	-	-
Labeobarbus polylepis	X	-	-	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	2	8.33	5	5.44
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	5	20.83	-	-
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	2	8.33	9	9.78
Tilapia sparrmanii	X	15	62.51	78	84.78
Number of species recorded	10	4		3	
Number of individuals		24		92	
Electro-fishing time (minutes)				26 minutes	
Catch/Unit Effort (CPUE)				3.54	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 70.7%		**CATEGORY C** 64.6%	

The fish assemblage recorded during the present survey consisted of only three indigenous fish species of an expected ten species, one species less than recorded for the 2015 survey (Table 95). Both of the two limnophilic Cichlids, *Tilapia sparrmanii* and *Pseudocrenilabrus philander* expected to occur, was collected with *Tilapia sparrmanii* (84.78% of all fish collected; 78 individuals) in abundance at the available slow shallow habitat in between the rocks and boulders. *Chiloglanis anoterus* was recorded as the second most abundant species for the 2015 survey, but was not recorded

during the present survey and can be related to the extreme low flow conditions with an absence of instream available fish habitat to the species. The CPUE (catch per unit effort) calculated for the site is 3.54 (92 individuals; 26 minutes) indicating a relative abundance of fish present, but with a low diversity of species. The time for the electrofishing for the 2015 survey was not noted.

A Fish Ecostatus rating of 64.6% was determined for this reach placing it in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey but with a lower rating.

Invertebrates

Two SASS sampling events are on record for the W5BONN-BROAD site in this reach on the Bonnie Brook. These sampling events occurred in August 2015 and this survey in August 2019. In total 41 SASS taxa have been recorded during these eight sampling events. Sensitive rated SASS taxa were dominant during both sampling events, SASS taxa diversity relatively high. The biggest difference between the 2015 and 2019 results were in the stones biotope, with the community composition and an increase in taxa diversity. Sensitive taxa absent from the 2019 sample but present in 2015 included Polymitarcidae. Sensitive taxa absent from the 2015 sample but present in 2019 included Chlorocyphidae, Aeshnidae, and Dixidae.

Table 96: Comparison of the 2015 and 2019 SASS5 results for SQ reach W54C-01556.

W54C-01556	W5BONN-BROAD	2015	2019	
	Total SASS Score	198	210	
	No. of SASS Families	33	35	Change
	Average Score Per Taxon	6.0	6.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 74.9%	Category BC 78.9%	↗

The MIRAI 2019 results (Table 96) indicate a slight improvement in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 74.9%) in August 2015 and close to largely natural most of the time (Category BC – 78.9%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 85% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 70.5% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- Sedimentation and siltation

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (74%)	**Category BC (80%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.

Integrated Ecostatus NOT consistent to Recommended Target Ecological Category ✗

Possible reason

- High loads of siltation and sedimentation impacting on instream habitat
- Riparian vegetation reduced

RIVER			TRIBUTARY OF	
Bonnie Brook			Usuthu	
SITE NUMBER		QUATERNARY SUB-CATCHMENT		REACH
W5BONN-BROAD		W54C		W54C-01556
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.50559	E 30.64736	1 489	Upper foothills
AQUATIC ECOREGION	Level I			Level II
	11. Highveld			11.04

Figure A-128. Upstream view of the site on the Bonnie Brook, W5BONN-BROAD (20 August 2015).

Figure A-129. Downstream view of the site on the Bonnie Brook, W5BONN-BROAD (20 August 2015).

Figure A-130. Upstream view of the site on the Bonnie Brook, W5BONN-BROAD (19 August 2019).

Figure A-131. Downstream view of the site on the Bonnie Brook, W5BONN-BROAD (19 August 2019).

SQ REACH NUMBER W54D-01593

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W54D-01593	W5USUT-STAFF	Usutu	S-26.50336 E 30.77666	1 413	42.5	B	C 70%	BC* 78.2%	C 73.2%	B** 82.5%	C 77.2%	BC 80%	2015
	W5LUSU-MANGC	Lusutfu	S-26.54346 E 30.85552	1 287			C 73.7%	BC 79.5%	C 76.6%	B 82.5%	BC 79.1%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W54D-01593: Confluence of Usuthu River with Bonnie Brook to confluence of Usuthu with Mpuluzi River in Swaziland.

Two sites, namely W5USUT-STAFF and W5LUSU-MANGC are located within this PESEIS Reach Code W54D-01593. The length of the reach code is indicated as 42.5 km (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Usuthu River with the Bonnie Brook (downstream from the Westoe Dam) and ends at the confluence of the Lusutfu with the Mpuluzi River in Swaziland. The length from the source of the Usuthu River to the W5USUT-STAFF sampling point measured on Google Earth Pro is 89.4 km. The site is located 17.6 km downstream from the Westoe Dam wall. The length from the source of the Usuthu River to the W5LUSU-MANGC sampling point measured on Google Earth Pro is 101 km, located 11.6 km downstream from the Stafford site (W5USUT-STAFF). The W5LUSU-MANGC site is located 38 km downstream from the Westoe Dam wall. The main river (Usuthu-Lusutfu-Indian Ocean) is 451 km, originating at an elevation of 1,714 m a.s.l., flowing in an east by southerly direction towards the sampling point, W5USUT-STAFF (elevation of 1,413 m a.s.l.) and W5LUSU-MANGC, which is at an elevation of 1,287 m a.s.l. Both sites fall within the KaNgwane Montane Grassland (from Mucina & Rutherford 2006) and Highveld aquatic ecoregion (from Kleynhans et al. 2005). Landcover consists mainly of wetlands (5%) and grasslands (14%). Landuse practises include agriculture with cattle, dry land and irrigated crops (>1%) as well as *Pinus and Eucalyptus* forestry (plantations 39%) and the Westoe Dam within the catchment (GEOTERRAIMAGE, 2015).

Instream Habitat Integrity

The IHI for the SQ reach W54D-01593 was calculated at 75.8% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This SQ Reach (W54D-01593) is 42,5km and is represented by two biomonitoring sites, namely W5USUT-STAFF and W5LUSU-MANGC:

The W5USUT-STAFF site is characteristic of a lower foothill stream with a gentle gradient and fast flowing river. This river reach habitat presented similar to previous surveys with mostly fast habitat: The fish velocity depth classes present were fast shallow (abundant), slow deep (sparse) and slow shallow (moderate). The fish cover present rated sparse to moderately for overhanging vegetation created by grass in the riparian zone. The substratum varied from sparse to moderate and consisted of a bedrock, rocks, cobbles and pebbles. Aquatic macrphytes provided some cover for fish at the shallow habitats.

The W5LUSU-MANGC site is at a bridge over bedrock and the habitat remained relatively consistent since the 2015 survey. All of the fish velocity depth classes were present with slow deep (moderate), slow shallow (sparse), fast deep (sparse) and fast shallow (abundant). Overhanging vegetation and undercut banks was moderately present at the slow deep habitat. Boulders, rocks and cobbles over bedrock provide the necessary in-stream cover for especially the flow dependant fish species, but also provided cover for limnophilic fish in the slow shallow habitat. No aquatic macrophytes provided any cover for fish.

Table 97: Fish species expected based on the PESEIS Reach Code (W54D-01593) W5USUT-STAFFand W5LUSU-MANGC is listed, and the fish species percentage composition during the different surveys is indicated.

W54D-01593	Expected Species	W5USUT-STAFF			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	1	1.02	1	1.30
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeobarbus marequensis	X	-	-	-	-
Labeobarbus nelspruitensis	X	-	-	-	-
Labeobarbus polylepis	X	-	-	1	1.30
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	6	6.12	4	5.20
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	65	66.33	27	35.06
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	17	17.35	29	37.66
Tilapia sparrmanii	X	9	9.18	15	19.48
Number of species recorded	12	5		6	
Number of individuals		98		77	
Electro-fishing time (minutes)		41 minutes		29 minutes	
Catch/Unit Effort (CPUE)		2.39		2.66	
Fish Ecostatus (FRAI Value) for W5USUT-STAFF		**CATEGORY C** 70%		**CATEGORY C** 73.6%	

W54E-01593	Expected Species	W5LUSU-MANGC			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Labeobarbus marequensis	X	-	-	2	1.61
Labeobarbus nelspruitensis	X	14	5.30	-	-
Labeobarbus polylepis	X	153	57.96	59	47.58
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	5	1.89	9	7.26
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	63	23.86	46	37.10
Chiloglanis emarginatus	X	17	6.44	-	-
Cichlidae (Cichlids)					-
Pseudocrenilabrus philander	X	9	3.41	7	5.64
Tilapia sparrmanii	X	3	1.14	1	0.81
Number of species recorded	12	7		6	
Number of individuals		264		124	
Electro-fishing time (minutes)		42 minutes		36 minutes	
Catch/Unit Effort (CPUE)		6.29		3.44	
Fish Ecostatus (FRAI Value) for W5LUSU-MANGC		**CATEGORY C** 70%		**CATEGORY C** 73.8%	
SQ REACH SUMMARY for Fish Ecostatus (FRAI Value)		**Category C** 70%		**Category C** 73.7%	

At the W5USUT-STAFF site six of the expected 12 fish species were recorded, one species less than the 2015 survey (Table 97). The assemblage was dominated by the flow dependant intolerant species, *Labeobarbus marequensis* (1.61%; 2 individuals), *Labeobarbus polylepis* (47.58%; 59 individuals), *Amphilius uranoscopus* (7.26%; 9 individuals) and *Chiloglanis anoterus* (37.1%; 46 individuals). The limnophilic fish assemblage consisted of *Pseudocrenilabrus philander* (5.64%; 7 individuals) and *Tilapia sparrmanii* (0.81%; 1 individuals). Based on the absence and low abundance of certain fish species not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered due to flow regulation from the Westoe Dam. The CPUE (catch per unit effort) calculated for this site is 2.66 (77 individuals; 29 minutes) which is slightly higher than the 2015 survey when a CPUE of 2.39 was calculated.

A total of 12 indigenous species of fish are expected to occur in this reach of which six were collected during the present survey at that W5LUSU-MANGC site (Table 97). The large barb and reophilic species, *Labeobarbus polylepis* (59 individuals; 47.58%), was the most abundant species collected during both the present and 2015 surveys. Another

reophilic, *Chiloglanis anoterus* (46 individuals; 37.10%), was the second most abundant species collected in the fast fish velocity habitats with an increase in abundance in comparison to the 2015 survey when it was recorded at a relative abundance of 23.86% of all fish found at the site. The two Cichlid species expected were recorded during both the present and 2015 surveys. Based on the absence and low abundance of certain fish species not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered. The CPUE for the present survey was calculated at 3.44 (124 individuals; 36 minutes) indicating a lower abundance of fish than recorded during the 2015 survey when a CPUE of 6.29 was calculated.

A Fish Ecostatus rating of 73.6% was calculated for the W5USUT-STAFF site based on all available information, placing this site in an Ecological Category C (moderately impaired with low diversity and moderate abundance of species) consistent with the 2015 survey. A Fish Ecostatus rating of 73.8% was calculated for the W5LUSU-MANGC site based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) which is a slightly higher rating than determined for the 2015 survey, but in the same Ecological Category (Category C – 70%).

The combinded Fish Ecostatus rating for this reach W54D-01593 was calculated at 73.7% based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) consistent with the 2015 survey results (Category C – 70%).

Invertebrates

Nine SASS sampling events are on record for the W5USUT-STAFF site in this reach on the Usutu River. These sampling events occurred in September 2003, August 2004, 2005, July 2008, June 2011, March 2015, August 2015, March 2018 and August 2019. In total 50 SASS taxa have been recorded during these nine sampling events. Non-SASS taxa recorded during the different surveys include Cladocera, Copepoda, Machadorythidae, and Lampyridae. The diversity of SASS taxa is relatively high, with sensitive taxa dominant. Total SASS scores for the nine sampling events range from 126 – 186 (avg.) – 234, and SASS-taxa diversity from 27 – 30 (avg.) – 33. Flow regulation from the upstream Westoe Dam has the biggest influence on the results at the W5USUT-STAFF.

Two sampling events are on record for the W5LUSU-MANGC on the Lusutfu River in Swaziland, 11.6 km downstream from the W5USUT-STAFF) site. These sampling events occurred in July 2015 and September 2019. In total 38 SASS taxa have been recorded during these two sampling events, with Machadorythidae representing non-SASS taxa. The diversity of SASS taxa increased considerably from 2015 to 2019, with the biggest improvement in the stones biotope and the percentage sensitive taxa. The improvement in conditions from the W5USUT-STAFF to the W5LUSU-MANGC site are attributed to increased contributions from tributaries, reducing the impact of flow regulation from the Westoe Dam.

Table 98: Comparison of the 2015 and 2019 SASS5 results for SQ reach W54D-01593.

W54D-01593	W5USUT-STAFF	2015	2019	
	Total SASS Score	180	186	
	No. of SASS Families	31	33	Change
	Average Score Per Taxon	5.8	5.6	
	SITE SUMMARY Invertebrate Ecostatus	Category BC 81.6%	Category BC 79.8%	→
	W5LUSU-MANGC	2015	2019	
	Total SASS Score	189	234	
	No. of SASS Families	29	33	Change
	Average Score Per Taxon	6.5	7.1	
	SITE SUMMARY Invertebrate Ecostatus	Category C 74.8%	Category BC 79.2%	↗
	SQ REACH SUMMARY Invertebrate Ecostatus	Category BC 78.2%	Category BC 79.5%	→

MIRAI results for 2019 (Table 98) at the W5USUT-STAFF site indicates similar conditions when compared to 2015, with both 2015 and 2019 rated as close to largely natural most of the time (BC-Category). At the W5LUSU-MANGC site further downstream, conditions improved slightly. In 2015 MIRAI results indicated moderately modified conditions at W5LUSU-MANGC, improving to close to largely natural conditions most of the time (Category-BC) in 2019. Overall, the reach was rated as largely natural to moderately impaired in 2015 and 2019 (Category BC – 78.2% and 79.5% respectively). Improved conditions are attributed to the change in flow conditions, regulated by releases or no releases from the upstream, Westoe Dam (Figure 60).

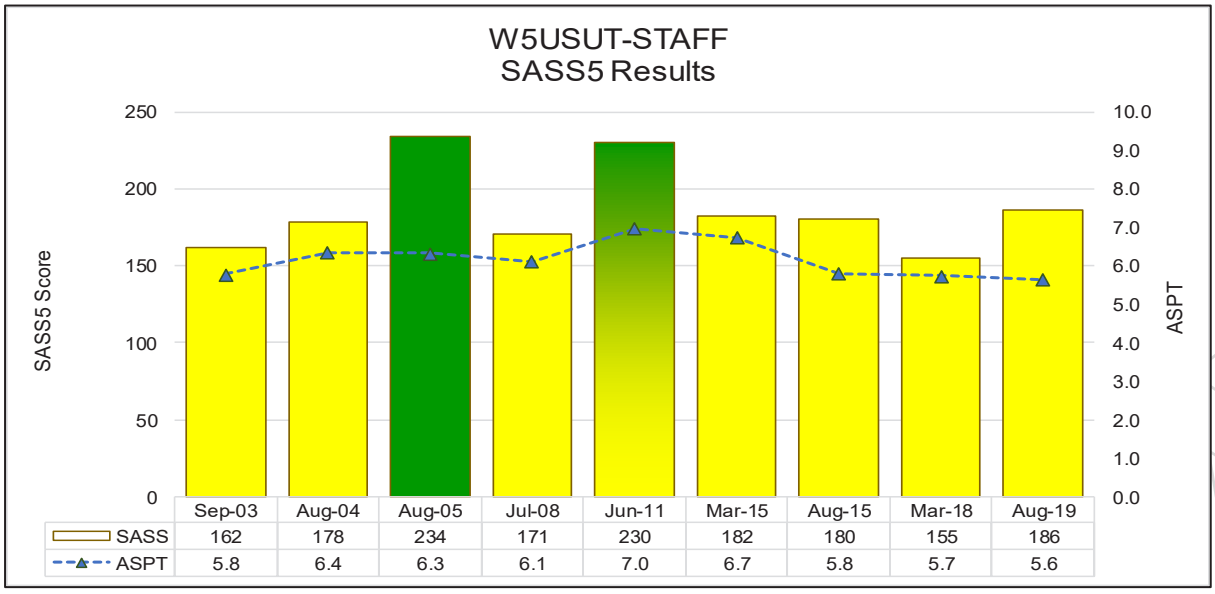


Figure 60. Graphic illustration of historical SASS results for the W5USUT-STAFF sampling site.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 82.5% and is consistent with a Category B – largely natural with few modifications. The Riparian IHI was calculated at 74.4% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category B (82.5%) indicating that the riparian vegetation for this SQ reach is largely natural with few modifications.

Water Quality

The GE image below (Figure 61) shows the water quality monitoring sites which represent the water quality state of the selected reach of the Usuthu River, i.e. IUCMA monitoring point U-53 and DWS gauging weir W5H025Q01. Note that little monitoring data was collected at W5H025Q01 between 2009 and 2015.

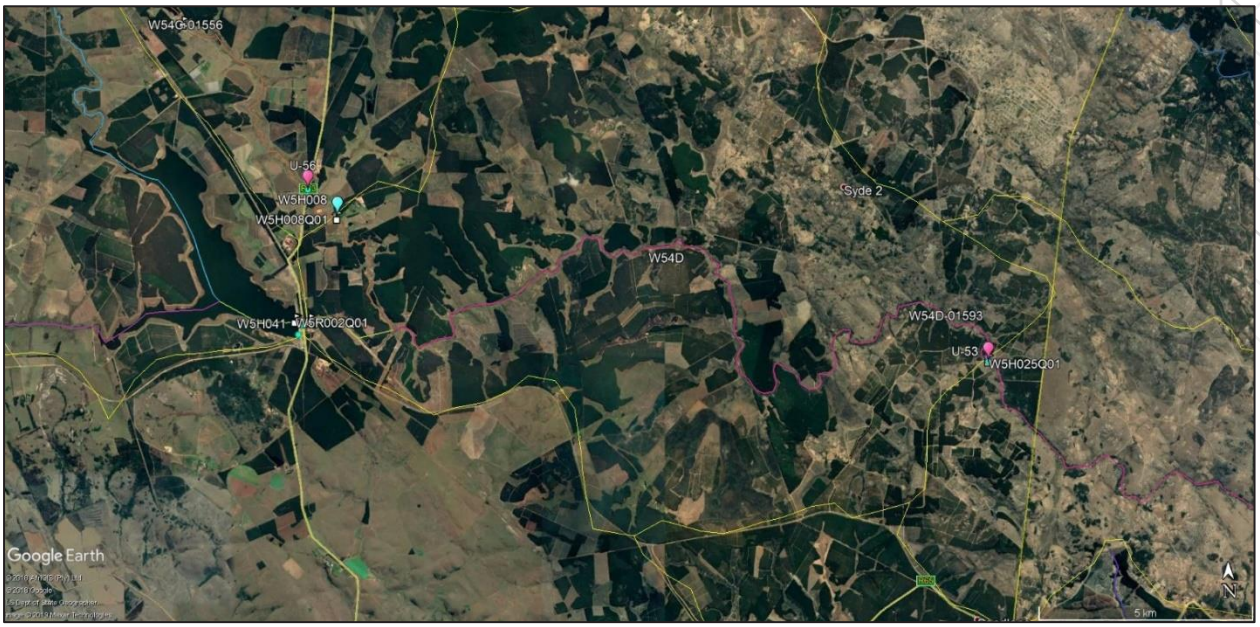


Figure 61: Google Earth image of SQR W54D-01593, Usuthu River, and water quality monitoring points in the middle of the reach.

Table 99 shows the present state assessment according to this study, with Table 100 being the associated PAI table. SQR W54D-01593 is a long river reach downstream of Westoe Dam, with the left bank upstream of the site showing little land-use, and plantations on the right bank. Forestry and cultivation are also present in the reach, particularly downstream of the dam. The water quality monitoring points are approximately in the middle of the reach, with little land-use further downstream as the Usuthu becomes the Lusutfu and travels through Swaziland in a 13km gorge.

Table 99: Water quality PES: SQR W54D-01593, Usuthu River (U-53)

		Water Quality Monitoring Points

RIVER	Usuthu River	**RC**	Benchmark boundary tables (DWAF, 2008).
IUCMA site code	U-53	**PES**	IUCMA data, U-53: July 2016-Sept 2019; n=39. W5H025Q01: 2015-2019 (n=56 for most variables).
Confidence assessment	Confidence in the assessment is **low-moderate**, as little DO, temp., turbidity or metal data.		

Water Quality Constituents		**Value**	**Category (PAI rating) / Comment**
Inorganic salts (mg/L)	$MgSO_4$	-	No method available. Electrical conductivity used as surrogate.
	Na_2SO_4	-	
	$MgCl_2$	-	
	$CaCl_2$	-	
	NaCl	-	
	$CaSO_4$	-	
Nutrients (mg/L)	PO_4-P (mg/L)	0.005: IUCMA 0.05: DWS *	C (2)
	TIN-N (mg/L)	0.05: IUCMA 0.05: DWS (TIN-N = NO_3-N + NH_4-N).	A (0)
Physical variables	pH (5^{th}+95^{th} percentiles)	6.53+7.8: IUCMA 6.68+7.8: DWS	A (0)
	Temperature	-	Although Westoe Dam is upstream of the monitoring points, little impact is expected due to the distance from the dams to the site. A/B (0.5)
	Dissolved oxygen	-	
	Turbidity (NTU)	-	Some impact expected from forestry activities and cattle trampling. C (2)
	Electrical conductivity (mS/m)	16.01: IUCMA 17.08: DWS	A (0)
Response variable	Chl-a: periphyton	-	
	Chl-a: phytoplankton	-	
	Diatoms	-	-
	Macroinvertebrates	MIRAI category	BC (Diedericks, 2019)
Toxics	Ammonia (mg/L N)	0.1: IUCMA 1.03: DWS (n=44)*	E/F (4)
OVERALL SITE CLASSIFICATION (from PAI)		**B (83.6%)**	

- No data.
** Data skewed by a few high readings*

Table 100: PAI table for SQR W54D-01593, Usuthu River (U-53)

PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC	RATING	THRESHOLD EXCEEDED?	CONF	DEFAULT WEIGHTS	ADJUSTED RANKS	ADJUSTED WEIGHTS
pH	0.00	N	4.00	60.00		50.00
Salts	0.00	NONE SPECIFIED	4.00	50.00		50.00
Nutrients	1.50	NONE SPECIFIED	4.00	70.00		65.00
Water Temperature	0.50	N	2.50	60.00		70.00
Water clarity	2.00	NONE SPECIFIED	2.50	50.00		60.00
Oxygen	0.50	N	2.50	65.00		70.00
Toxics	2.00	N	2.00	100.00		100.00
PC MODIFICATION RATING WITH THRESHOLD APPLIED (MAX)	1.03	MEAN CONF →	3.07			
CALCULATED PC MODIFICATION RATING WITHOUT THRESHOLD AND WITH DEFAULT WEIGHTS	1.03					
CALCULATED P-C RATING WITHOUT THRESHOLD AND BASED ON ADJUSTED WEIGHTS	1.05					
FINAL PC MODIFICATION RATING	1.03					
P-C CATEGORY %	P-C CATEGORY					
83.6	B	REVISED % & CATEGORY (2014)				

Table 101 shows the water quality state at this site as compared to the International Obligations guidelines. Green indicates where guidelines have been met, while red shows a contravention of the selected guideline.

Table 101: Comparison to water quality guidelines: SQR W54D-01593, Usuthu River (U-53)

Metric		International Obligations
Physical variables	pH	6.5-8.5
	Electrical Conductivity (mS/m)	150
Nutrients	PO_4 (mg/L P)	2
	NO_2+NO_3 (mg/L N)	50
Toxics	Ammonia (mg/L N)	1
	Sulphate (mg/L)	250 *
Microbial	Faecal coliforms (cfu/100mL)	2 000 (650, n=1, Sept 2019)
	Total coliforms (cfu/100mL)	10 000 (2 420, n=1, Sept 2019)

**** an indicative evaluation only, as based on 2000-2009 data (n=111; 95th percentile is 10.37 mg/L) from W5H025Q01.***

Note the following points regarding analysis:

- Data records are short, with the assessment therefore being of low confidence.
- Water quality state appears **Good** for this river reach; confirmed by the macroinvertebrate assessment (MIRAI: B category).

- There is some uncertainty regarding ammonia levels (as mg/L N). The median level for DWS data was 0.2 mg/L vs the 1.03 mg/L for the 95th percentile (which is the summary statistic used to evaluate ammonia levels according to DWAF (2008), but even the median is elevated for ecological requirement. Although recent (past 3 years) levels are within International Obligations, longer-term monitoring of this variable is recommended.
- *E. coli* data for the river reach were within DWAF's (1996b) guideline for full contact recreational use (0-130 cfu/100mL) using the *mean* assessment of status. However, data suggests that there have been incidents where *E. coli* records have been elevated enough for the *median* to be well above the TWQR for full-contact recreational use. This data, together with the small IUCMA database for coliforms, suggests that sporadic and localized incidences of elevated coliforms may occur, possibly related to the extensive cattle-trampling seen in the reach.
    - IUCMA data (n=1, Sept 2019): 33
    - DWS data (n=52):

Median	24
Mean	961

Impacts for SQR

- Flow regulation from the Westoe Dam.
- Steep road approach with poor drainage at the W5USUT-STAFF site results in high sediment inputs into the river during rainfall events.
- A new bridge was constructed at the W5LUSU-MANGC site between the 2015 and 2019 sampling events.
- High weed infestation in the marginal and lower zones of the riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (79.1%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time.Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓	

RIVER			TRIBUTARY OF	
Usuthu			Rio de Maputo	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5USUT-STAFF			W54D	W54D-01593
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.50336	E 30.77666	1 413	Lower foothill
AQUATIC ECOREGION	Level I			Level II
	11. Highveld			11.04

Figure A-132. Upstream view of the site on the Usutu River, W5USUT-STAFF (20 August 2015).

Figure A-133. Downstream view of the site on the Usutu River, W5USUT-STAFF (20 August 2015).

Figure A-134. Upstream view of the site on the Usutu River, W5USUT-STAFF (19 August 2019).

Figure A-135. Downstream view of the site on the Usutu River, W5USUT-STAFF (19 August 2019).

RIVER			TRIBUTARY OF	
Lusutfu			Rio de Maputo	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5LUSU-MANGC			W54D	W54D-01593
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.54346	E 30.85552	1 287	Upper foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	11. Highveld		11.04	

Figure A-136. Upstream view of the site on the Lusutfu River, W5LUSU-MANGC (22 July 2015).

Figure A-137. Downstream view of the site on the Lusutfu River, W5LUSU-MANGC (22 July 2015).

Figure A-138. Upstream view of the site on the Lusutfu River, W5LUSU-MANGC (09 September 2019).

Figure A-139. Downstream view of the site on the Lusutfu River, W5LUSU-MANGC (09 September 2019).

SQ REACH NUMBER W54F-01729

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W54F-01729	W5LUSU-MABUZ	Lusutfu	S-26.58243 E 31.10297	744	13.8	C	C 67%	C* 74.5%	C 71.8%	C** 77.5%	C 74.6%	BC 80%	2015
							C 77.1%	BC 80.9%	BC 79%	C 77.5%	BC 78.4 %		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W54F-01729: Lusutfu River confluence with Dubusi River to confluence with Umvenvane River

The site falls within PESEIS Reach Code W54F-01729, which is indicated as 13.8 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Lusutfu River with the Dudusi River between Mapanga and Mabovana (W54F-01739) and the Lusutfu's confluence with the Umvenvane River (W54G-01682). The length from the source of the Usuthu River to the W5LUSU-MABUZ sampling point measured on Google Earth Pro is 136 km. The main river (Usuthu-Lusutfu—Indian Ocean) is 451 km, originating at an elevation of 1,714 m a.m.s.l., flowing in an east by southerly direction towards the sampling point, W5LUSU-MABUZ,which is at an elevation of 774 m a.m.s.l. The site is located in the Swaziland Sour Bushveld (from Mucina & Rutherford 2006) and falls within North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005).

Landcover consist of open spaces dominated by grassland. The land use practises consist of mixed agriculture, pine and eucalyptus forestry as well as the presence of the Westoe Dam in the catchment. No landcover and landuse practise data is available on GEOTERRAIMAGE, 2015 for this SQ reach.

Instream Habitat Integrity

The IHI for the SQ reach W54F-01729 was calculated at 78% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This biomonitoring site W5LUSU-MABUZ (W54F-01729) is on the mainstem Lusutfu River and consisted of mainly large riffles, rapids and runs. Fish velocity depth classes for fish was in the form of fast shallow abundant, with the slow habitat (shallow and deep) sparsely present, fast shallow moderately and fast deep riffle in abundance. Overhanging vegetation, as well as undercut banks and root wads were not present to provide cover for fish. The substrate in the fast deep habitats was abundant consisting of boulders, large rocks, cobbles and pebbles providing the necessary

instream fish habitat. The substrate as cover in the slow habitat was sparse. Aquatic macrophytes as cover was sparsely present in the slow shallow habitat.

Table 102: Fish species expected based on the PESEIS Reach Code (W54F-01729) W5LUSU-MABUZ; is listed, and the fish species percentage composition during the different surveys is indicated.

W54F-01729	Expected Species	W5LUSU-MABUZ			
		2015		2019	
		Individuals	%	Individuals	%
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	2	3.77
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius anoplus	X	-	-	-	-
Enteromius crocodilensis	X	-	-	-	-
Enteromius trimaculatus	X	-	-	3	5.66
Enteromius unitaeniatus	X	-	-	-	-
Labeobarbus marequensis	X	136	54.40	17	32.08
Labeobarbus polylepis	X	1	0.40	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	14	5.60	7	13.21
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	-	-	-	-
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	86	34.40	15	28.30
Chiloglanis emarginatus	X	-	-	-	-
Cichlidae (Cichlids)					
Pseudocrenilabrus philander	X	4	1.60	2	3.77
Tilapia sparrmanii	X	9	3.60	7	13.21
Number of species recorded	13	6		7	
Number of individuals		250		53	
Electro-fishing time (minutes)		53 minutes		30 minutes	
Catch/Unit Effort (CPUE)		4.72		1.77	
Fish Ecostatus (FRAI Value)		**CATEGORY C** 67%		**CATEGORY C** 77.1%	

The fish assemblage recorded for the present survey consisted of seven species of an expected 13 species of indigenous fish for this reach (Table 102). The most abundant fish species collected was *Labeobarbus marequensis*, a hardy reophilic species (moderately tolerant to modified water quality – 2.9) which was also the most abundant species during the 2015 survey. Other reophilic fish species recorded include *Enteromius trimaculatus and Amphilius uranoscopus*. *Chiloglanis anoterus*, the riffle dwelling species fish species, was collected in the fast-shallow habitat available in relative abundance (28.3%; 15 individuals). The migratory specialist, *Anguilla mossambica*, was also recorded indicating the river continuity still being intact. This catadromous species breed in the ocean, enters rivers as larvae and migrate upstream as far as they can go where they develop further. Adult eels return to the ocean at some stage to breed. Disruption of the river continuity, especially due to large impoundments, result in the decline of abundance of this species as migration to headwaters following their larval stage in the ocean is obstructed by weirs and impoundments. In general the Frequency of Occurrence (FROC) of the recorded species is low and have been

altered. The CPUE for the present survey was calculated at 1.77 (53 individuals; 30 minutes) indicating a decline in abundance from the 2015 surveys when a CPUE of 4.72 was calculated. A possible reason for the lower abundance of fish collected, could be related to a sudden increase of flow after good rains that occurred a few days prior to the survey.

A Fish Ecostatus rating of 77.1% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance) consistent with the 2015 survey results but with a lower rating (Category C – 67%).

Invertebrates

Two SASS sampling events are on record for the W5LUSU-MABUZ site in this reach on the Lusutfu River. These sampling events occurred in July 2015 and this survey in September 2019. In total 34 SASS taxa have been recorded during these two sampling events. Sensitive rated SASS taxa were dominant during both sampling events, but abundances of sensitive taxa were low. SASS taxa diversity was higher in the stones biotope in 2019 than in 2015. Sensitive-rated SASS taxa recorded in 209 absent in 2015 included Crambidae, Scirtidae, and Psephenidae. Taxa tolerant to organic pollution dominated during both sampling events, with gathering collectors the dominant functional feeding group.

Table 103: Comparison of the 2015 and 2019 SASS5 results for SQ reach W54F-01729.

W54F-01729	W5LUSU-MABUZ	2015	2019	
	Total SASS Score	178	202	
	No. of SASS Families	28	29	Change
	Average Score Per Taxon	6.4	7.0	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 75.4%	Category BC 80.9%	↗

The MIRAI 2019 results (Table 103) indicate slight improvement in conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 75.4%) in August 2015 and improved slightly to largely natural to moderately impaired (Category BC – 80.9%) in August 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 75.4% rating this reach as a Category C indicating a moderately modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (77.5%) indicating that the

riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- High quantities of domestic waste in the river and its riparian zone

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category BC (78.4%)	**Category BC (80%)**
Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.	Close to largely natural with few modifications most of the time. Conditions may rarely and temporarily decrease below the upper boundary of the C category.
Integrated Ecostatus remained consistent to Recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Lusutfu			Rio de Maputo	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5LUSU-MABUZ			W54F	W54F-01729
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.58243	E 31.10297	774	Upper foothill
AQUATIC ECOREGION	Level I		Level II	
	4. North Eastern Highlands		4.06	

Figure A-140. Upstream view of the site on the Lusutfu River, W5LUSU-MABUZ (22 July 2015).

Figure A-141. Downstream view of the site on the Lusutfu River, W5LUSU-MABUZ (22 July 2015).

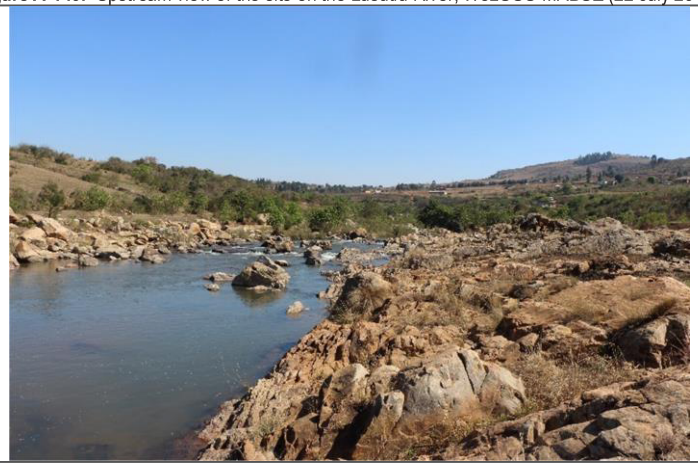


Figure A-142. Upstream view of the site on the Lusutfu River, W5LUSU-MABUZ (10 September 2019).

Figure A-143. Downstream view of the site on the Lusutfu River, W5LUSU-MABUZ (10 September 2019).

SQ REACH NUMBER W57A-01803

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W57A-01803	W5LUSU-LIBET	Lusutfu	S-26.66424 E 31.47224	271	7.7	C	BC 80.1%	C* 73.4%	C 76.3%	C** 77.5%	C 76.9%	C 70%	2015
							C 75.6%	C 73.5%	C 74.6%	C 75%	C 74.7%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa ** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W57A-01803: Lusutfu confluence with Mkhondvo River to confluence with Mhlamanti River

The site falls within PESEIS Reach Code W57F-01803, which is indicated as 7.7 km in length (from Department of Water and Sanitation 2014). The reach starts at the Lusutfu River's confluence with the Mkhondvo River and ends at its confluence with the Mhlamanti River (W57A-01705). The main river channel originates at an elevation of 1,740 m a.s.l., flowing first in an easterly direction towards the sampling point, W5LUSU-LIBET, which is at an elevation of 271 m a.s.l. The site is in the Swaziland Sour Bushveld (from Mucina & Rutherford 2006) vegetation type and falls within North Eastern Highlands aquatic ecoregion (from Kleynhans et al. 2005).

No data available on GEOTERRAIMAGE, 2015 regarding landcover or landuse practises for this SQ reach.

Instream Habitat Integrity

The IHI for the SQ reach W57A-01803 was calculated at 70.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

The aquatic habitat surveyed at the site W5LUSU-LIBET (W57A-01803) is downstream from the confluences of the Ngwempisi, Lusushwane and Assegai rivers. All of the fish velocity depth classes were present at this site with both fast shallow and fast deep abundant, slow shallow sparse and slow deep habitat moderately present. The fish cover present was rare to sparse for overhanging vegetation provided by terrestrial grasses on the river banks with sparse to moderate undercut banks and root wads. The substrate rated sparse in the slow habitat with a sandy substrate with a few boulders and rocks providing moderate to abundant cover in both the fast shallow and deep fish velocity depth classes. Aquatic macrophytes were moderately present as cover for fish.

Table 104: Fish species expected based on the PESEIS Reach Code (W57A-01803) W5LUSU-LIBET; is listed, and the fish species percentage composition during the different surveys is indicated.

W57A-01803	Expected Species	W5LUSU-LIBET			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	3	0.57	-	-
Petrocephalus wesselsi	X	-	-	-	-
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	-	-
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius paludinosus	X	9	1.74	2	2.44
Enteromius radiatus	X	5	0.97	-	-
Enteromius toppini	X	4	0.77	-	-
Enteromius trimaculatus	X	57	11.03	7	8.54
Enteromius unitaeniatus	X	46	8.90	-	-
Enteromius viviparus	X	26	5.03	17	20.73
Labeo cylindricus	X	5	0.97	-	-
Labeo molybdinus	X	29	5.61	5	6.09
Labeobarbus marequensis	X	43	8.32	6	7.32
Labeobarbus polylepis	X	11	2.13	-	-
Mesobola brevianalis	X	9	1.74	-	-
Opsaridium peringueyi	X	10	1.93	-	-
Characidae (Characins)					
Micralestes acutidens	X	9	1.74	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	-	-	-	-
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	17	3.29	1	1.22
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	-	-	-	-
Chiloglanis emarginatus	X	-	-	-	-
Chiloglanis paratus	X	27	5.22	5	6.09
Chiloglanis swierstrae	X	34	6.58	8	9.76
Cichlidae (Cichlids)					
Coptodon rendalii	X	15	2.90	-	-
Oreochromis mossambicus	X	117	22.63	7	8.54
Pseudocrenilabrus philander	X	41	7.93	22	26.83
Tilapia sparrmanii	X	-	-	2	2.44
Number of species recorded	26	20		11	
Number of individuals		517		82	
Electro-fishing time (minutes)		84 minutes		51 minutes	
Catch/Unit Effort (CPUE)		6.15		1.61	
Fish Ecostatus (FRAI Value)		**CATEGORY BC** 80%		**CATEGORY C** 75.6%	

At this site only 11 of the expected 26 fish species were recorded, nine species less than recorded for the 2015 survey (Table 104). A reason for this decrease in species and abundance is the sudden increase in flow after good rains providing new habitat not yet occupied by the fish. Not all the expected fish species are present within this resource unit and the Frequency of Occurrence (FROC) of some species has been reduced from the reference conditions. The Frequency of Occurrence (FROC) of the recorded species has furthermore been altered as a result of inaccesability of

available fish habitat for electro-shocking technique. Therefore the results of this survey can be seen as a skewed representation of the entire fish assemblage present at this site for the present survey.
The CPUE (catch per unit effort) calculated for this site is 1.61 (82 individuals; 51 minutes) which indicates a much lower abundance of fish corede than recorded during the 2015 survey when a CPUE of 6.15 was recorded.

A Fish Ecostatus rating of 75.6% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with moderate diversity and abundance of species), and a lower category than for the 2015 survey when an Ecological Category BC (80%) was determined.

Invertebrates

Two SASS sampling events are on record for the W5LUSU-LIBET site in this reach on the Lusutfu River. These sampling events occurred in August 2015, and September 2019. In total 39 SASS taxa have been recorded during these nine sampling events. Sensitive rated SASS taxa were present during both sampling events, but abundances of sensitive taxa were low. Taxa tolerant to organic pollution dominated during both surveys, with high abundances of Physidae. The Ephemeroptera family Tricorythidae was absent from the 2019 sample.

Table 105: Comparison of the 2015 and 2019 SASS5 results for SQ reach W57A-01803.

W57A-01803	W5LUSU-LIBET	2015	2019	
	Total SASS Score	174	184	
	No. of SASS Families	32	34	Change
	Average Score Per Taxon	5.4	5.4	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 73.4%	Category C 73.5%	→

MIRAI results for 2019 (Table 105) at the W5LUSU-LIBET site indicates similar conditions when compared to 2015, with both 2015 and 2019 rated as moderately impaired (C-class).

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 53.5% rating this reach as a Category D indicating a largely modified riparian habitat. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (75%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- High weed infestation in the marginal and lower zones of the riparian zone
- High quantities of domestic waste in the riparian zone.

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (74.7%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged
Integrated Ecostatus remained consistent to recommended Target Ecological Category ✔	

RIVER			TRIBUTARY OF	
Lusutfu			Rio de Maputo	
SITE NUMBER			**QUATERNARY SUB-CATCHMENT**	**REACH**
W5LUSU-LIBET			W57A	W57A-01803
GPS CO-ORDINATES (WGS84 – dd.ddddd):	**Latitude**	**Longitude**	**Elevation (m. a.m.s.l.)**	**Geomorphological Zone**
	S -26.66424	E 31.47224	271	Lower Foothill
AQUATIC ECOREGION	**Level I**		**Level II**	
	4. North Eastern Highlands		4.06	

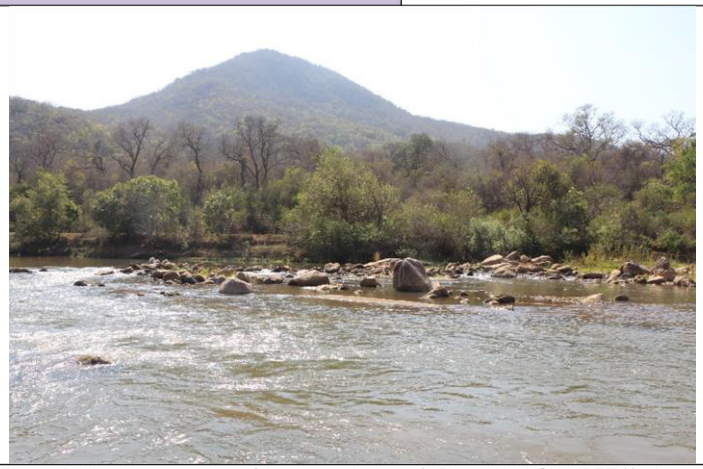


Figure A-144. Upstream view of the site on the Lusutfu River, W5LUSU-LIBET (17 August 2015).

Figure A-145. Downstream view of the site on the Lusutfu River, W5LUSU-LIBET (17 August 2015).

Figure A-146. Upstream view of the site on the Lusutfu River, W5LUSU-LIBET (12 September 2019).

Figure A-147. Downstream view of the site on the Lusutfu River, W5LUSU-LIBET (12 September 2019).

SQ REACH NUMBER W57E-01810

Reach Code	Site Code	River	GPS (dd.ddddd)	Elevation (m a.s.l.)	SQR Length (km)	PES Category	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Recommended TEC	Biomonitoring Year
W57E-01810	W5LUSU-SIPHO	Lusutfu	S-26.68981 E 31.68215	180	7.7	C	BC 80.7%	C* 73%	C 76.4%	C** 77.5%	C 76.9%	C 70%	2015
							C 73.9%	C 73.4%	C 73.7%	C 63%	C 69.1%		2019

* Corrected MIRAI value for 2015 due to changes of Reference taxa

** PES Desktop Assessment value for reach – RIVDINT Model 2015

General description

Reach W57E-01810: Lusutfu confluence with Mzimnene River to confluence with Phuzumoya River

This site on the Lusutfu River falls within PESEIS Reach Code W57E-01810, which is indicated as 13.7 km in length (from Department of Water and Sanitation 2014). The reach starts at the confluence of the Lusutfu River's with the Mzimnene River (W56F-01591) and ends at its confluence with the Phuzumoya River (W57B-01755). The main river channel originates at an elevation of 1,740 m a.s.l., flowing in an easterly direction towards the sampling point, W5LUSU-SIPHO, which is at an elevation of 179 m a.s.l. The site is in the Granite Lowveld (from Mucina & Rutherford 2006) and falls within Lowveld aquatic ecoregion (from Kleynhans et al. 2005). No data regarding landcover or landuse practises available on GEOTERRAIMAGE, 2015 for this SQ reach.

Instream Habitat Integrity

The IHI for the SQ reach W57E-01810 was calculated at 70.5% rating this SQ reach as a C category indicating that the instream habitat integrity is moderately modified. Loss and change of natural habitat and biota have occurred, but basic ecosystem functions are still predominantly unchanged. (RIVDINT model Usuthu-Lusutfu System, 2019).

Fish

This monitoring site, W5LUSU-SIPHO (W57E-01810) is just downstream from a river crossing which is also acting as a weir. This multi-channel site's fish velocity depth classes present and sampled included fast shallow (abundant), slow shallow (sparse), slow deep (moderate) and fast deep (abundant). The fish cover observed was mostly moderate with emerging macrophytes providing the necessary cover as overhanging vegetation. Undercut banks and root wads were moderate to abundant. The substrate as cover provided only a moderate protection for fish with a few small rocks and cobbles present. Substrate in the form of sandy runs were further observed in the fast shallow habitats with floating aquatic plants providing the necessary cover.

Table 106: Fish species expected based on the PESEIS Reach Code (W57E-01810) W5LUSU-SIPHO; is listed, and the fish species percentage composition during the different surveys is indicated.

W57E-01810	Expected Species	W5LUSU-SIPHO			
		2015		2019	
		Individuals	%	Individuals	%
Mormyridae (Snoutfishes)					
Marcusenius (macrolepidotus) pongolensis	X	6	2.01	6	4.72
Petrocephalus wesselsi	X	-	-	-	-
Anguillidae (Freshwater Eels)					
Anguilla mossambica	X	-	-	1	0.79
Cyprinidae (Barbs, Yellow-fishes and Labeos)					
Enteromius paludinosus	X	7	2.35	-	-
Enteromius radiatus	X	-	-	1	0.79
Enteromius toppini	X	-	-	-	-
Enteromius trimaculatus	X	19	6.38	4	3.15
Enteromius unitaeniatus	X	17	5.70	5	3.94
Enteromius viviparus	X	-	-	53	41.73
Labeo cylindricus	X	3	1.01	-	-
Labeo molybdinus	X	15	5.03	16	12.60
Labeo rosae	X	1	0.34	-	-
Labeobarbus marequensis	X	57	19.13	-	-
Labeobarbus polylepis	X	3	1.01	-	-
Mesobola brevianalis	X	-	-	-	-
Opsaridium peringueyi	X	35	11.74	-	-
Characidae (Characins)					
Micralestes acutidens	X	12	4.03	-	-
Amphiliidae (Mountain catfishes)					
Amphilius uranoscopus	X	2	0.67	-	-
Schilbeidae (Butter catfishes)					
Schilbe intermedius	X	-	-	6	4.72
Clariidae (Air-breathing catfishes)					
Clarias gariepinus	X	5	1.68	10	7.87
Mochokidae (Squeakers, suckermouth catlets)					
Chiloglanis anoterus	X	3	1.01	-	-
Chiloglanis emarginatus	X	-	-	-	-
Chiloglanis paratus	X	5	1.68	3	2.36
Chiloglanis swierstrae	X	28	9.40	11	8.67
Gobiidae (Gobies)					
Awaous aeneofuscus	X	1	0.34	-	-
Cichlidae (Cichlids)					
Coptodon rendalli	X	6	2.01	4	3.15
Oreochromis mossambicus	X	44	14.75	3	2.36
Pseudocrenilabrus philander	X	29	9.73	4	3.15
Tilapia sparrmanii	X	-	-	-	-
Number of species recorded	29	20		14	
Number of individuals		298		127	
Electro-fishing time (minutes)		51 minutes		32 minutes	
Catch/Unit Effort (CPUE)		5.84		3.97	
Fish Ecostatus (FRAI Value)		**CATEGORY BC** 80.7%		**CATEGORY C** 73.9%	

A total of 14 fish species were collected at this site of the 29 expected indigenous fish species, six species less than recorded for the 2015 survey (Table 106). A reason for this decrease in species and abundance is the sudden increase

in flow after good rains providing new habitat not yet occupied by the fish. Of the six expected small barb species four were collected with *Enteromius viviparus* (53 individuals; 41.73%) the most abundant fish species recorded. None of the large barb species or the sensitive reophilic species, *Opsaridium peringueyi*, was recorded for the present survey. Only two of the four expected *Chiloglanis* species were recorded which included the sandy habitat specialist, *Chiloglanis swierstrae* (11 individuals, 8.67%) and *Chiloglanis paratus* (3 individuals, 2.36%). A very small *Anguilla mossambica*, was collected at this site and the fresh river flow after the rains could have stimulated these migratory fish to move. Six individuals of *Schilbe intermedius*, which is not often recorded in surveys, was collected for the first time at this site. Three cichlids, *Coptodon rendalli*, *Oreochromis mossambicus* and *Pseudocrenilabrus philander*, were as with the 2015 survey, recorded but at much lower abundances.

The CPUE (catch per unit effort) calculated for this site is 3.97 (127 individuals; 32 minutes) which indicate a relative abundance of fish, but a decrease in abundance compared to the 2015 survey when a CPUE of 5.84 was calculated.

A Fish Ecostatus rating of 73.9% was calculated for this reach based on all available information, placing this reach in an Ecological Category C (moderately impaired with low diversity of species and abundance), indicating a slight deterioration from the 2015 survey when a Fish Ecostatus rating of 80.7%, Category BC, was determined.

Invertebrates

Two SASS sampling events are on record for the W5LUSU-SIPHO site in this reach on the Lusutfu. These sampling events occurred in August 2015 and this survey in September 2019. In total 34 SASS taxa have been recorded during these two sampling events. Sensitive rated SASS taxa were present during both sampling events, but not dominant (low abundances).

Macrobrachium sp. (Palaemonidae) was recorded in July 2015 but was absent in September 2019. The species is amphidromous, so its absence might be linked to different sampling periods. Of concern is the presence of *Cherax quandricarinatus* (Parastacidae), a highly invasive species, recorded in at the W5LUSU-SIPHO site 2019. *C. quandricarinatus* was absent in the September 2015 sample, event, when it was targeted by Andre Hoffman as a species to look out for. *C. quandricarinatus* was recorded at the W5LUSU-KUHLE site in September 2015, located 44 km (in straight line) further downstream on the Lusutfu.

In 2019, community shifts were in the taxa tolerant to organic pollution and functional feeding groups. Taxa tolerant to organic pollution increased from July 2015 to September 2019. The dominance of gathering collectors in the functional feeding groups increased. The exotic invasive Gastropod *Tarebia granifera* (Thiaridae) was also recorded for the first time in 2019.

Table 107: Comparison of the 2015 and 2019 SASS5 results for SQ reach W57E-01810.

W57E-01810	W5LUSU-SIPHO	2015	2019	
	Total SASS Score	178	160	
	No. of SASS Families	28	27	Change
	Average Score Per Taxon	6.4	5.9	
	SQ REACH SUMMARY Invertebrate Ecostatus	Category C 73.1%	Category C 73.4%	→

The MIRAI 2019 results (Table 107) indicate similair conditions when compared to 2015. Conditions in the PESEIS reach based on MIRAI were rated as moderately impaired (Category C – 73.1%) in July 2015 and (Category C – 73.4%) in September 2019.

Riparian Vegetation

The Vegetation Conditions derived from the PES-EIS model for this reach is calculated at 77.5% and is consistent with a Category C – moderately modified. The Riparian IHI was calculated at 60.5% rating this reach as a Category CD indicating a close to largely modified riparian habitat most of the time. The overall Riparian Ecostatus consisting of a combination of the Vegetation Condition and the Riparian IHI was therefore determined as a Category C (63%) indicating that the riparian vegetation for this SQ reach is moderately modified with a loss and change of natural habitat and biota, but the basic ecosystem functions are still predominantly unchanged.

Impacts for SQR

- High quantities of domestic waste, with the site now extensively used for bathing, washing cars, carpets, clothes, and more.
- High quantities of aquatic weeds such as *Eichhornia crassipes* and *Pistia stratiotes*.
- High quantities of invasive weeds in the riparian zone.
- Polluted water flowing directly into the river (Figure 62).

Figure 62. Highly polluted stream flowing directly into the river downstream from the bridge (12 September 2019, G Diedericks).

Integrated Ecostatus Category and Recommended Target Ecological Category (RTEC)

INTEGRATED ECOSTATUS	RECOMMENDED TARGET ECOSTATUS
Category C (69.1%)	**Category C (70%)**
Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged	Moderately modified habitat with loss and change of natural habitat and biota has occurred in terms of frequencies of occurrence and abundance. The basic ecosystem functions are still predominantly unchanged

Integrated Ecostatus remained consistent to recommended Target Ecological Category ✓

Discussion:

Although the Recommended Ecological Category has been met, concern regarding the water quality has been raised. Regular monitoring of water quality regime to be implimented.

RIVER			TRIBUTARY OF	
Lusutfu			Maputo	
SITE NUMBER			QUATERNARY SUB-CATCHMENT	REACH
W5LUSU-SIPHO			W57E	W57E-01810
GPS CO-ORDINATES (WGS84 – dd.ddddd):	Latitude	Longitude	Elevation (m. a.m.s.l.)	Geomorphological Zone
	S -26.68981	E 31.68215	180	Lower Foothill
AQUATIC ECOREGION	Level I		Level II	
	3. Lowveld		3.07	

Figure A-148. Upstream view of the site on the Lusutfu River, W5LUSU-SIPHO (21 July 2015).

Figure A-149. Downstream view of the site on the Lusutfu River, W5LUSU-SIPHO (21 July 2015).

Figure A-150. Upstream view of the site on the Lusutfu River, W5LUSU-SIPHO (12 September 2019).

Figure A-151. Downstream view of the site on the Lusutfu River, W5LUSU-SIPHO (12 September 2019).

Discussion Usuthu- Lusutfu Sub-catchment Reaches

Fish

A total of 39 indigenous fish species are expected to occur in this sub-catchment of which 20 species were recorded for the present survey, seven species less than recorded during the 2015 IUCMA survey. One species, *Schilbe intermedius*, was collected during the present survey but not recorded for the 2015 survey. The species recorded during the 2015 survey but not found during the 2019 survey are *Awaous aeneofuscus*, *Enteromius toppini*, *Glossogobius giurus*, *Labeo cylindricus*, *Labeo rosae*, *Mesobola brevianalis, Opsaridium peringueyi* and *Petrocephalus wesselsi*. To date a total of 30 species are recorded of the expected 39 species for this sub-catchment since the IUCMA surveys started. The most abundant fish species collected for the present survey is *Tilapia sparrmanii* with a relative abundance of 18.56% of the total number of fish collected. *Labeobarbus marequensis* was the most abundant species found during the 2015 survey with a relative abundance of 13.71% of the total number of fish collected.

Only one species of fish, *Pseudocrenilabrus philander*, was found at all of the sites done for this sub-catchment.

The site where the highest number of fish species were found is also the furthest downstream site, W5LUSU-SIPHO, where a total of 14 fish species was recorded. The highest abundance of fish was also found at this site where a CPUE of 3.97 fish caught per minute was recorded.

An increase in the number of sites where *Anguilla mossambica* was found during the present survey indicates that the river connectivity is still in place and the eels still migrates upstream into the catchment. During the 2015 survey *A. mossambica* was only found at one site and for the 2019 survey this species was found at three sites.

Figure 63 summarise the Fish Ecostatus categories for the 5 SQ reaches on the Usuthu-Lusutfu River. Of concern is the decline of the Fish Ecostatus rating from the SQ reach W57A-01803 (W5LUSU-LIBET) and W57E-01810 (W5LUSU-SIPHO). The deterioration from a Category BC to C for both reaches can be attributed to reduced water quality and loss of instream fish habitat as a result of excessive sedimentation due to land usage practises in the upper reaches. The overall Fish Ecostatus rating for 2019 is 72.9% placing the mainstem in a high Category C. This is consistent with the 2015 results of 73.7% and also a high Category C. The present category C (72.9%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

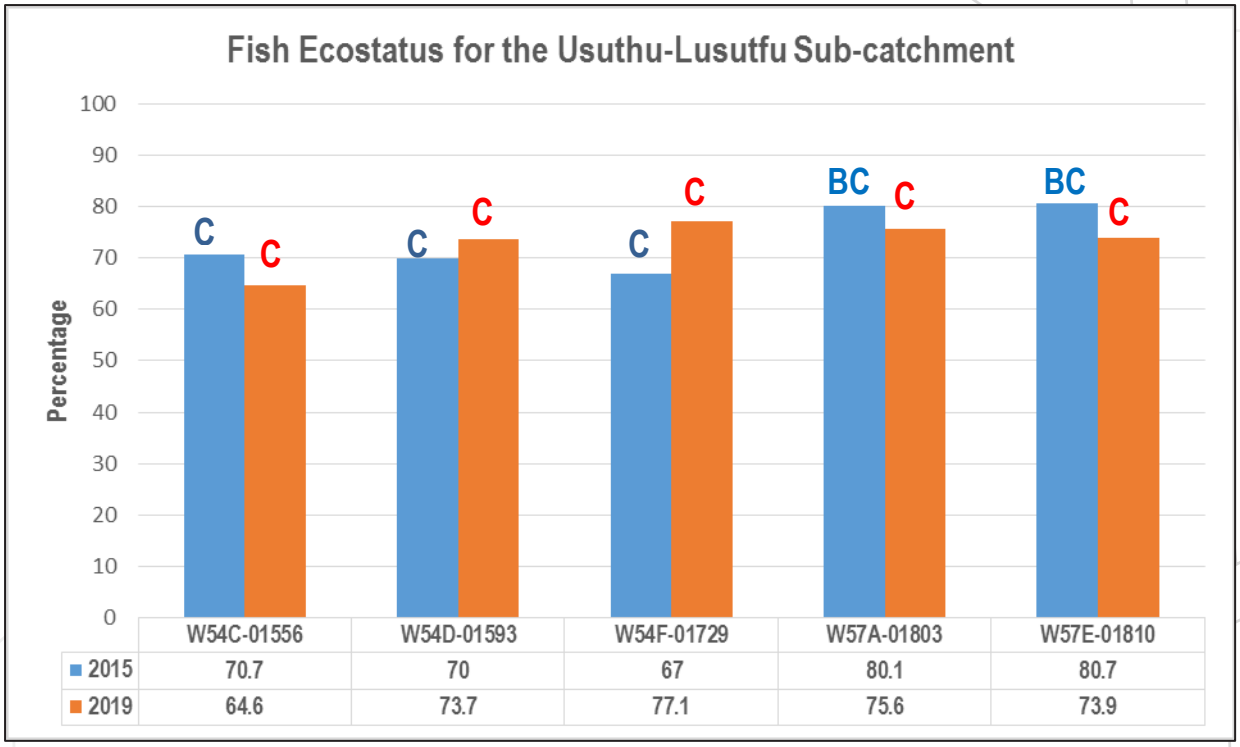


Figure 63: Summary of the Fish Ecostatus for the Usuthu-Lusutfu for biomonitoring in 2015 and 2019 as calculated on the RIVDINT model.

Invertebrates

Overall conditions were mostly similar (Table 108 and Figure 64) for the Usuthu-Lusutfu River, with the only slight improvement in SQ Reach W54F-01729 (W5LUSU-MABUZ) and the W54C-01556 (W5BONN-BROAD) on the Bonnie Broad tributary. The biggest concern is the increase in invasive taxa recorded (*Cherax quandricarinatus* and *Tarebia grandifera*), and water use pressures in terms of lack of flow releases from Westoe Dam.

Table 108: Summary of stream conditions per SQ Reach based on MIRAI, comparing 2015 to 2019 results.

QUATERNARY	RIVER	SQ REACH CODE	2015	2019	CHANGE
W54 & W57	Usutu-Lusutfu	W54D-01593	78.2	79.5	→
		W51F-01729	75.4	80.9	↗
		W57A-01803	73.4	73.5	→
		W57E-01810	73.1	73.4	→
	Bonnie Broad	W54C-01556	74.9	78.9	↗

The overall Invertebrate Ecostatus rating for 2019 is 77.2% placing the mainstem in a high Category C. This is consistent with the 2015 results of 75% and also a Category C. The present category C (77.2%) indicates a moderately modified habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

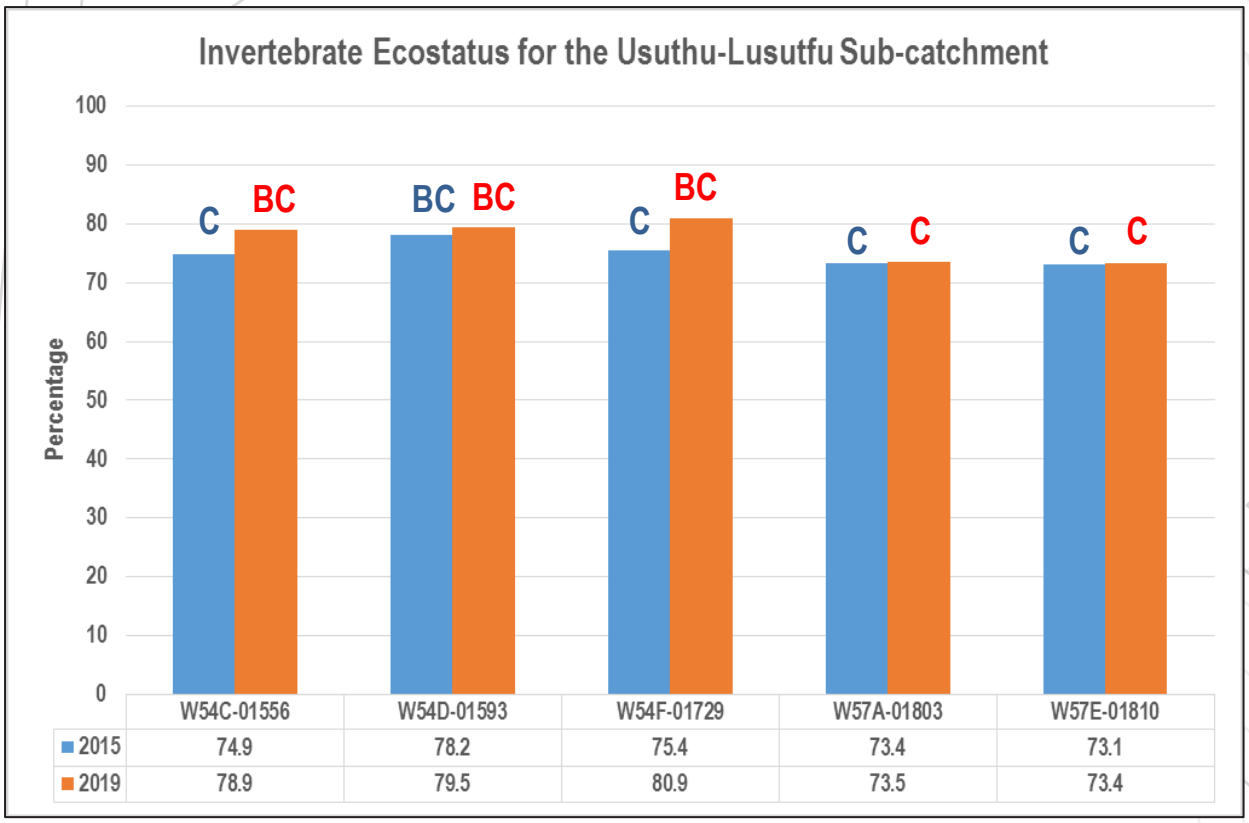


Figure 64: Graphical comparison of the Invertebrate Ecostatus of the Usuthu-Lusutfu in 2015 and 2019.

Water Quality

The water quality assessment was limited to a specific site, with a discussion of results provided below the results of the data assessment. Water quality state of the Usuthu reach assessed was Good (B category), although data records are too short to make any assessment with confidence. This assessment was confirmed by the macroinvertebrate assessment (MIRAI: B category).

.Instream - and Integrated Ecostatus rating and Recommended Ecological Category of the Usuthu-Lusutfu

The Instream Ecostatus rating is derived from the Fish Ecostatus, Invertebrate Ecostatus and Instream Habitat Integrity assessment. From Figure 65 it is evident that the Instream Ecostatus remains consistent throughout the Usuthu-Lusutfu River ranging from 71.8% (Category C) to a 79% (Category BC) with a mean of 75.1% category C. This remains consistent with the Instream Ecostatus for 2015 surveys at (74.3% Category C).

The Integrated Ecostatus is derived from the Fish Ecostatus, Invertebrate Ecostatus and the Riparian Vegetation Ecostatus calculated on the RIVDINT (River Data Integration) model. The Integrated Ecostatus for the Usuthu-Lusutfu River (Figure 66) also remained consistent throughout the 2015 (77%) and 2019 (75.1%) monitoring with

a category C indicating a moderately impaired habitat with a moderate diversity and abundance of species where especially intolerant species may be reduced in number or in extent of distribution.

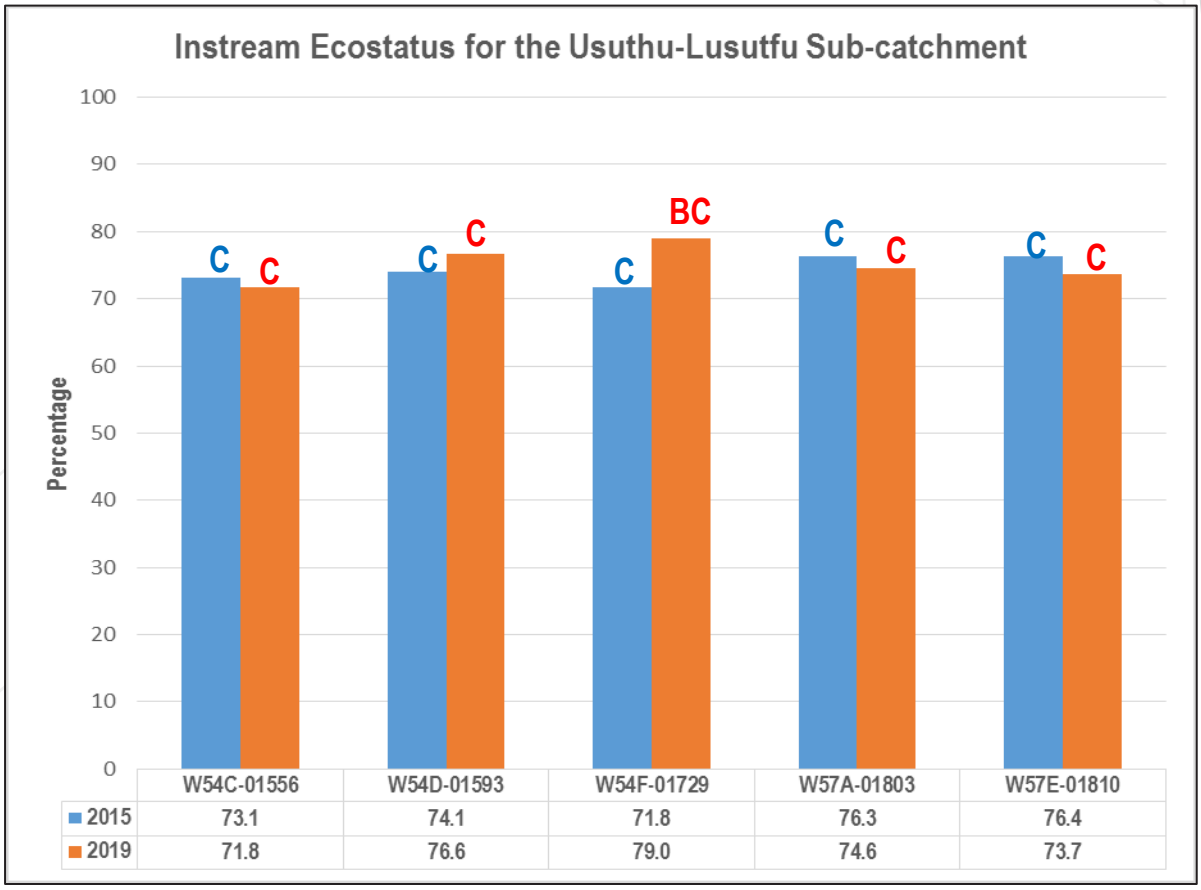
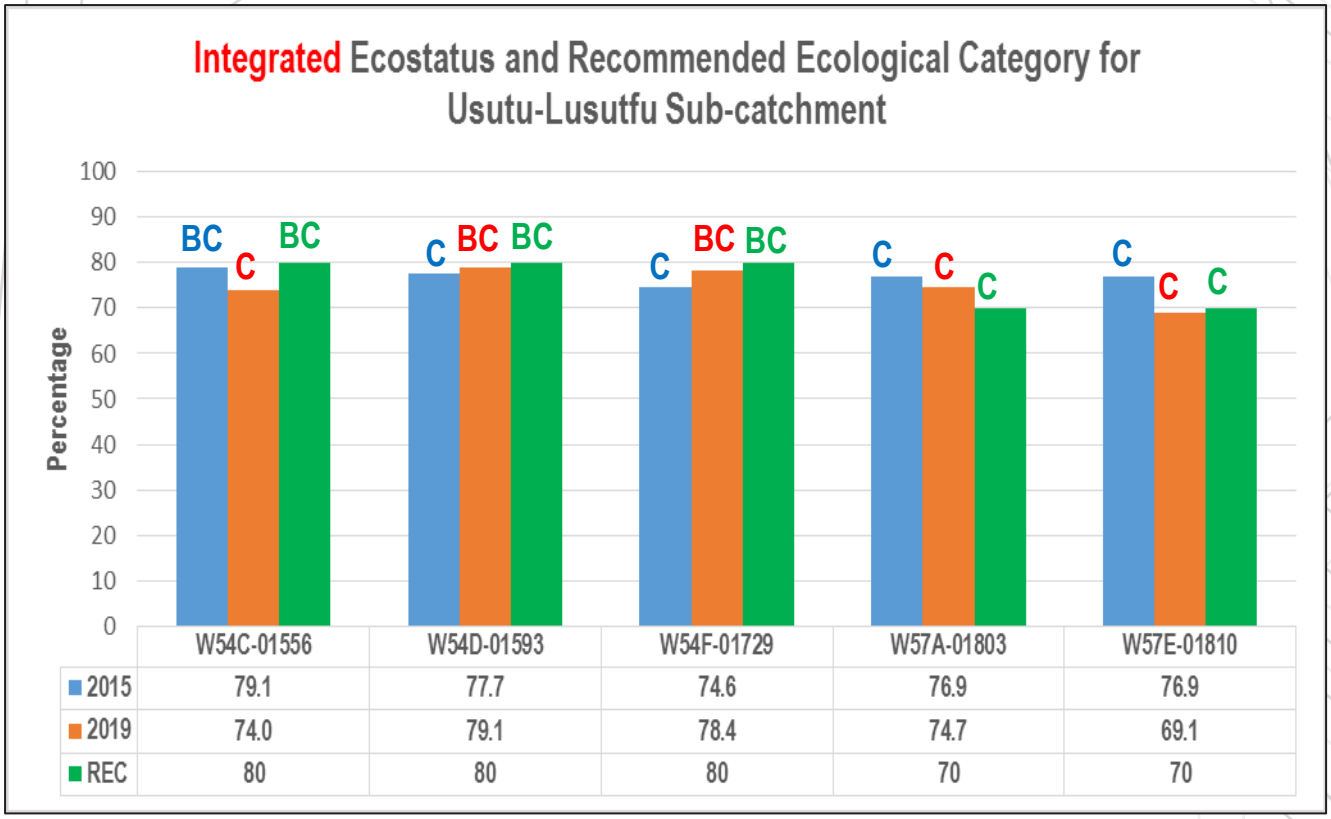


Figure 65: Comparison of the Instream Ecostatus of the Usuthu-Lusutfu in 2015 and 2019

When comparing the Integrated Ecostatus with the Recommended Target Ecological Category within the various SQ reaches, it needs to be noted that SQ reach W54C-01556 did not meet the set Recommended Ecological Category. Of concern in the Usuthu-Lusutfu catchment is decreasing water quality and the dominat land use practice consist of forestry and related activities resulting in a loss of instream habitat, reduced riparian zone, over-abstraction of water and high siltation and sedimentation loads.



	W54C-01556	W54D-01593	W54F-01729	W57A-01803	W57E-01810
2015	79.1	77.7	74.6	76.9	76.9
2019	74.0	79.1	78.4	74.7	69.1
REC	80	80	80	70	70

Figure 66: Comparison of the Integrated Ecostatus and Target Ecological Category for the Usuthu-Lusutfu in 2015 and 2019.

5. CONCLUSION

A total of 41 indigenous fish species are expected to occur in the catchment of which 27 species were recorded for the present survey, six species less than recorded during the 2015 IUCMA survey. One species, *Schilbe intermedius*, was collected during the present survey but not recorded for the 2015 survey. The species recorded during the 2015 survey but not found during the 2019 survey are *Awaous aeneofuscus*, *Enteromius brevipinnis*, *E. toppini*, *Glossogobius giurus*, *Labeo rosae*, *Mesobola brevianalis* and *Petrocephalus wesselsi*. The most abundant fish species collected for the present survey is *Chiloglanis anoterus* with a relative abundance of 27.13% of the total number of fish collected for the catchment. This species was also the most abundant species found during the 2015 survey.

Six species of fish were found at all of the sub-catchments done for this catchment. The species are *Amphilius uranoscopus*, *Chiloglanis anoterus*, *Labeobarbus marequensis, L. polylepis, Pseudocrenilabrus philander* and *Tilapia sparrmanii*.

The site where the highest number of fish species were found is also the furthest downstream site, W5LUSU-MALUN, where a total of 15 fish species was recorded. The highest abundance of fish was found at site W5MPON-SWAZI where a CPUE of 8.68 fish caught per minute was recorded. This site is on a tributary of the Ngwempisi and this high abundance of fish in a tributary indicates the importance of tributaries as refuge areas for fish.

An increase in the number of sites where *Anguilla mossambica* (Longfin eel) was found in the catchment indicates that the river connectivity is largely still in place. During the 2015 survey eight *A. mossambica* was found at seven sites over four sub-catchments. For the 2019 survey 14 eels were found at ten sites over four sub-catchments.

Of a concern is the increase in the prevalence of the alien and invasive *Micropterus salmoides*. During the 2015 survey 13 *M. salmoides* was only found at six sites, but for the 2019 survey 27 was found at ten sites.

During this survey (2019) 41 biomonitoring sites in 37 Sub-quaternary reaches were surveyed with a total length assessed of 1085.14 km. Table 109 and Figure 67 summarise all the SQ data which include the Fish Ecostatus, the Invertebrate Ecostatus, Riparian and Vegetation Ecostatus, Instream Ecostatus and Integrated Ecostatus, Instream Habitat Integrity, as well as the Riparian IHI comparing the 2015 and 2019 surveys. This calculated biomonitoring results indicate the overall PES Category remain consistent from a Category C (73.5%) in 2015 to a Category C (62%) in 2019. The overall Fish Ecostatus also remains consistent at a Category C (2015: 70.9%; 2019: 73.1%). The Invertebrate Ecostatus indicate a slight improvement from a Category C (73.7%) in 2015 to a Category C (75.9%) in 2019. The Instream Ecostatus that is derived from the Fish and Invertebrate Ecostatus, as well as the Instream Habitat Integrity improved slightly with an overall Instream Ecostatus Category of C (2015:72.3% and 2019:74.5%). VEGRAI surveys were conducted at 2 EWR sites in the Usuthu-Lusutfu system and the sites not assessed were derived from the RIVDINT model compilation, it was therefore possible to calculate the Integrated Ecostatus which is a combination between the Fish Ecostatus, Invertebrate Ecostatus, the Riparian and Vegetation Ecostatus, as well as the Riparian IHI. The overall Integrated Ecostatus for the Usuthu-Lusutfu system was calculated at a Category C (75.9%) which remains consistent with the Integrated Ecostatus calculated

for 2015 at a Category C (76.8%). These results indicate that although site specific problems occurred the overall Ecological condition of the Usuthu-Lusutfu catchment remained consistent at a Category C – moderately modified with a loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged. The resilience of the system to recover from human impacts has not been lost and its ability to recover to a moderately modified condition following disturbance has been maintained.

When comparing the results of the Integrated Ecostatus with the Recommended TEC's for the Usuthu-Lusutfu Catchment, which comprises of 37 SQ reaches (2 EWR sites), it is evident that 76% (28 of 37 SQ reaches) of SQ reaches in the Usuthu-Lusutfu River system met the set Recommended TEC, while 24% of targets (9 of 37 SQ reaches) were not met. Results for the two EWR sites indicate that set targets are met for EWR KU1 (W56A-01372), but not for the EWR AS1 (W51E-02049)

Table 109: Summary of the Ecostatus for the Usuthu-Lusutfu catchment and a comparison between 2015 and 2019 biomonitoring

X1: 2015	Total PES	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Instream IHI	Riparian IHI
Nr of SQ Reaches Assessed	33	33	33	33	33	33	Not assessed	Not assessed
Total Length of SQ Reaches Assessed	1047.5	1047.5	1047.5	1047.5	1047.5	1047.5		
Overall Rating	73.5	70.9	73.7	72.3	82.0	76.8		
Overall Category	C	C	C	C	B	C		

X1: 2019	Total PES	Fish Ecostatus	Invertebrate Ecostatus	Instream Ecostatus	Riparian Vegetation Ecostatus	Integrated Ecostatus	Instream IHI	Riparian IHI
Nr of SQ Reaches Assessed	37	37	37	37	37	37	37	37
Total Length of SQ Reaches Assessed	1085.14	1085.14	1085.14	1085.14	1085.14	1085.14	1085.14	1085.14
Overall Rating	62	73.1	75.9	74.5	77.7	75.9	75.8	66.3
Overall Category	C	C	C	C	C	C	C	C

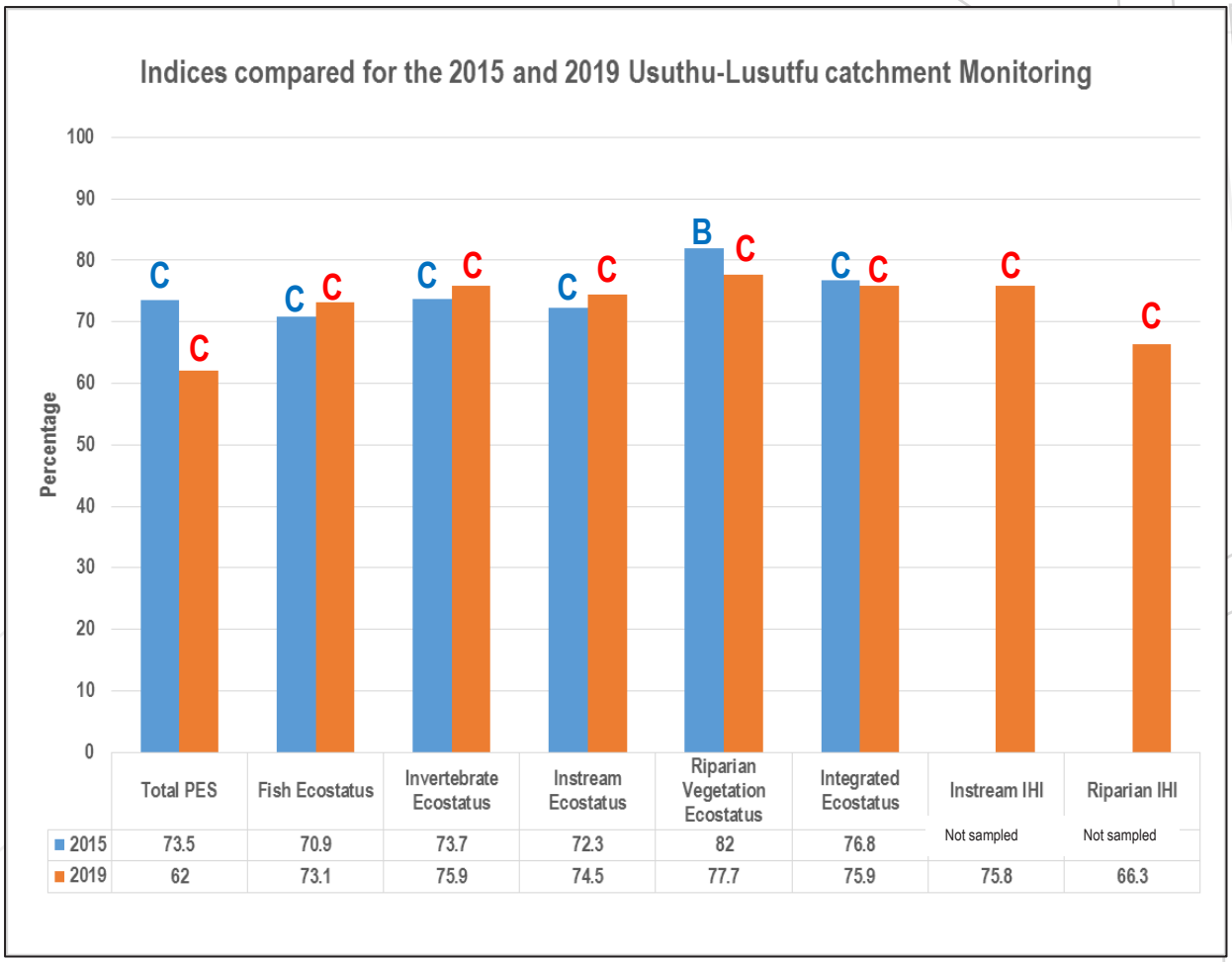


Figure 67: Summary of the Ecostatus for the Usuthu-Lusutfu Catchment and a comparison between 2015 and 2019 biomonitoring.

Water quality, as indicated by the sites assessed, is generally **Good** across the area, with a few localized problem areas, e.g. the Mpuluzi River (SQR W55C-01395). Although data are not available to quantitatively assess the water quality state at the W5LUSU-MALUN biomonitoring site on the Lusushwane, it is expected to be Poor due to the upstream potentially polluting activities of Matsapha and Manzini urban centres.

A summary of the PES for ecological water quality is shown below:

IUCMA site code	Biomonitoring site	SQR	Water quality category
U-26, Assegaai River		W51E-02049	BC (80.6%)
U-43, Hlelo River		W52C-01867	B (87.3%)
U-44, Ngwempisi River		W53E-01790	B (85.5%)
U-53, Usuthu River		W54D-01593	B (83.6%)
U-57, Mpuluzi River		W55C-01395	C (75.9%)
U-61, Lusushwane River		W56A-01372	B (85.5%)
	W5BLES-WEEHO, Blesbokspruit	W51F-01986	C
	W5LUSU-MALUN, Lusushwane River	W56F-01762	CD

Coliform contamination is evident in certain areas, generally linked to land-use such as WWTW, urban activities and rural setttlements. However, water quality data records are short, and this assessment is therefore a high level assessment. As more data is collected by the IUCMA, confidence in the assessments will improve.

Du Plessis (2019) defines the Inkomati-Usuthu WMA to be predominantly low risk in terms of a range of physical and chemical water quality parameters, but of concerning high risk in terms of chlorophyll a and faecal coliforms. Risk areas are generally downstream or within close proximity of urban centres, cultivates areas, mining developments as well as WWTWs. Most of the WWTWs do not comply with set standards due to mismanagement, inadequate facilities or are in need of maintenance.

Note the difference in aquatic ecosystem guidelines vs. International Obligations, with the former being significantly more conservative than the latter. International Obligations were generally met at all sites assessed. Exceedences are noted in the text.

6. RECOMMENDATIONS

Table 110: Integrated Ecostatus for the Usuthu-Lusutfu River catchment for the 2015 and 2019 biomonitoring results. A comparison between Integrated Ecostatus and Recommended Ecological Category followed by comments to clarify suggestions are indicated.

Reach Code	Site Code	PES Desktop Assessment	Integrated Ecostatus 2015	Integrated Ecostatus 2019	Recommended Ecological Category	Target met?	Water Quality PES	Comments
Assegoi-Mkhondvo Sub-catchment								
W51A-02082	W5ASSE-PLATJ	C 70%	C 74.4%	BC 79.0%	BC 80%	✓		
W51C-02022	W5ASSE-KLIPS	D 50%	C 73.0%	C 68.6%	C 70%	✓		
W51C-02074	W5ANYS-KLOPP	C 70%	C 77.6%	BC 78.5%	BC 80%	✓		
W51C-01981	W5ASSE-WITK1	C 70%	BC 80.2%	C 77.7%	BC 80%	✗		
W51C-02109	W5BOES-ANHAL	B 85%	BC 80.8%	BC 81.2%	BC 80%	✓		
W51D-02151	W5SWAR-ZWART	B 85%	BC 80.4%	BC 81.6%	BC 80%	✓		
W51E-02049	W5ASSE-ZAND1 (EWR AS1) W5MKHO-NHLAN	B 85%	BC 78.6%	C 71.2%	BC 80%	✗	BC 80.6%	
W51F-01986	W5BLES-WEEHO	C 70%	C 74.6%	C 67.2%	C 70%	✓	C	
W51F-01973	W5NDHL-SWAZI	-	-	BC 78.9%	BC 80%	✓		
W51H-01808	W5MKHO-SWAZI	C 70%	-	C 77.2%	C 70%	✓		
Hlelo Sub-catchment								
W52A-01983	W5HLEL-WITBA	B 85%	C 77.3%	C 75.3%	C 70%	✓		
W52B-01964	W5HLEL-TWYFE	C 70%	C 74.6%	C 75.5%	C 70%	✓		
W52C-01867	W5HLEL-HOLDE	B 85%	BC 78.3%	C 76.7%	BC 80%	✗	BC 87.3%	
W52C-01888	W5TWEE-MONDI	B 85%	-	C 77.6%	C 70%	✓		
W52D-01862	W5HLEL-SWAZI	B 85%	B 84.3%	BC 79.8%	B 85%	✗		
Ngwempisi Sub-catchment								
W53A-01853	W5NGWE-POMPO	D 50%	C 76.5%	C 77.2%	C 70%	✓		
W53A-01757	W5SAND-ZANDS	B 85%	C 74.8%	C 77.9%	C 70%	✓		
W53D-01764	W5MPAM-GLENE	B 85%	C 72.2%	C 69.7%	C 70%	✓		
W53D-01773	W5NGWE-STERK	C 70%	C 76.2%	C 75.2%	C 70%	✓		

Reach Code	Site Code	PES Desktop Assessment	Integrated Ecostatus 2015	Integrated Ecostatus 2019	Recommended Ecological Category	Target met?	Water Quality PES	Comments
W53D-01814	W5SWAR-WOLVE	B 85%	B 82.5%	C 73.0%	B 85%	✗		
W53C-01679	W5THOL-ATHOL	C 70%	C 75.5%	BC 78.0%	BC 80%	✓		
W53E-01790	W5NGWE-SKURW	C 70%	BC 81.2%	BC 78.6%	BC 80%	✓	BC 85.5%	
W53E-01841	W5NGWE-MPONO	C 70%	C 77.1%	BC 79.5%	BC 80%	✓		
W53G-01788	W5MPON-SWAZI	C 70%	C 75.4%	C 73.1%	C 70%	✓		
W53E-01785	W5NGWE-MZIMN	-	-	C 72.5%	C 70%	✓		
Mpuluzi Sub-catchment								
W55C-01395	W5MPUL-BUSBY W5MPUL-ARDE1	B 85%	BC 79.2%	C 77.0%	BC 80%	✗	C 75.9%	
W55C-01489	W5SWAR-IZIND	B 85%	C 70.6%	C 75.1%	C 70%	✓		
W55D-01506	W5METU-SWAZI	C 70%	BC 78.7%	C 76.3%	BC 80%	✗		
W55E-01651	W5MPUL-VELAB	C 70%	C 75.3%	C 74.5%	C 70%	✓		
Lushushwane Sub-catchment								
W56A-01372	W5LUSU-IFRSI (EWR KU1)	D 50%	C 67.9%	BC 80.4%	BC 80%	✓	B 85.5%	
W56C-01514	W5LUSU-FORES	D 50%	-	C 77.2%	C 70%	✓		
W56F-01762	W5LUSU-MALUN	C 70%	BC 78.7%	C 71.1%	BC 80%	✗	CD	
Usuthu-Lusutfu Catchment								
W54C-01556	W5BONN-BROAD	C 70%	BC 79.1%	C 74.0%	BC 80%	✗		
W54D-01593	W5USUT-STAFF W5LUSU-MANGC	B 85%	C 77.7%	BC 79.1%	BC 80%	✓	BC 83.6%	
W54F-01729	W5LUSU-MABUZ	C 70%	C 74.7%	BC 78.4%	BC 80%	✓		
W57A-01803	W5LUSU-LIBET	C 70%	C 76.9%	C 74.7%	C 70%	✓		
W57E-01810	W5LUSU-SIPHO	C 70%	C 76.9%	C 69.1%	C 70%	✓		

The following recommendations are made regarding **water quality** data curation and analyses:

1. IUCMA data: Be clear on whether a reading is, for example, NO_2+NO_3 or NO_2+NO_3-N. Similarly, PO_4 or PO_4-P. The two ways of recording information are not interchangeable, and method requirements by DWAF (2008) are specific.
2. Sulphate, *E. coli* and Faecal streptococci monitoring still needs to be initiated by the IUCMA. A number of studies (e.g. Vilane and Tembe, 2016) have reported on *E.coli* pollution of river water upstream of the

Great Usuthu River in Swaziland, thereby emphasizing the significance of including coliforms in regular monitoring exercises. Recreational guidelines should be included in evaluations of data.

3. It is suggested that more definitive tests are assessed for coliforms, as it is unknown whether (for example) >1 000 cfu actually exceeds the 2 000 cfu guideline. It appears that there is a mismatch between the detectable limits of the tests or analytical laboratory, vs the guideline levels being used.
4. The other variable that is some cause for concern is Ammonia. Some clarification of analyses is required to confirm that data collected is for the unionized form of ammonia, which is toxic to aquatic organisms.
5. International Obligations water quality guidelines – see commentary below on the use and application of these guidelines for assessing water quality.

The South African Mine Water Atlas (2018) lists the following as Generic Resource Water Quality Objectives (RWQOs) available for all rivers in South Africa, where specific RQOs or EcoSpecs (for Reserve or EWR sites) are not available. The category boundaries are related to fitness for use.

Variable	Units	Bound	Ideal	Acceptable	Tolerable	Unacceptable
Cl	mg/L	Upper	40	120	175	>175
Electrical Conductivity	mS/m	Upper	30	50	85	>85
pH	Units	Lower	≥6.5	>6.5	-	<6.5
SO_4	mg/L	Upper	80	165	250	>250
TDS	mg/L	Upper	200	350	800	>800

As the comparable International Obligations guidelines are substantially higher than the Unacceptable generic fitness for use guidelines for SO_4 (250 mg/L) and Electrical Conductivity (150 mS/m), it is recommended that the IUCMA consider managing the International Obligations sites assessed during this study using more conservative and site-specific guidelines.

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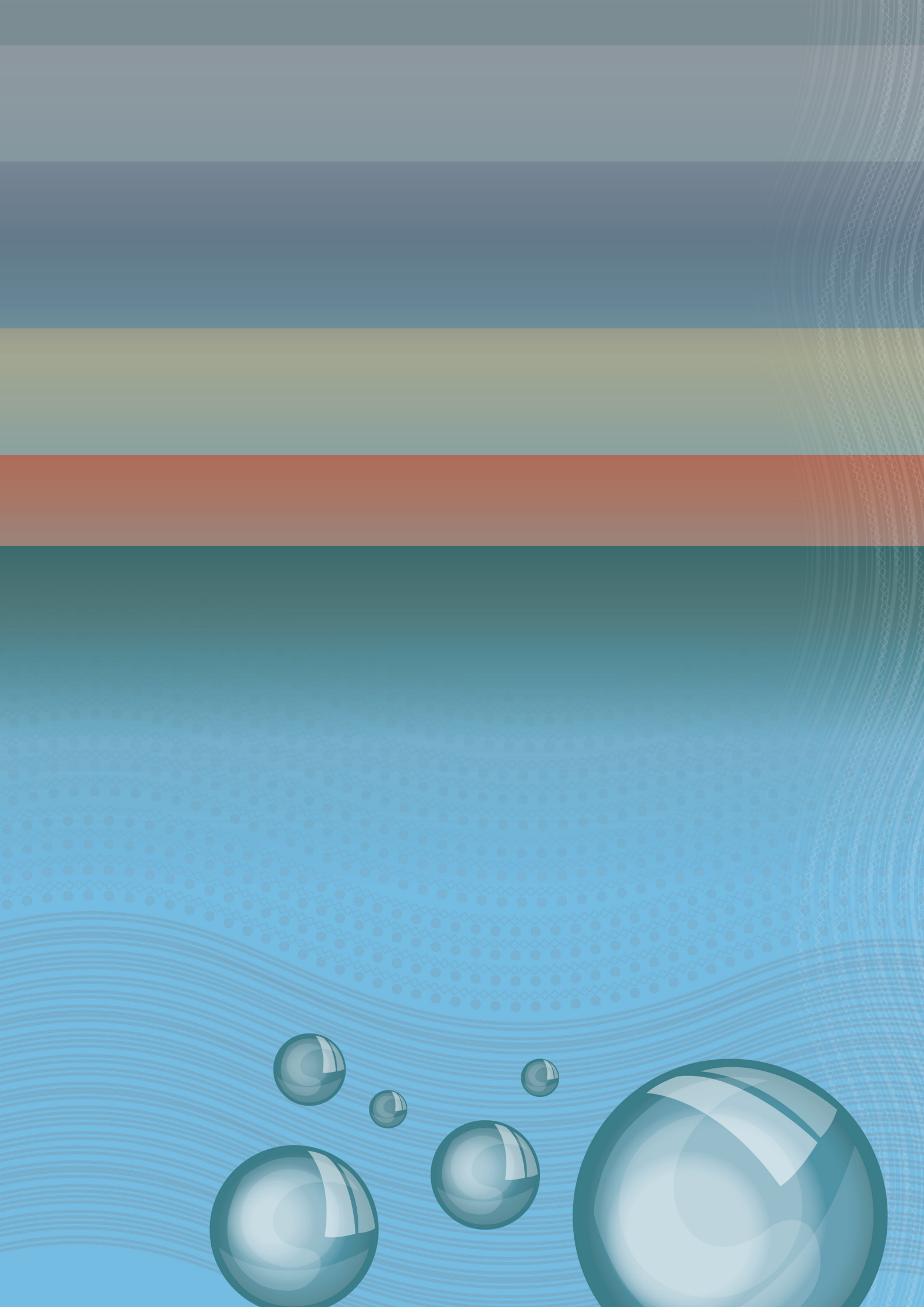

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