RESERVE DETERMINATION STUDIES FOR SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE USUTU/MHLATUZE WATER MANAGEMENT AREA
WP 10544

RIVER INTERMEDIATE EWR

VOLUME 4: ECOSPECS AND MONITORING

FINAL

DECEMBER 2014

water & sanitation

Department:
Water and Sanitation
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DEPARTMENT OF WATER AND SANITATION

CHIEF DIRECTORATE: WATER ECOSYSTEMS

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This report was compiled by Dr C. Brown with specialist input from the following project members.

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ABBREVIATIONS AND ACRONYMS

AEC	Alternative Ecological Condition
AS	Assegaai River
ASPT	Average Score Per Taxon
BM	Black Mfolozi River
DRIFT	Downstream Response to Imposed Flow Transformations
DSS	Decision Support System
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EF	Environmental Flow
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
GSM	Gravel, Stones, Mud
MA	Matigulu River
MIRAI	Macroinvertebrate Response Assessment Index
MK	Mkuze River
NCMP	National Chemical Monitoring Programme
NMMP	National Microbiological Monitoring Programme
NS	Nseleni River
PES	Present Ecological State
REC	Recommended Ecological Condition
RHP	River Health Programme
RQOs	Resource Quality Objectives
SASS5	South African Scoring System Version 5 method
TPCs	Thresholds of Potential Concern
UP	Upper Pongola
VEGRAI	Vegetation Response Assessment Index
WM	White Mfolozi River
WMA	Water Management Area
WRCS	Water Resource Classification System.
WQ	Water Quality

GLOSSARY OF TERMS

Ecological Category	Defines the ecological condition of a river in terms of the deviation of biophysical components from the reference condition. There are six Ecological Categories that range from A (natural) to F (critically modified).
EcoClassification	The determination and categorisation of the Present Ecological Status or various biophysical attributes of rivers relative to the natural and/or reference condition.
EcoStatus	The totality of features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services.
Ecological Water Requirements	The pattern (magnitude, timing and duration) and quality of flow needed to maintain an aquatic ecosystem in a particular condition (Ecological Category).
Ecological Reserve	The quantity and quality of water required to satisfy basic human needs by securing a basic water supply and in order to ensure ecologically sustainable development and use of water resources, as prescribed in the NWA.
EcoSpecs	Clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that defines the Ecological Category.
Eupotamon	Main channel
Euryhaline	Ability to adapt to a wide range of salinities
Lithophilic	Affinity for rock substrata
Present Ecological Status	The degree to which ecological conditions have been modified from reference conditions, based on water quality, biota and habitat information that is scored on a six point scale from A (natural) to F (critically modified).
Potamonic	Lower reaches of rivers, low gradient, slower velocities, deeper
Reference conditions	Natural ecological conditions prior to anthropogenic disturbance.
Rhithronic	Upper reaches of rivers, fast flowing, turbulent, rheophilic main channel residents, longitudinal pool-riffle-pool sequence

1   INTRODUCTION

1.1   Background to the study

The Chief Directorate: Resource Directed Measures issued an open tender invitation for the "Appointment of a Professional Service Provider to undertake Reserve Determinations for selected Surface water, Groundwater, Estuaries and Wetlands in the Usutu to Mhlatuze Basins". The focus on this area was a result of the high conservation status and importance of various water resources in the basin and the significant development pressures in the area affecting the availability of water.

Preliminary Reserve determinations are required to assist the DWA in making informed decisions regarding the authorisations of future water use and the magnitude of the impacts of the proposed developments on the water resources in the WMA, and to provide the input data for Classification of the area's water resources, and eventual gazetting of the Reserve (DWA 1998).

DWS appointed Tlou Consulting to undertake the project in July 2013.

1.1.1   Study objectives

The objectives of the study are to:
- determine the Ecological Reserve (DWAF 1999a), at various levels of detail, for the Nyoni, Matigulu, Mlalazi, Mhlatuze, Mfolozi, Nyalazi, Hluhluwe, Mzinene, Mkuze, Assegaai and Pongola Rivers;
- determine the Ecological Reserve, at an Intermediate level for the Pongola floodplain;
- determine the Ecological Reserve, at an Intermediate level for the St Lucia/Mfolozi, Estuary System;
- determine the Ecological Reserve, at an Rapid level for the Mlalazi Estuary;
- determine the Ecological Reserve, at a Rapid level for the Amatikulu Estuary;
- determine the Ecological Reserve, at an Intermediate level for Lake Sibaya;
- determine the Ecological Reserve, at a Rapid level for Kozi Lake and Estuary;
- classify the causal links between water supply and condition of key wetlands
- incorporate existing EWR assessments on the Mhlatuze (river and estuary) and Nhlabane (lake and estuary) into study outputs;
- determine the groundwater contribution to the Ecological Reserve, with particular reference to the wetlands;
- determine the Basic Human Needs Reserve for the Usutu/Mhlatuze WMA;
- outline the socio-economic water use in the Usutu/Mhlatuze WMA;

- build the capacity of team members and stakeholders with respect to EWR determinations and the ecological Reserve.

1.2   This report

This report is Volume 4 of four volumes of the River Intermediate EWR Report:

Volume 1: EcoClassification

Volume 2: EWR Assessment – Results

Volume 3: Specialist reports

Volume 4: EcoSpecs and Monitoring Programme.

This report covers the activities required for Step 7 of the Reserve determination process (Figure 1-1) as prescribed by the CD: RDM of DWA (DWAF 1999; DWAF 2002; Kleynhans *et al.* 2005; Kleynhans and Louw 2007).
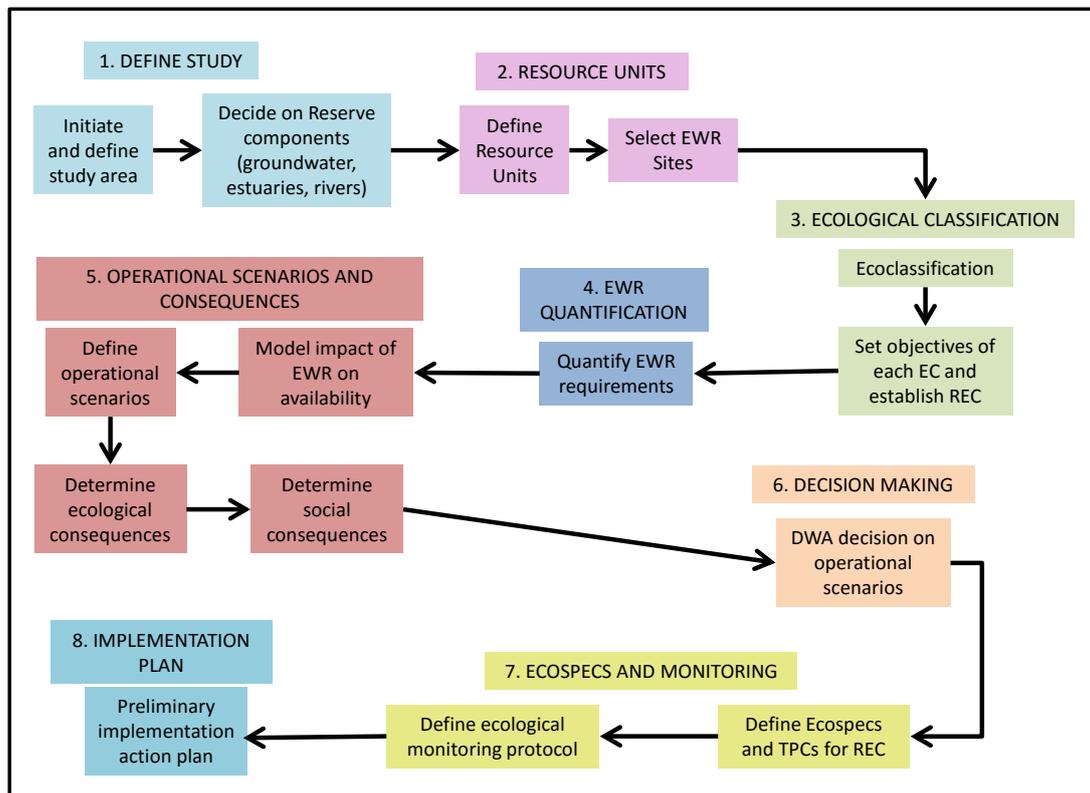
Figure 1-1   Generic procedure for the determination of the Ecological Reserve

2   STUDY AREA AND EWR SITES

2.1   Study area

The extent of the study area is shown in (Figure 2-1).
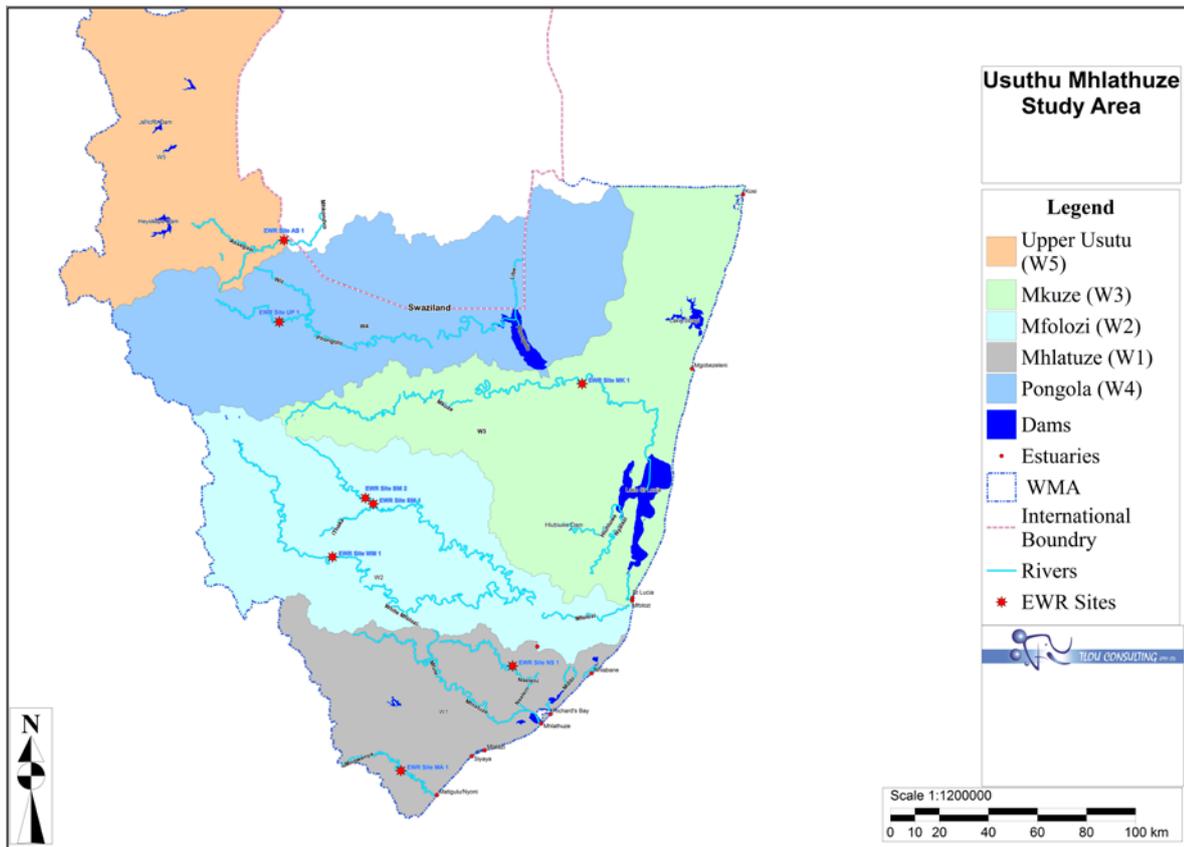
Figure 2-1   Map of the study area

It comprises the following catchment areas, and main rivers (rivers in bold denote locations of Intermediate EWR determinations):

- Mhlatuze (W1), including:
  - Mhlatuze River;
  - **Matigulu River;**
  - Mfule River;
  - **Nseleni River;**
  - Mlalazi River.
- Mfolozi (W2), including:
  - Mfolozi River;
  - **White Mfolozi River;**

- o **Black Mfolozi River;**
- o Mlalazi River;
- o Mvunyane River;
- o Nondweni River;
- o Hlonyane River;
- o SikweBezi River;
- o Mona River;
- o Msunduzi River.
- Mkuze (W3) , including:
  - o **Mkuze River;**
  - o Nkongolwana River;
  - o Msunduzi River;
  - o Mzinene River;
  - o Nzimane River;
  - o Hluhluwe River;
  - o Nylalazi River.
- Pongola (W4) , including:
  - o **Pongola River;**
  - o Bivane River;
  - o Manzana River;
  - o Mozana River;
  - o Ngwavuma River.
- Upper Usutu (W5) , including:
  - o **Assegaai River;**
  - o Ohlelo River;
  - o Ngwempisi River;
  - o Usuthu River;
  - o Bonnie Brook River.
- Lake Sibaya / Kosi (W7).

2.2   EWR sites

The NWRCS node delineation process identified 49 river nodes for which EWR data will be required for Classification. In accordance with the Terms of Reference for the study, these data will be informed by intermediate assessments at eight sites that will be used to extrapolate results across the remainder of the area.

The locations of the eight EWR sites for which Intermediate assessments were done are provided in Table 2-1.

Table 2-1   Locations of the eight EWR sites in the Intermediate EWR assessment

Quaternary	River name	Site Name	Location description	Latitude	Longitude
W51D	Assegaai	EWR Site AS1	Downstream of Heyshope Dam, near the Swaziland border.	27º3'44.28"S	30º59'19.68"E
W42E	Upper Pongola	EWR Site UP1	Near Frischgewaagd and Bilayoni Townships	27º21'50.88"S	30º58'10.62"E
W31J	Mkuze	EWR Site MK1	Adjacent to Mkuze National Park, almost opposite Mantuma Camp	27º35'31.56"S	32º13'4.80"E
W22C	Black Mfolozi	EWR Site BM1	Downstream of W2H028.	27º56'20.04"S	31º12'37.08"E
W22C	Black Mfolozi	EWR Site BM2	Near Basonhoek	28º0'50.04"S	31º19'27.48"E
W21H	White Mfolozi	EWR Site WM1	Just downstream of the R34 at the confluence with the Mvutshini River	28º13'53.24"S	31º11'17.97"E
W12H	Nseleni	EWR Site NS1	Near Cwaka. Enter through property at the end of the road	28º38'2.76"S	31º55'51.24"E
W11B	Matigulu	EWR Site MA1	Downstream of old DWA gauging station.	29º1'12.36"S	31º28'13.44"E

3 RECOMMENDED AND ALTERNATIVE ECOLOGICAL CATEGORIES

The recommended and alternative ecological categories for each of the EWR sites are provided in Table 3-1. These are based solely on ecological considerations.

Table 3-1   Recommended and alternative ecological categories for the EWR sites

River	Site	REC	AEC1	AEC2	AEC3
Assegaai	AS1	C	B	D	-
Upper Pongola	UP1	C	B	D	-
Mkuze	MK1	C	B	D	-
Black Mfolozi	BM1	C	B	D	-
Black Mfolozi	BM2	C	B	D	-
White Mfolozi	WM1	B	C	D	-
Nseleni	NS1	C	B	D	-
Matigulu	MA1	B/C	B	C	D

4   WHICH ECOSPECS ARE PROVIDED

In this report Ecospecs and TPCs are provided for the following disciplines:
- Hydrology
- Water Quality
- Geomorphology
- Vegetation
- Macroinvertebrates
- Fish.

4.1   Hydrology

The following descriptors of the hydrological characteristics are used:
- Total Mean Annual Maintenance volume
- Monthly Mean Maintenance flow
- Monthly exceedence curves for the lowflows
- Monthly exceedence curves for the complete flow regime
- Duration, magnitude (in daily average peak), volume and timing of intra-annual floods
- Duration, magnitude (in daily average peak) and volume of intra-annual floods.

The Reserve information for the EWR sites is provided in detail in River Intermediate EWR Report (No. RDM/WMA6/CON/COMP/0713, Volume 2) and is not repeated here.

4.2   Water quality

The water quality Ecospecs are encompassed in the water quality aspects of the Ecological Reserve, which are presented in Section 5 of this report.

The following water quality variables are included in the water quality Ecospecs either quantitatively or qualitatively:
- Magnesium Sulphate ($MgSO_4$) in mg/L
- Sodium Sulphate (Na_2SO_4) in mg/L
- Magesium Chloride ($MgCl_2$) in mg/L
- Calcium Chloride ($CaCl_2$) in mg/L
- Sodium Chloride (NaCl) in mg/L
- Total inorganic nitrogen (TIN) in mg/L
- Soluble Reactive Phosphorus (SRP) in mg/L
- pH
- Water temperature (°C)
- Dissolved oxygen (DO) in mg/L

- Turbidity (NTU)
- Electrical conductivity (mS/m)
- Chlorophyll a (Chl a) as periphyton algae (mg/m^2)
- Chlorophyll a as phytoplankton algae (µg/L)
- Toxic substances.

4.3   Geomorphology

The geomorphological condition at an EWR or monitoring site can be affected by both the upstream flow alterations as well as adjacent landuse activities. Thus there may not always be simple cause-effect relationships between geomorphological descriptors and flow conditions, and one should be aware of possible changes to river geomorphology that are not directly flow related.

The descriptors that were selected for geomorphology were chosen based on their assumed potential to indicate responses to flow changes. Three categories of descriptors were identified:

- Channel width
- Extent of cut banks
- Secondary channels
- Pool depth
- Bed sediment conditions
- Inundated floodplain (MK1 only)

Specifications for the range of conditions expected for the recommended Ecostatus at each EWR site were determined.

4.4   Vegetation

The plant communities will respond to habitat changes related to changes in water level as follows:

- changes in distribution of species along the vertical axis (i.e., laterally up the banks), and along the rivers (i.e., longitudinal zones);
- changes in relative species abundance;
- the loss of existing species or the gain of new species.

For this reason, descriptors of change consist of (1) a lateral zone and (2) species within the lateral zone. Details of the zonation of the riparian vegetation at the EWR sites are provided in the Intermediate EWR Report (No. RDM/WMA6/CON/COMP/0813 Volume 3).

4.5   Macroinvertebrates

Indicators selected and used in the study are presented in Table 4-1 below. Flow-, habitat- and water quality preferences are also indicated. Changes in flow patterns will have a resultant impact (negative or positive) on these taxa, often observed as changes in their abundances or frequencies of occurrence and sometimes as a loss of an entire taxon, sometimes for short periods, occasionally permanently. The indicator taxa are not all used at each site, relevant taxa are selected per site. EcoSpecs and TPCs are set for taxa representative of different biotopes available per site.

Table 4-1   Macroinvertebrate indicator groups and taxa

Group	Taxon	Flow preference	Habitat preference	Water quality preference
Vegetation dwellers with slow flowing water	Atyidae (Freshwater Shrimps)	Slow (0.1 - 0.3m/s)	Vegetation	Sensitive
	Coenagrionidae (Sprites & Blues)	Slow (0.1 - 0.3m/s)	Vegetation	Low
Cobble dwellers with fast flow	Palaemonidae (Freshwater Prawns)	Very fast (>0.6m/s)	Cobbles	Sensitive
	Perlidae (Stoneflies)	Very fast (>0.6m/s)	Cobbles	Highly Sensitive
	Philopotamidae	Very fast (>0.6m/s)	Cobbles	Sensitive
	Psephenidae (Water pennies)	Very fast (>0.6m/s)	Cobbles	Sensitive
	Hydropsychidae (Caddisflies)	Very fast (>0.6m/s)	Cobbles	Low to highly sensitive
Cobble dwellers with moderate flow	Heptageniidae (Flatheaded mayfly)	Moderate (0.3 - 0.6m/s)	Cobbles	Highly Sensitive
	Elmidae (Riffle Beetles)	Moderate (0.3 - 0.6m/s)	Cobbles	Sensitive
GSM dwellers	Gomphidae (Clubtails)	Slow (0.1 - 0.3m/s)	Gravel, sand, mud	Low
	Polymitarcyidae (Pale Burrowers)	Moderate (0.3 - 0.6m/s)	Gravel, sand, mud	Sensitive
Standing water over cobbles	Leptophlebiidae (Prongills)	Standing water (<0.1m/s	Cobbles	Moderate
All flow ranges, all habitat	Baetidae	Moderate (all flow rang	Cobbles, Veg, GSM	Low to highly sensitive
	Chironomidae			
	Simuliidae	Preferably >0.3m/s	Cobbles, Veg, GSM	(coarser substrate)

4.6   Fish

The fish communities will be affected in several ways by flow regulation. These include both beneficial and adverse effects. Some species may increase in abundance in the rivers whereas others may be lost from a specific reach. In particular, flow plays a critical role in mediating relative abundances of native and non-native species, with low, constant flows benefiting invasive alien species.

The species used as descriptors of the fish communities are given below:
- *Amphilius uranoscopus*
- *Oreochromis mossambicus*
- *Labeo molybdinus*

- *Labeobarbus marequensis*
- *Labeobarbus natalensis*
- *Barbus trimaculatus*
- *Barbus paludinosus*
- *Barbus eutenia*
- *Glossobius callidus*
- *Anguilla mossambica*
- *Varicorhinus nelspruitensis*
- *Brycinus lateralis.*

5   HYDROLOGY: ECOSPECS AND MONITORING

The Reserve information for the EWR sites, which serve as the hydrology ecospecs is provided in detail in River Intermediate EWR Report (No. RDM/WMA6/CON/COMP/0713, Volume 2) and is not repeated here.

6   WATER QUALITY: ECOSPECS AND MONITORING

6.1   EcoSpecs and Thresholds of Probable Concern

This section lists, per EWR site, the ecospecifications (EcoSpecs) for WQ and the Thresholds of Probable Concern (TPCs) for each WQ parameter. According to DWAF (2005; cited in DWAF 2008 *in prep.*), EcoSpecs are "the values of water quality parameters that should not be exceeded in order to meet the water quality component of the Recommended Ecological Category (REC). EcoSpecs are clear and measurable specifications of ecological attributes (e.g. water quality, flow, biological integrity) that define the Ecological Category (EC Cat) and serve as an input to Resource Quality Objectives (RQOs). EcoSpecs refer explicitly and only to ecological information whereas RQOs include economic and social objectives." Thresholds of Probable Concern (TPCs), on the other hand, are defined as "upper and lower levels along a continuum of change in selected environmental indicators. When this level is reached (or when modelling predicts it will be reached), it prompts an assessment of the causes of the extent of the change." In this study, WQ EcoSpecs and TPCs were derived according to the method prescribed in DWAF (2008).

Table 6-1 summarises the output of the study, for each EWR site, in terms of the overall PES, the PES for WQ, the EIS, and the Recommended Ecological Category, both overall and for WQ. It can be seen from the table that for all the sites (except for WM1-White Mfolozi), the overall REC is equal to the overall PES i.e. the recommendation is that all sites be maintained in the current EcoStatus. In order to achieve this, it is necessary for water quality also to be maintained at the current level of impact. In the case of the Mkuze site, the reach in which the EWR site is situated is currently in a C/D for WQ and because of the important conservation areas at the site and downstream (e.g. iSimangaliso Wetland Park) it is recommended that the WQ be improved to a "C" category. Table 6-2 to Table 6-9 detail the EcoSpecs for each EWR site. For most variables and for most sites these are equivalent to the boundary value of the current rating category. For a few variables it is recommended that these be improved. In the case of sulphate, which is a salt, but also is an indicator of impacts from mining (e.g. toxic metals), in river reaches where there is a risk of mining impacts this WQ variable is reported both under "salts" and "toxics".

Table 6-1   Summary of the output of the study and the REC for water quality

River	EWR site	Overall PES	WQ PES	EIS	Overall REC	REC for water quality
Matigulu	MA1	B/C	B	Moderate	B/C	B
Nseleni	NS1	C	B	Moderate	C	B
White Mfolozi	WM1	B/C	B	High	B	B
Black Mfolozi	BM1	C	B	Moderate	C	B
Black Mfolozi	BM2	C	B	Moderate	C	B
Mkuze	MK1	C	C/D	Moderate	C	C
Phongolo	UP1	C	B	Moderate	C	B
Assegai	AS1	C	B	Moderate	C	B

6.2   Monitoring

Table 6-2 to Table 6-9 provide suggestions for a water quality monitoring programme (e.g. the frequency of measurements, TPCs to be monitored). Data collected as part of the monitoring programme should be analysed according to the methods used in the EcoClassification process and results assessed against TPCs to evaluate whether monitoring objectives are being met (DWAF 2008 *in prep.*). For each site, recommendations are given as to what specific steps need be taken to ensure that the WQ component of the Ecological Reserve is attained, or in other words, to ensure that the river reach at the EWR site will remain in (or improve to, in the case of the Mkuze River) the REC for WQ. For some sites WQ monitoring stations will need to be re-instated or initiated. For other areas, e.g. the upper Nseleni River (NS1) where it is suspected that naturally saline groundwater may be present, an in-depth investigation is recommended.

Table 6-2   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Matigulu River

RIVER			Matigulu		WATER QUALITY MONITORING POINTS			
WQSU					DWAF WQ WMS		None (PES extrapolated from Mhlatuze)	
EWR SITE			MA1		RHP		None	
Confidence in PES assessment			Low - because no monitoring station in catchment. Once-off data for temperature, DO, pH, EC July 2014.					
Water Quality Constituents		RC	PES		WQ EcoSpecs	Improvement required?	TPC	Monitoring frequency
Salts (mg/L)	SO4	-	Median = 9		-	No	95th percentile to be < 20 mg/L	Every 2 months Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =1 (median = 0.006)		≤0.015 mg/L	No	50th percentile to be < 0.01 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.222)		≤0.25 mg/L	No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.4)		< 8.8	No	95th percentile to be < 8.8	Every 2 months
	Temperature	-	No/ limited data. Suspected turbidity problem due to erosion in catchment.		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)	-			No change	N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =1 (median = 35)		≤55 mS/m	No	95th percentile to be < 45 mS/m	Every 2 months
Response variables	Chl a: periphyton	<1.7 mg/m²	No data. Visual inspection did not indicate a problem.		≤ 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/C (this study)		See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	B (this study)					
	Instream toxicity	-	No data		Unlikely to be a problem. Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown.			
Toxics			No data.					
Current PES EcoClassification = B					Recommended Ecological Category = B			

Table 6-3   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Nseleni River

RIVER	Nseleni			WATER QUALITY MONITORING POINTS		
WQSU	5			**DWAF WQ WMS**	W12 188841 Nseleni R. @ Maitlands u/s Nezi Lake (in lower catchment)	
EWR SITE	NS1			**RHP**	None	
Confidence in PES assessment	Low-medium because no monitoring station in upper part of catchment where EWR site located.					

Water Quality Constituents		RC	PES	WQ EcoSpecs	Improvement required?	TPC	Monitoring frequency
Salts (mg/L)	SO4	-	Median = 14	-	No	95th percentile to be < 20 mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =0 (median = 0.005)	≤0.005 mg/L	No	50th percentile to be < 0.006 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.077)	≤0.25 mg/L	No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.6)	95%ile < 8.8	No	95th percentile to be < 8.8	Every 2 months
	Temperature	-	No/ limited data. Suspected turbidity problem due to subsistence agriculture in catchment.	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)	-		No change	N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =1* (median = 55)	≤55 mS/m	No	95th percentile to be < 55 mS/m	Every 2 months
Response variables	Chl a: periphyton	<1.7 mg/m²	No data. Visual inspection did not reveal a problem.	≤ 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/C (this study)	See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	C (this study				
	Instream toxicity	-	No data	Unlikely to be a problem. Assess only if the biomonitoring results indicate there is a serious problem and the cause is unknown. Ensure there is routine monitoring of sulphate.			
Toxics	Sulphate		14 mg/L				
Current PES EcoClassification = B				**Recommended Ecological Category = B**			

*Adjusted from Rating =2 because of suspected high natural salinity.

Table 6-4   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the White Mfolozi River

RIVER		White Mfolozi			**WATER QUALITY MONITORING POINTS**		
WQSU		4			**DWAF WQ WMS**	W2H005Q01 White Umfolozi @ Overvloed/Ulundi	
EWR SITE		WM1			**RHP**	W2MFOL-CONFL (in lower catchment, below EWR site)	
Confidence in PES assessment		**High confidence as WQ station in same WQSU and recent data available, although n < 60 points and the WQ station is ca. 30 km d/s.**					
Water Quality Constituents		**RC**	**PES**	**WQ EcoSpecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Salts (mg/L)	SO4	-	Median = 15	-	No	95th percentile to be < 20mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =0 (median = 0.005)	≤0.005 mg/L	No	50th percentile to be < 0.006 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.113)	≤0.25 mg/L	No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.5)	< 8.8	No	95th percentile to be < 8.8	Every 2 months
	Temperature	-	No/ limited data. Suspected turbidity problem due to erosion in catchment.	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)	-		No change	N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =1 (median = 30.4)	≤55 mS/m	No	95th percentile to be < 40 mS/m	Every 2 months
Response variables	Chl a: periphyton	<1.7 mg/m²	No data. Visual inspection did not reveal a problem.	≤ 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/C (this study)	See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	C (this study				
	Instream toxicity	-	No data	Although currently low, sulphate should be monitored as an indicator of potential impacts from mining u/s.			
Toxics	Sulphate (mg/L)		15				
Current PES EcoClassification = B				**Recommended Ecological Category = B**			

Table 6-5   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Black Mfolozi River (EWR BM1)

RIVER			Black Mfolozi		WATER QUALITY MONITORING POINTS			
WQSU			7		DWAF WQ WMS	W2H028Q01 (W22 102857) Black Umfolozi @Ekuhlengeni		
EWR SITE			BM1		RHP	None		
Confidence in PES assessment			High confidence as WQ station in same WQSU, close to EWR site and recent data available, although n < 60 points.					
Water Quality Constituents		RC	PES	WQ EcoSpecs		Improvement required?	TPC	Monitoring frequency
Salts (mg/L)	SO4	-	Median = 56	-		Yes	95th percentile to be < 20 mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =0 (median = 0.005)	≤0.005 mg/L		No	50th percentile to be < 0.006 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.05)	≤0.25 mg/L		No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.1)	95%ile < 8.8		No	95th percentile to be < 8.8	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)	-		No change		N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =0 (median = 25)	≤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. Visual inspection did not reveal a problem.	≤ 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/C (this study)	See EcoSpecs for fish and invertebrates respectively				
	Fish community score	-	C (this study					
	Instream toxicity	-	No data	Sulphate should be monitored as it is an indicator of potential impacts from u/s mining. Median levels are currently high.				
Toxics	Sulphate	-	Median =56 mg/L					
Current PES EcoClassification = B				Recommended Ecological Category = B				

Table 6-6   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Black Mfolozi River (EWR BM2)

RIVER	Black Mfolozi			WATER QUALITY MONITORING POINTS	
WQSU	8			DWAF WQ WMS	W2H006Q01 (W22 102835) Black Umfolozi @ Reserve no 12
EWR SITE	BM2			RHP	None
Confidence in PES assessment	**High confidence as WQ station in same WQSU, and recent data available, although n < 60 points and the monitoring station is ca. 20 km d/s.**				

Water Quality Constituents		RC	PES	WQ EcoSpecs	Improvement required?	TPC	Monitoring frequency
Salts (mg/L)	SO4	-	Median = 12	-	No	95th percentile to be < 20 mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =0 (median = 0.005)	≤0.005 mg/L	No	50th percentile to be < 0.006 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.089)	≤0.25 mg/L	No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.3)	95%ile < 8.8	No	95th percentile to be < 8.8	Every 2 months
	Temperature	-	No/ limited 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 = 2 (from visual inspection)	No change	N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =0 (median = 21)	≤30 mS/m	No	95th percentile to be < 30 mS/m	Every 2 months
Response variables	Chl a: periphyton	<1.7 mg/m^2	No data. Visual inspection did not reveal a problem.	≤ 1.7 mg/m^2 (A category)	N/A	50th percentile to be < 1.7 mg/m^2	Quarterly
	Chl a: phytoplankton	< 10 µg/L		≤ 10 µg/L (A category)		50th percentile to be < 10 µg/L	
	Macroinvertebrates (Ec Cat)	-	B/C (this study)	See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	C (this study)				
	Instream toxicity	-	No data	Sulphate should be monitored as it is an indicator of impacts from mining in the upper catchment. It is currently high in the u/s WQSU, but low in this WQSU.			
Toxics	Sulphate (mg/L)	-	Median =12				
Current PES EcoClassification = B				**Recommended Ecological Category = B**			

Table 6-7   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Mkuze River (EWR MK1)

RIVER	Mkuze			WATER QUALITY MONITORING POINTS			
WQSU	5			DWAF WQ WMS	W3H032Q01 (W31 102886) Mkuze River @ Overwin (stopped 2009)		
EWR SITE	MK1			RHP	W3MKZE-D0230 (in middle catchment) and W3MKZE-DNYDR (at EWR site).		
Confidence in PES assessment	**Medium confidence as WQ station in same WQSU, but monitoring ended in 2009 and < 60 points.**						
Water Quality Constituents		RC	PES	WQ EcoSpecs	Improvement required?	TPC	Monitoring frequency
Salts (mg/L)	SO4	-	Median = 167	-	Yes	95th percentile to be < 40 mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =2 (median = 0.02)	≤0.015 mg/L	Yes	50th percentile to be < 0.015 mg/L	Every 2 months
	TIN	0.25	Rating =1 (median = 0.53)	≤0.25 mg/L	Yes	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (8.2- 8.7)	95%ile < 8.8	No	95th percentile to be < 8.8	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 =4 (median = 245)	≤85 mS/m	Yes	95th percentile to be < 85 mS/m	Every 2 months
Response variables	Chl a: periphyton	<1.7 mg/m²	No data. Visual inspection did not reveal a problem.	≤ 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)	-	C (this study)	See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	B/C (this study				
	Instream toxicity	-	No data	Sulphate is very high at this site and should be monitored. Pesticides levels may also reach problematic levels at this site due to intensive cultivation upstream.			
Toxics	Sulphate (mg/L)	-	Median =167				
Current PES EcoClassification = C/D				**Recommended Ecological Category = C**			

Table 6-8   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Upper Phongolo River.

RIVER	Phongolo				WATER QUALITY MONITORING POINTS		
WQSU	1				**DWAF WQ WMS**	None	
EWR SITE	UP1				**RHP**	None	
Confidence in PES assessment	**Medium as WQ station from Bivane River (with some limited supporting data from the Phongolo River).**						
Water Quality Constituents		**RC**	**PES**	**WQ ecospecs**	**Improvement required?**	**TPC**	**Monitoring frequency**
Salts (mg/L)	SO4	-	Median = 4-13	-	No	95th percentile to be < 20 mg/L	Every 2 months
Nutrients (mg/L)	PO4	0.005	Rating =0 (median = 0.005)	≤0.005 mg/L	No	50th percentile to be < 0.006 mg/L	Every 2 months
	TIN	0.25	Rating =0 (median = 0.17)	≤0.25 mg/L	No	50th percentile to be < 0.25 mg/L	Every 2 months
Physical variables	pH (5 – 95%ile)	6.5-8.0	Rating =1 (95%ile = 8.2)	95%ile < 8.8	No	95th percentile to be < 8.8	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 = 0	No change	N/A	No change allowed.	Every 2 months
	EC (mS/m)	≤30	Rating =0 (median = 11)	≤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. Visual inspection noted extensive algae at the site..	≤ 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/C (this study)	See EcoSpecs for fish and invertebrates respectively			
	Fish community score	-	C (this study				
	Instream toxicity	-	No data	Toxic substances not expected at this site. Assess only if the biomonitoring results indicate that there is a serious problem and the cause is unknown. Sulphates low at this site but should be monitored because of the risk from mining in the area.			
Toxics	Sulphate (mg/L)	-	Median = 4 -13				
Current PES EcoClassification = B					**Recommended Ecological Category = B**		

Table 6-9   Water quality EcoSpecs and thresholds of potential concern (TPCs) for the Assegaai River.

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**			

6.2.1   Recommendations for MA1:

- Total Suspended Sediments or turbidity should be monitored at the site to establish if sedimentation is a problem.
- Consider re-establishing WQ monitoring station W1H010Q01 (W11 102810) and ensure the WQ parameters listed in Table 6-2 are monitored.
- A RHP monitoring site should be established in this reach.

6.2.2   Recommendations for NS1

- Total Suspended Sediments or turbidity should be monitored at the site to establish if there is a problem with regard to this parameter.
- Temperature and DO should be measured routinely.
- A RHP site should be established in this reach.
- Consider establishing a WQ monitoring station in the upper catchment, near the EWR site.
- Investigate cooperation between the NMMP and the NCMP in the lower (and upper) Nseleni so that sampling is undertaken at the same time and place.
- Consider initiating an investigation into the salinity levels in the Nseleni River. The aims of this would be to establish the possible sources of salts, whether natural/anthropogenic, the risk to the environment/agriculture/subsistence livelihoods from elevated salinity, and a management strategy to minimise these risks if required. This information should then be used to revise the TPC and EcoSpecs for EC given in Table 6-3.

6.2.3   Recommendations for WM1

- Maintain the current WQ monitoring site.
- Total Suspended Sediments or turbidity should also be monitored at the site to establish if there is a problem with regard to this parameter.
- Temperature and DO should be measured routinely.
- If possibly an RHP site should be established in this reach (the existing RHP site is in the lower catchment).

6.2.4   Recommendations for BM1

- Instream concentrations of sulphate are very high at this site and are an indicator of potential impacts from mining (i.e. toxic constituents such as metals) from upstream in the catchment. Sources of contaminants should be stopped from leaching into the river.
- Temperature and DO should be measured routinely.
- A RHP site should be established in this reach.

- There appears to be no current WQ monitoring station u/s of the Klipfontein Dam (as opposed to point-sources of pollution). This should be addressed.

6.2.5   Recommendations for BM2

- Continue monitoring of sulphates.
- Total Suspended Sediments or turbidity should be monitored at the site to establish if there is a problem with regard to this parameter.
- Temperature and DO should be measured routinely.
- A RHP site should be established in this reach.

6.2.6   Recommendations for MK1

- Minimise contamination from mining in the upper catchment from entering into the Mkuze River and establish an instream monitoring station to monitor compliance.
- Ensure that as far as possible good agricultural practices are followed especially in the middle portion of the catchment. This would include ensuring that wide buffer strips of natural vegetation are maintained between cultivated fields and the river in order to minimise agricultural return-flows containing elevated concentrations of salts, nutrients and pesticides.
- Similarly, ensure good agricultural practices are also practised upstream of the Pongolapoort Dam in order to maintain good WQ in the dam - which can be used to improve WQ in the Mkuze (via the existing IBT). But note that pollution impacts should be tackled at source first, before dilution is used to address the problem.
- Resume monitoring at W3H032Q01 (W31 102886) Mkuze River @ Overwin or another site in order to monitor the impacts from mining and cultivation in the upper and middle catchment on downstream conservation areas.
- Ensure there is regular biomonitoring at the current EWR/RHP site to monitor general WQ and the impacts of possible toxic substances such as pesticides.

6.2.7   Recommendations for UP1

- Monitoring at station W42 189409 (Silverton 21 u/s Paul Pietersburg-Piet Retief Road Bridge on Phongolo River) should be resumed and the standard set of WQ parameters, including nutrients should be monitored.
- A RHP should be established in this river reach.
- Note that on-site observations indicate that there might be localised impact from nutrients in the area. Because of a lack of data it was impossible to substantiate this, but this matter should be investigated further (establishing a WQ monitoring station and/or an RHP site should help towards this aim).

6.2.8   Recommendations for AS1

- Monitoring at station W5H022Q01 (W51 102914 @ Zandbank on Assegaai R) should be resumed and the standard set of WQ parameters, including nutrients should be monitored.
- A RHP site should be established in this reach.
- Efforts should be taken to establish the source(s) of nutrients entering into the river and to address them.

6.2.8   Recommendations for AS1

7   GEOMORPHOLOGY: ECOSPECS AND MONITORING

Ecological monitoring should be focussed on the critical indicators of change - those indicators:

1. that relate most directly to the agents of change or causes of concern in the catchment,
2. that respond within a timeframe appropriate for management decisions, and;
3. whose changes can be detected with relative ease using practicable, cost-effective monitoring methods.

Indicators of physical habitats and gross geomorphology generally respond slowly to flow changes, and display wide natural variations in response to natural flow events, particularly to large floods. The interpretation of geomorpholgical changes requires specialist insight to distinguish between changes caused by natural flow events and those resulting from flow manipulations or landuse changes in the catchment.

The generally slow, and occasionally punctuated, rates of change of geomorphological features makes the monitoring of geomorphological condition less suitable than monitoring of other ecosystem attributes such as hydrology, water quality, invertebrates or fish. However, at EWR sites with large upstream dams where there is the potential for large scale changes in flood and sediment delivery patterns, monitoring of the geomorphological (physical habitat) conditions is important to explain and predict patterns of biotic response.

There are several monitoring methods and associated frequencies of data collection and analysis which could be implemented. Of these, simple fixed point photograph monitoring at the EWR sites offers a cheap but effective method to monitor site conditions. Due to the ease and cost-effectiveness of this method, fixed point site photograph monitoring is considered the priority and minimum basic monitoring which should be undertaken.

In Section 7.1, geomorphological indicators are tabulate as used in the DRIFT modelling. Not all of these are good monitoring indicators, mainly because they are impractical or expensive to monitor, and so are not included in the monitoring programme in Section 7.2.

7.1   EcoSpecs and Thresholds of Probable Concern

7.1.1   EWR Site AS1 (Assegaai River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River) are provided in Table 7-1.

Table 7-1   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River)

Indicator	Predicted change as % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	-1.74	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections, channel width should be monitored with the cross-section or, ideally, with aerial photos and satellite imagery.*	1) Any shallowing or widening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	-1.22	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	1.79	Maintain secondary channels in the reach. *This site is a pool riffle cross-section within an anastomosing (multi-channel) reach. The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 75% of the secondary channel reaches.
Pool depth	0.87	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-5.28	Maintain similar gross channel characteristics: a predominantly boulder bed with no fines in the riffles. *Monitor with step-point surveys of bed sediments.*	Sands should be equal to or less than 30% of the area of the active channel bed at the cross-section.

7.1.2   EWR Site UP1 (Upper Pongola River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site UP1 (Upper Pongola River) are provided in Table 7-2.

Table 7-2   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for Site UP1 (Upper Pongola River)

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	7.78	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections, channel width should be monitored with the cross-section or, ideally, with aerial photos and satellite imagery.*	1) Any shallowing or widening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	3.01	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	-0.03	Maintain secondary channels in the reach. *The number of active secondary channels can ne assessed with aerial photos and satellite imagery.*	Maintain more than 50% of the secondary channel reaches.
Pool depth	0.98	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	0.92	Maintain similar gross channel characteristics: a predominantly boulder/bedrock rapid with few fines in the riffles.	Sands should be equal to or less than 10% of the area of the active channel bed at the cross-section.

7.1.3   EWR Site MK1 (Mkuze River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mukuze River) are provided in Table 7-3.

Table 7-3   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mkuze River)

Indicator	Predicted change as % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	-9.41	There should be no incision or narrowing of the river channel at the EWR site. Incision of the channel is highly undesirable as it alters habitat conditions and reduces flood deliver to the riparian zone and floodplain. *Incision and narrowing of the channel can be monitored through resurveyed cross-sections, reach-characteristics of channel width should be monitored with aerial photos and satellite imagery.*	1) Any narrowing or deepening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	-2.57	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	1.80	Maintain secondary channels in the reach. *The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 75% of the secondary channel reaches.
Pool depth	-5.22	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-3.97	Maintain similar gross channel characteristics: The reach is a completely sand bed channel and there should be very few cobbles or large gravels.	Cobbles and gravels should be less than 10% of the area on the cross-section

7.1.4   EWR Site BM1 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River)are provided in Table 7-4.

Table 7-4   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River)

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	-1.81	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections, channel width should be monitored with the cross-section or, ideally, with aerial photos and satellite imagery.*	1) Any shallowing or widening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	-2.63	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	-0.13	Maintain secondary channels in the reach. *The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 50% of the secondary channel reaches.
Pool depth	2.10	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-6.07	Maintain similar gross channel characteristics: a bedrock and cobble riffle and pool section.	Sands should be equal to or less than 10% of the area of the riffles

7.1.5 EWR Site BM2 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River) are provided in Table 7-5.

Table 7-5   **Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River)**

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	-1.35	There should be no widening of the mainstem channel through the reach. *Aggradation of the channel can be monitored with aerial photos and satellite imagery.*	Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	-5.64	n/a - the site is highly stable due to the influence of bedrock and monitoring is not practicable.	n/a
Secondary channels	0.58	Maintain the few secondary channels in the reach. *The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 50% of the secondary channel reaches.
Pool depth	-0.11	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-5.53	Maintain similar gross channel characteristics: a site is a bedrock dominated reach. *Monitoring should take place at the riffle located immediately upstream of the drift road crossing.*	Sands should be equal to or less than 10% of the area of the riffle bed .

7.1.6 EWR Site WM1 (White Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River) are provided in Table 7-6.

Table 7-6   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River)

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	1.47	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections, channel width should be monitored with the cross-section or, ideally, with aerial photos and satellite imagery.*	1) Any shallowing or widening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	0.61	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	-2.20	Maintain secondary channels in the reach. *The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 50% of the secondary channel reaches.
Pool depth	5.94	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-5.42	Maintain similar gross channel characteristics a predominantly sand and boulder bed.	Gravels, cobbles and boulders should be greater or equal to 40% of the area of the active channel bed at the cross-section.

7.1.7   EWR Site NS1 (Nseleni River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River) are provided in Table 7-7.

Table 7-7   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River)

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	2.00	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections.*	Any shallowing or widening of the active channel caused at the riffle cross-section.
Extent of cut banks	1.20	Maintain the very stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 10% cut bank extent at the EWR site.
Secondary channels	2.27	There are few secondary channels in this incised reach, and moreover, monitoring of them due to the dense riparian canopy is not practicable using remote data sources such as satellite imagery. EcoSpecs and TPCs are not set for this indicator because it is impractical.	n/a
Pool depth	0.90	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-4.63	Maintain similar gross channel characteristics: a predominantly cobble riffle with few fines in the riffle, separating a long run (upstream) and pool (downstream). *Monitor with step-point surveys of bed sediments.*	Sands and silts should be equal to or less than 10% of the area of the active channel bed at the cross-section.

7.1.8   EWR Site MA1 (Matigulu River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River) are provided in Table 7-8.

Table 7-8   Geomorphology: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River)

Indicator	Predicted change at % of Baseline	Ecospecs and recommended monitoring approach	TPC
Channel width	2.13	There should be no shallowing or widening of the mainstem channel at the riffle cross-section of the EWR site. *Aggradation of the channel can be monitored through resurveyed cross-sections, channel width should be monitored with the cross-section or, ideally, with aerial photos and satellite imagery.*	1) Any shallowing or widening of the active channel caused by accumulations of sand at the riffle cross-section. 2) Reach-wide narrowing of the river channel (indicative of flow stabilisation and/or vegetation encroachment and fine accumulations at the margins) observed from aerial photo analysis.
Extent of cut banks	-6.12	Maintain the stable marginal banks. *The condition of the marginal banks can be monitored with comparisons with geotagged site photographs.*	Less than 20% cut bank extent at the EWR site.
Secondary channels	6.31	Maintain secondary channels in the reach. *The number of active secondary channels can be assessed with aerial photos and satellite imagery.*	Maintain more than 50% of the secondary channel reaches.
Pool depth	-5.03	Pool depth is an important habitat, hence its inclusion in the DRIFT analysis. However no baseline data exist for pool depth across the reach and EcoSpecs have thus not been set for this indicator.	n/a
Bed sediment conditions	-0.24	Maintain similar gross channel characteristics: a predominantly boulder bed with no fines in the riffles. *Monitor with step-point surveys of bed sediments.*	Sands should be equal to or less than 10% of the area of the riffles

7.2   Monitoring

There are several monitoring methods and associated frequencies of data collection and analysis which could be implemented. Of these, simple fixed point photograph monitoring at the EWR sites, or analysis of available aerial photographic data, offers cheap but very effective methods to monitor site conditions. ***Due to the ease and cost-effectiveness of these methods, monitoring using fixed point site photographs for cut banks and aerial photographic for channel widths is recommended as the minimum basic monitoring which should be undertaken***.

The recommended methods, frequency of sampling and interpretation of data collected are addressed in Table 7-9.

Table 7-9   Recommended methods, frequency of sampling and interpretation of geomorphological data

Indicator	Frequency	Collection of data	Interpretation
Bed sediment[1]	Every 5 years	*BED SEDIMENT CHARACTERISTICS:* Resurvey the surface bed sediments after 5 years along the cross-section to provide an indication of instream physical habitat conditions. Undertake a 100 step point survey of the sediments within the active channel (at the cross-section unless stated otherwise).	Analyse bed material distribution data and compare to TPCs provided for each site.
Secondary channels	Every 5 to 10 years	*REACH MORPHOLOGY (using aerial photographs): Analysis of aerial photographs or Google Earth imagery.*	Assess the aerial photographs (aerial photographs or satellite imagery) for reductions in secondary channel reaches with the wider study region.

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[1] After any 1:20-year or greater return period flood, it is recommended that the fixed point photographs, cross sections and bed material are resurveyed to recalibrate the site conditions in response to natural extreme flood events. All information should be reviewed in the context of the antecedent (drought and flood) events of the period being evaluated, and the expected trajectories of change following large floods.

Indicator	Frequency	Collection of data	Interpretation
Cut banks	Every 2 years to 5 years	*FIXED POINT PHOTOGRAPHS* Fixed-point photography - photograph the site and compare with the 2014 geotagged site photographs.	Fixed point photography should be analysed for changes in channel geometry and hydraulic habitat (comparing the condition between the monitoring intervals). Reduction in critical habitats, and generally of channel width, is undesirable. Interpret guided by the site-specific guidelines provided in the Ecospecs tables.
Channe l width	Every 5 to 10 years	*CROSS-SECTION MONITORING:* Re-survey of fixed cross-sections	Assess the re-surveyed cross-sections and aerial photographs for changes in channel width at the site (cross section) or reach (aerial photographs or satellite imagery) scale. Interpret these in terms of short- medium- changes in hydrology and land use. Some of the EWR sites have narrowed channels, and further reductions in available habitat at these sites are undesirable.
	Approx every 5 to 10 years	*REACH MORPHOLOGY (using aerial photographs):* Analysis of aerial photographs or Google Earth imagery.	

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8   VEGETATION: ECOSPECS AND MONITORING

8.1   EcoSpecs and Thresholds of Probable Concern

The vegetation Ecospecs are intended to provide narrative, and where possible quantifiable and enforceable, descriptors of the riparian vegetation for the recommended ecological category (REC) for each of the study rivers. In each of the tables below (Section 8.1.1 to 8.1.8), predicted change as % of Baseline refers to the change expected for the Ecological Reserve to maintain REC.

Figure 8-1   Riparian vegetation on the Mkuze River (vegetation Ecospecs for the Mkuze River are provided in Section 8.1.3)

8.1.1   EWR Site AS1 (Assegaai River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River) are provided in Table 8-1.

Table 8-1   **Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River)**

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 20%	An increase in perennial alien species cover above 30%		VEGRAI measurement: 19%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-33.99	VEGRAI measurement: 48%
		Lower Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-46.70	VEGRAI measurement: 37%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover below 80%, but not absent	The absence of riparian woody species OR an increase in riparian woody cover above 80%	27.71	VEGRAI measurement: 50%
		Lower Zone	Maintain riparian woody species cover between 5-60%	The absence of riparian woody species OR an increase in riparian woody cover above 60%	-36.82	VEGRAI measurement: 25%
		Upper Zone	Maintain riparian woody species cover between 20-70%	An increase in riparian woody cover above 70% OR a decrease below 15%	-12.11	VEGRAI measurement: 30%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	22.28	VEGRAI measurement: 5%
	Phragmites (reed) cover	Marginal and Lower Zones	Reed cover between 10% and 90%	The absence of reeds OR an increase in reed cover above 90%		VEGRAI measurement: 45%

8.1.2   EWR Site UP1 (Upper Pongola River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site UP1 (Upper Pongola River) are provided in Table 8-2.

Table 8-2   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for Site UP1 (Upper Pongola River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 20%	An increase in perennial alien species cover above 30%		VEGRAI measurement: 14%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 20%	A decrease in indigenous graminoid cover below 20%		VEGRAI measurement: 24%
		Lower Zone	Maintain indigenous graminoid cover above 20%	A decrease in indigenous graminoid cover below 20%	-19.52	VEGRAI measurement: 22%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover below 80%, but not absent	The absence of riparian woody species OR an increase in riparian woody cover above 80%	3.53	VEGRAI measurement: 10%
		Lower Zone	Maintain riparian woody species cover between 5-60%	The absence of riparian woody species OR an increase in riparian woody cover above 60%	-16.80	VEGRAI measurement: 10%
		Upper Zone	Maintain riparian woody species cover between 20-70%	An increase in riparian woody cover above 70% OR a decrease below 10%	-23.46	VEGRAI measurement: 10%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	-21.90	VEGRAI measurement: 8%
	Phragmites (reed) cover	Marginal and Lower Zones	Reed cover between 10% and 90%	The absence of reeds OR an increase in reed cover above 90%		VEGRAI measurement: 40%

8.1.3   EWR Site MK1 (Mkuze River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mukuze River) are provided in Table 8-3.

Table 8-3   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mkuze River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change as % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone (excluding floodplain)	Maintain alien species cover below 10%	An increase in perennial alien species cover above 20%	0	VEGRAI measurement: <10%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	2.79	VEGRAI measurement: 30%
		Lower Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-19.06	VEGRAI measurement: 50%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover below 80%, but not absent	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-4.89	VEGRAI measurement: 40%
		Lower Zone	Maintain riparian woody species cover between 5-80%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-26.70	VEGRAI measurement: 70%
		Upper Zone	Maintain riparian woody species cover between 20-100%	An decrease in riparian woody cover below 50%	-10.54	VEGRAI measurement: 80%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	20.96	VEGRAI measurement: 10%
		Floodplain	Maintain woody terrestrial species cover below 50%	An increase in woody terrestrial species cover above 60%	-	VEGRAI measurement: 25%
	Phragmites (reed) cover	Marginal and Lower Zones	Maintain reed cover between 10% and 90%	The absence of reeds OR an increase in reed cover above 90%	-	VEGRAI measurement: 10%

8.1.4   EWR Site BM1 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River) are provided in Table 8-4.

Table 8-4   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 20%	An increase in perennial alien species cover above 30%		VEGRAI measurement: 20%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-40.15	VEGRAI measurement: 40%
		Lower Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-71.14	VEGRAI measurement: 48%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover between 5-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-55.61	VEGRAI measurement: 5%
		Lower Zone	Maintain riparian woody species cover between 5-60%	The absence of riparian woody species OR an increase in riparian woody cover above 60%	-66.82	VEGRAI measurement: 5%
		Upper Zone	Maintain riparian woody species cover between 20-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-28.67	VEGRAI measurement: 5%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	93.00	VEGRAI measurement: 9%
	Phragmites (reed) cover	Marginal and Lower Zones	Reed cover between 10% and 90%	The absence of reeds OR an increase in reed cover above 90%		VEGRAI measurement: 20%

8.1.5   EWR Site BM2 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River) are provided in Table 8-5.

Table 8-5   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 20%	An increase in perennial alien species cover above 30%		VEGRAI measurement: 12%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-46.50	VEGRAI measurement: 45%
		Lower Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-84.19	VEGRAI measurement: 48%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover between 5-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-63.44	VEGRAI measurement: 5%
		Lower Zone	Maintain riparian woody species cover between 5-60%	The absence of riparian woody species OR an increase in riparian woody cover above 60%	-70.33	VEGRAI measurement: 5%
		Upper Zone	Maintain riparian woody species cover between 20-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-24.64	VEGRAI measurement: 5%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	28.78	VEGRAI measurement: 9%
	Phragmites (reed) cover	Marginal and Lower Zones	Reed cover between 10% and 90%	The absence of reeds OR an increase in reed cover above 90%		VEGRAI measurement: 16%

8.1.6   EWR Site WM1 (White Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River) are provided in Table 8-6.

Table 8-6   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
B/C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 15%	An increase in perennial alien species cover above 20%	0	VEGRAI measurement: 5%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 10%	An absence of indigenous graminoids	-0.40	VEGRAI measurement: 19%
		Lower Zone	Maintain indigenous graminoid cover above 15%	A decrease in indigenous graminoid cover below 10%	-12.56	VEGRAI measurement: 25%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover between 5-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-4.09	VEGRAI measurement: 5%
		Lower Zone	Maintain riparian woody species cover between 10-50%	The absence of riparian woody species OR an increase in riparian woody cover above 60%	0.89	VEGRAI measurement: 5%
		Upper Zone	Maintain riparian woody species cover between 30-60%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-9.41	VEGRAI measurement: 5%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 20%	An increase in woody terrestrial species cover above 30%	33.50	VEGRAI measurement: 7%
	Phragmites (reed) cover	Marginal and Lower Zones	maintain reed cover between 5% and 80%	The absence of reeds OR an increase in reed cover above 90%	-	VEGRAI measurement: 5%

8.1.7   EWR Site NS1 (Nseleni River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River) are provided in Table 8-7.

Table 8-7   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 20%	An increase in perennial alien species cover above 30%	0	VEGRAI measurement: 20%
	Indigenous riparian graminoids	Marginal Zone	Maintain some indigenous graminoid cover	An absence of indigenous graminoids	-2.35	VEGRAI measurement: 5%
		Lower Zone	Maintain some indigenous graminoid cover	An absence of indigenous graminoids	-13.24	VEGRAI measurement: 10%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover between 20-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-16.46	VEGRAI measurement: 50%
		Lower Zone	Maintain riparian woody species cover between 20-80%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-23.82	VEGRAI measurement: 60%
		Upper Zone	Maintain riparian woody species cover above 40%	The decrease of riparian woody species cover below 50%	-23.50	VEGRAI measurement: 75%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 30%	An increase in woody terrestrial species cover above 40%	10.50	VEGRAI measurement: 10%
	Phragmites (reed) cover	Marginal and Lower Zones	Maintain reed cover below 10%	The increase in reed cover above 20%		VEGRAI measurement: 2%

8.1.8   EWR Site MA1 (Matigulu River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River) are provided in Table 8-8.

Table 8-8   Vegetation: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River)

PES	Assessed Component	Zone Assessed	EcoSpec (for REC)	TPC (for REC)	Predicted change at % of Baseline	Status quo: 2014
B/C	Alien Invasion (perennial aliens)	Riparian zone	Maintain alien species cover below 15%	An increase in perennial alien species cover above 20%	0	VEGRAI measurement: 10%
	Indigenous riparian graminoids	Marginal Zone	Maintain indigenous graminoid cover above 20%	A decrease in indigenous graminoid cover below 10%	-31.13	VEGRAI measurement: 30%
		Lower Zone	Maintain indigenous graminoid cover above 30%	A decrease in indigenous graminoid cover below 20%	-49.80	VEGRAI measurement: 40%
	Indigenous Riparian Woody Cover	Marginal Zone	Maintain riparian woody species cover between 5-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-50.61	VEGRAI measurement: 5%
		Lower Zone	Maintain riparian woody species cover between 10-70%	The absence of riparian woody species OR an increase in riparian woody cover above 80%	-39.25	VEGRAI measurement: 10%
		Upper Zone	Maintain riparian woody species cover between 20-70%	The decrease of riparian woody species cover below 20% OR above 80%	-4.57	VEGRAI measurement: 20%
	Terrestrialisation	Riparian zone	Maintain woody terrestrial species cover below 20%	An increase in woody terrestrial species cover above 30%	35.60	VEGRAI measurement: 10%
	Phragmites (reed) cover	Marginal and Lower Zones	Maintain reed cover below 10%	The increase in reed cover above 20%	-	VEGRAI measurement: 5%

8.2   Monitoring

Permanently marked plots should be established along the cross-sections at the EWR sites and density counts of shrubs within them should be done every second year.

- Vertical photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the Ecostatus table for each site.
- Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded.

In order to reduce time and financial costs, it is possible to restrict the transects to one side of the river.

9   MACROINVERTEBRATES: ECOSPECS   AND MONITORING

9.1   EcoSpecs and Thresholds of Probable Concern

EcoSpecs and TPCs are set per site including those for the MIRAI EC, SASS5 total score, ASPT, as well as for selected indicators per biotope. Biotopes include stones, marginal vegetation and GSM. Substrate, velocity and water quality preferences are indicated. Only selected indicators will be used to set EcoSpecs and TPCs.

9.1.1   EWR Site AS1 (Assegaai River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River) are provided in Table 9-1 and Table 9-2.

Table 9-1   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences (Assegaai River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Atyidae	-22.47	0.1-0.3m/s	Vegetation	Sensitive
Perlidae	-59.07	>0.6m/s	Cobbles	Highly sensitive
Gomphidae	11.13	0.1-0.3m/s	GSM	Low

Table 9-2   Macroinvertebrate EcoSpecs and TPCs for Site AS1 (Assegaai River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >200; ASPT value: >6.3.	SASS5 scores less than 205 and ASPT less than 6.5.
To ensure that the MIRAI score remains within the range of a B category (>82% – <88%), using the same reference data used in this study.	A MIRAI score of 83% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae (Abundance A)	If Perlidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Atyidae (Abundance A)	Atyidae missing in two consecutive surveys or has a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Perlidae Atyidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.2   EWR Site UP1 (Upper Pongola River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site UP1 (Upper Pongola River) are provided in Table 9-3 and Table 9-4.

Table 9-3   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for Site UP1 (Upper Pongola River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Coenagrionidae	-1.24	0.1-0.3m/s	Vegetation	Low
Perlidae		>0.6m/s	Cobbles	Highly Sensitive
Gomphidae		0.1-0.3m/s	GSM	Low

Table 9-4   Macroinvertebrate EcoSpecs and TPCs for Site UP1 (Upper Pongola River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >175; ASPT value: >6.	SASS5 scores less than 190 and ASPT less than 6.5.
To ensure that the MIRAI score remains within the range of a B/C category (>78% – <82%), using the same reference data used in this study.	A MIRAI score of 78.5% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae (Abundance A)	If Perlidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance A)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Perlidae Coenagrionidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.3   EWR Site MK1 (Mkuze River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mukuze River) are provided in Table 9-5.

Table 9-5   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for Site MK1 (Mkuze River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Coenagrionidae	-1.39	0.1-0.3m/s	Vegetation	Low
Gomphidae	-0.77	0.1-0.3m/s	GSM	Low

Table 9-6   Macroinvertebrate EcoSpecs and TPCs for Site MK1 (Mkuze River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >100; ASPT value: >5.	SASS5 scores less than 110 and ASPT less than 5.2.
To ensure that the MIRAI score remains within the range of a C category (<60% – <78%), using the same reference data used in this study.	A MIRAI score of 65% or less.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance B)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Coenagrionidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.4   EWR Site BM1 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River) are provided in Table 9-7.

Table 9-7   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for EWR Site BM1 (Black Mfolozi River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Atyidae	-20.05	0.1-0.3m/s	Vegetation	Sensitive
Perlidae	-39.41	>0.6m/s	Cobbles	Highly sensitive
Gomphidae	-11.91	0.1-0.3m/s	GSM	Low

Table 9-8   Macroinvertebrate EcoSpecs and TPCs for Site BM1 (Black Mfolozi River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >175; ASPT value: >6.	SASS5 scores less than 190 and ASPT less than 6.5.
To ensure that the MIRAI score remains within the range of a B/C category (>78% – <82%), using the same reference data used in this study.	A MIRAI score of 81.5% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae (Abundance B)	If Perlidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Atyidae (Abundance A)	Atyidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Perlidae Atyidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.5   EWR Site BM2 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River) are provided in Table 9-9.

Table 9-9   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for EWR Site BM2 (Black Mfolozi River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Coenagrionidae	-63.64	0.1-0.3m/s	Vegetation	Low
Perlidae	-34.36	>0.6m/s	Cobbles	Highly Sensitive
Gomphidae	-8.20	0.1-0.3m/s	GSM	Low

Table 9-10   Macroinvertebrate EcoSpecs and TPCs for Site BM2 (Black Mfolozi River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >175; ASPT value: >6.	SASS5 scores less than 180 and ASPT less than 6.1.
To ensure that the MIRAI score remains within the range of a B/C category (>78% – <82%), using the same reference data used in this study.	A MIRAI score of 78.5% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae (Abundance B)	If Perlidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance B)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Perlidae Coenagrionidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.6   EWR Site WM1 (White Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River) are provided in Table 9-11.

Table 9-11   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for EWR Site WM1 (White Mfolozi River)

Indicator	Predicted change at % of Baseline	Velocity	Substrate	Quality
Coenagrionidae	-7.47	0.1-0.3m/s	Vegetation	Low
Hydropsychidae	-13.92	>0.6m/s	Cobbles	Low to Highly Sensitive
Gomphidae	-3.19	0.1-0.3m/s	GSM	Low

Table 9-12   Macroinvertebrate EcoSpecs and TPCs for Site WM1 (White Mfolozi River)

The REC is a B category; therefore the EcoSpecs and TPCs are set for a B category.

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >180; ASPT value: >6.	SASS5 scores less than 185 and ASPT less than 6.2.
To ensure that the MIRAI score achieves a B category (>82% – <88%), using the same reference data used in this study.	A MIRAI score of 83% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Hydropsychidae (Abundance B)	If Hydropsychidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance A)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Hydropsychidae Coenagrionidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.7   EWR Site NS1 (Nseleni River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River) are provided in Table 9-13.

Table 9-13   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for EWR Site NS1 (Nseleni River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Coenagrionidae	-4.56	0.1-0.3m/s	Vegetation	Low
Hydropsychidae	-19.15	>0.6m/s	Cobbles	Variable
Elmidae	-8.76	0.3-0.6m/s	Cobbles	Sensitive

Table 9-14   Macroinvertebrate EcoSpecs and TPCs for Site NS1 (Nseleni River)

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >130; ASPT value: >5.	SASS5 scores less than 135 and ASPT less than 5.1.
To ensure that the MIRAI score achieves a B/C category (>78% – <82%), using the same reference data used in this study.	A MIRAI score of 79% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Hydropsychidae (Abundance B)	If Hydropsychidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance B)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Hydropsychidae Coenagrionidae Elmidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.1.8   EWR Site MA1 (Matigulu River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River) are provided in Table 9-15.

Table 9-15   Macroinvertebrates: Predicted percentage change from Baseline (2014), plus taxon preferences for EWR Site MA1 (Matigulu River)

Indicator	Predicted change as % from Baseline	Velocity	Substrate	Quality
Coenagrionidae	-30.54	0.1-0.3m/s	Vegetation	Low
Perlidae	-25.96	>0.6m/s	Cobbles	Highly Sensitive
Gomphidae	11.95	0.1-0.3m/s	GSM	Low

Table 9-16   **Macroinvertebrate EcoSpecs and TPCs for Site MA1 (Matigulu River)**

Biological Ecospecs	Biological TPCs
To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >180; ASPT value: >5.9.	SASS5 scores less than 190 and ASPT less than 6.
To ensure that the MIRAI score remains within the range of a B/C category (>78% – <82%), using the same reference data used in this study.	A MIRAI score of 79% or less.
To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae (Abundance A)	If Perlidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae (Abundance A)	Coenagrionidae missing in two consecutive surveys a single individual in two consecutive surveys.
To maintain suitable conditions for the following three key taxa: Perlidae Coenagrionidae Gomphidae	Presence of less than two of the three key taxa listed in any survey.
To ensure that no group consistently dominates the fauna, defined as C abundance (>100) over more than two consecutive surveys.	Any taxon occurring in an abundance of >100 for two consecutive surveys.

9.2   Monitoring

Sampling using the latest SASS (South African Scoring System) protocol is suggested, on an annual basis during the low flow season (June/July). Monitoring should only be conducted by a DWS accredited practitioner.

9.2.1   Interpretation of results

Data gathered should be entered into the MIRAI, which would allow for the determination of the macroinvertebrate EC. The MIRAI provides a habitat-based cause-and-effect foundation to interpret the deviation of the macroinvertebrate assemblage from reference condition (Thirion, 2007). The MIRAI generates an Ecological Category (EC) for macroinvertebrates by integrating the ecological requirements of an assemblage and relating this to modified flow, instream habitat and water quality conditions. The information generated from the MIRAI should be used to determine whether or not the EcoSpecs and TPCs are being met.

10   FISH: ECOSPECS AND MONITORING

10.1   EcoSpecs and Thresholds of Probable Concern

10.1.1   EWR Site AS1 (Assegaai River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River) are provided in Table 10-1.

The most important flow-related metrics at EWR Site AS1 include:

- Velocity-depth classes: particularly Fast-Shallow (FS) and Fast-Deep (FD) for the eupotamonic lithophilic guild members represented by *L. marequensis* over the spawning period (Oct-Mar) and for the rhithronic riffle guild members represented by *A. uranoscopus* and *V. nelspruitensis* all year.
- Flow modification and migration: reduced frequency of floods may disrupt migration and spawning cues for larger cyprinids.
- Cover: inundation of marginal vegetation for the potamonic lentic guild members represented by *B. trimaculatus*.
- Substratum: cobble and boulder size classes required for *A. uranoscopus* maintenance habitat and *L. marequensis* spawning habitat.

Table 10-1   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site AS1 (Assegaai River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Amphilius uranoscopus	-27.37	Retain current CPUE > 5 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (FS > 20%, FD > 20 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - CPUE <2 fish/hr of electrofishing. - Combined FS and FS flow depth class frequencies <20%. - Proportions of Cobble and Boulder substrata <20% at the site.
Labeobarbus marequensis	-37.85	Retain current CPUE > 5 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (FS > 20%, FD > 20 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - CPUE <2 fish/hr of electrofishing. - FS and FS flow depth class frequencies <20%. - Proportions of Cobble and Boulder substrata

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
			<20% at the site.
Barbus trimaculatus	-2.36	Retain current CPUE > 1 fish/hr of electrofishing. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - CPUE <1 fish/hr of electrofishing. No inundation of marginal graminoids
Varicorhinus nelspruitensis	-22.30	*V. Nelspruitensis* is rare in this reach. Use flow-depth classes as a proxy. FS and FD flow-depth classes present throughout the year (FS > 20%, FD > 20 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - Combined FS and FS flow depth class frequencies <20%. - Proportions of Cobble and Boulder substrata <20% at the site.

10.1.2 EWR Site UP1 (Upper Pongola River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site UP1 (Upper Pongola River) are provided in Table 10-2.

The most important flow-related metrics at EWR Site UP1 include:

- Velocity-depth classes: particularly Fast-Shallow (FS) and Fast-Deep (FD) for the eupotamonic lithophilic guild members represented by *L. marequensis* over the spawning period (Oct-Mar) and for the rhithronic riffle guild members represented by *A. uranoscopus* and *V. nelspruitensis* all year.
- Cover: inundation of marginal vegetation for the potamonic lentic guild members represented by *B. trimaculatus*.
- Substratum: cobble and boulder size classes required for *A. uranoscopus* maintenance habitat and *L. marequensis* spawning habitat.

Table 10-2   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for Site UP1 (Upper Pongola River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Amphilius uranoscopus	-9.52	*A. uranoscopus* uncommon in this reach. One of the rock catfish species should be present in the sample (*A. uranoscopus*, *Chiloglanis anoterus* or *C. emarginatus*). FS and FD flow-depth classes present throughout the year (FS > 20%, FD > 50 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - No rock catfish of any species present in the sample. - Combined FS and FS flow depth class frequencies <50%. - Proportions of Cobble and Boulder substrata <25% at the site.
Oreochromis mossambicus	11.23	*O. mossambicus* should comprise <25% of the catch.	TPC reached if: - *O.mossambicus* comprises >50% of the catch
Labeobarbus marequensis	-14.35	*L. marequensis* should be present in the catch. FS and FD flow-depth classes present throughout the year (FS > 20%, FD >50 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - CPUE <1 fish/hr of electrofishing. - Combined FS and FS flow depth class frequencies <25%. - Proportions of Cobble and Boulder substrata <25% at the site.
Barbus trimaculatus	3.01	> 1 fish/hr of electrofishing. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - CPUE <1 fish/hr of electrofishing. No inundation of marginal graminoids
Varichorinus nelspruitensis	-12.37	*V. Nelspruitensis* is rare in this reach. Use flow-depth classes as a proxy. FS and FD flow-depth classes present throughout the year (FS > 20%, FD >50 %). Retain cobble and boulder substrata at the site >50%.	TPC reached if: - Combined FS and FS flow depth class frequencies <25%. - Proportions of Cobble and Boulder substrata <25% at the site.

10.1.3 EWR Site MK1 (Mkuze River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mkuze River) are provided in Table 10-3.

The most important flow-related metrics at EWR Site MK1 include:

- Cover: sufficient inundation of marginal vegetation for the potamonic lentic guild members represented by *B. paludinosus* and *Brycinus lateralis*
- The predominance of fine sediments (100% Sand) and Slow-shallow Flow-Depth classes (80%) at EWR Site MK1 under Baseline conditions renders this site unsuitable for permanent occupation by eupotamonic lithophilic guild members represented by *L. natalensis* due to the absence of spawning and feeding habitat and juvenile cover. Migration requirements between reaches, however, remain an important consideration here – Fast-Deep (FD) and Slow-Deep (SD) habitat classes should be present.
- Flow modification and migration: reduced frequency of floods may disrupt migration and spawning cues for larger cyprinids and an increase in the proportion of Slow-shallow flow may curtail migrations.

Table 10-3   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MK1 (Mkuze River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Oreochromis mossambicus	24.18	*O. mossambicus* should comprise <50% of the catch. current CPUE <15 fish/hr of electrofishing.	TPC reached if: - CPUE >15 fish/hr of electrofishing or >50% of the catch
Labeobarbus natalensis	-11.88	*L. natalensis* not common in this reach. Use habitat as proxy. FD and SD flow classes should be present	TPC reached if: - Predominance of SS flow classes - No FD and SD flow classes present over Transitional and Wet Seasons
Barbus paludinosus	-11.78	Retain current CPUE > 10 fish/hr of electrofishing. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - CPUE <1 fish/hr of electrofishing. - No inundation of marginal graminoids
Brycinus lateralis	-6.19	*B. lateralis* not common in this reach. Use habitat as proxy. Inundation of at least 10 cm of marginal graminoids.	No inundation of marginal graminoids

10.1.4 EWR Site BM1 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River)are provided in Table 10-4.

The most important flow-related metrics at EWR Site BM1 include:

- Velocity-depth classes: particularly Fast-Shallow (FS) and Fast-Deep (FD) for the eupotamonic lithophilic guild members represented by *L. natalenis* and *L. molybdinus* over the spawning period (Oct-Mar) and for the rhithronic riffle guild members represented by *A. uranoscopus* all year.
- Cover: inundation of marginal vegetation for the potamonic lentic guild members represented by *B. eutaenia*.
- Substratum: cobble and boulder size classes required for *A. uranoscopus* maintenance habitat and *L. natalensis* spawning habitat.

Table 10-4   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM1 (Black Mfolozi River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Amphilius uranoscopus	-47.50	Retain current CPUE >5 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (FS >10 %). Retain cobble substrata at the site >50%.	TPC reached if: - CPUE <2 fish/hr of electrofishing. - FS and FD flow depth class frequencies <10% - Cobble substrata <20% at the site.
Oreochromis mossambicus	13.76	*O. mossambicus* should comprise <10% of the catch. Current CPUE <5 fish/hr of electrofishing.	TPC reached if: - CPUE >5 fish/hr of electrofishing or >10% of the catch.
Labeo molybdinus	-49.18	*L. molybdinus* were not common at this site. Use habitat as proxy. FS and FD flow-depth classes present throughout the year (>10%). Retain cobble substrata at the site >50%.	TPC reached if: - FS and FD flow depth class frequencies <10%. - Proportions of Cobble substrata <20% at the site.
Labeobarbus natalensis	-70.83	Retain current CPUE > 20 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (>10%). Retain cobble substrata at the site >50%.	TPC reached if - CPUE < 5 fish/hr of electrofishing. - FS and FS flow depth class frequencies <10% - Proportions of Cobble substrata <20% at the site.
Barbus eutaenia	-24.46	Retain current CPUE > 20 fish/hr of electrofishing. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - CPUE < 5 fish/hr of electrofishing. - No inundation of marginal graminoids

10.1.5 EWR Site BM2 (Black Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River) are provided in Table 10-5.

The most important flow-related metrics at EWR Site BM2 include:

- The abundance of *L. molybdinus* at this site was attributable to the combination of Fast-Deep (FD) velocity-depth class over boulders and bedrock overhangs and these conditions are considered necessary to maintain the site in the current condition.
- Velocity-depth classes: particularly Fast-Shallow (FS) and Fast-Deep (FD) for the eupotamonic lithophilic guild members represented by *L. natalenis* and *L. molybdinus* over the spawning period (Oct-Mar) and for the rhithronic riffle guild members represented by *A. uranoscopus* all year.
- Cover: inundation of marginal vegetation for the potamonic lentic guild members represented by *B. trimaculatus*.
- Substratum: cobble and boulder size classes required for *A. uranoscopus* maintenance habitat and *L. natalensis* spawning habitat.

Table 10-5   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site BM2 (Black Mfolozi River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Amphilius uranoscopus	-50.84	Retain current CPUE > 5 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (FS & FD > 10 % respectively). Proportions of boulder and gravel substrata >20%.	TPC reached if: - CPUE <2 fish/hr of electrofishing. - Combined FS and FD flow depth class frequencies <10% respectively. - Proportions of boulder and gravel substrata <10% at the site.
Oreochromis mossambicus	26.00	*O. mossambicus* should comprise <10% of the catch. Current CPUE < 5 fish/hr of electrofishing.	TPC reached if: - CPUE >10 fish/hr of electrofishing or >10% of the catch.
Labeo molybdinus	-44.45	Retain current CPUE >20 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (>10%). Proportions of boulder and gravel substrata >20%.	TPC reached if: - CPUE <5 fish/hr of electrofishing. FS and FD flow depth class frequencies <10% . - Proportions of boulder and gravel substrata <10% at the site.
Labeobarbus natalensis	-63.30	Retain current CPUE >20 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (>10%). Proportions of boulder and gravel substrata >20%.	TPC reached if: - CPUE <5 fish/hr of electrofishing. - FS and FS flow depth class frequencies <10% - Proportions of boulder and gravel substrata <10% at

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
			the site.
Barbus trimaculatus	-29.28	Retain current CPUE >20 fish/hr of electrofishing. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - CPUE <5 fish/hr of electrofishing. - No inundation of marginal graminoids

10.1.6 EWR Site WM1 (White Mfolozi River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River) are provided in Table 10-6.

The most important flow-related metrics at EWR Site WM1 include:

- The abundance of *L. molybdinus* at this site was attributable to the combination of Fast-Deep (FD) velocity-depth class over boulders and these conditions are considered necessary to maintain the site in the current condition.
- Velocity-depth classes: particularly Fast-Deep (FD) for the eupotamonic lithophilic guild members represented by *L. natalenis* and *L. molybdinus* over the spawning period (Oct-Mar) and for the rhithronic riffle guild members represented by *A. uranoscopus* all year.
- Substratum: cobble and boulder size classes required for *A. uranoscopus* maintenance habitat and *L. natalensis* spawning habitat.

Table 10-6 Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site WM1 (White Mfolozi River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Amphilius uranoscopus	-23.36	Retain current CPUE >1 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (combined FS & FD >50%). Combined proportions of boulder and cobble >50%.	TPC reached if: - *A. uranoscopus* should be present at the site. - Combined FS and FD flow depth class frequencies <25%. - Proportions of boulder and cobble substrata <25%
Oreochromis	4.70	*O. mossambicus* should	TPC reached if:

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
mossambicus		comprise <10% of the catch. Current CPUE <5 fish/hr of electrofishing.	- CPUE >10 fish/hr of electrofishing or >10% of the catch.
Labeo molybdinus	-21.97	Retain current CPUE >20 fish/hr of electrofishing. FS and FD flow-depth classes present throughout the year (combined FS & FD >50%). Combined proportions of boulder and cobble >50%.	TPC reached if: - CPUE <5 fish/hr of electrofishing. - Combined FS and FD flow depth class frequencies <25%. - Proportions of boulder and cobble substrata <25%
Labeobarbus natalensis	-22.69	Retain current CPUE >20 fish/hr of electrofishing FS and FD flow-depth classes present throughout the year (combined FS & FD >50%). Combined proportions of boulder and cobble >50%.	TPC reached if: - CPUE <5 fish/hr of electrofishing. - Combined FS and FD flow depth class frequencies <25%. - Proportions of boulder and cobble substrata <25%

10.1.7 EWR Site NS1 (Nseleni River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River) are provided in Table 10-7.

Note: of the indicators selected for this site; only *G. callidus* was sampled in significant numbers. In the event that they are not sampled here, habitat conditions should be used as a proxy.

The most important flow-related metrics at EWR Site NS1 include:
- Velocity-depth classes: particularly Fast-Shallow (FS) for the euryhaline gobies represented by *G. callidus*.
- Substratum: cobble and gravel size classes required for euryhaline gobies.
- Migration: adequate depths for fish passage of large cyprinids and catadromous eels over the Transitional and Wet Seasons.

Table 10-7   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site NS1 (Nseleni River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Oreochromis mossambicus	4.33	*O. mossambicus* should comprise <10% of the catch. Current CPUE <5 fish/hr of electrofishing.	TPC reached if: - CPUE >10 fish/hr of electrofishing or >10% of the catch.
Labeobarbus natalensis	-20.46	Not common in this reach. Use habitat as proxy. Maintain adequate depths for migration over the Transitional and Wet Seasons (>0.2 m)	TPC reached if: - Depths over the Transitional and Wet Seasons <0.2 m
Barbus paludinosus	0.25	Not common in this reach. Use habitat as proxy. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - No inundation of marginal graminoids
Glossogobius callidus	-3.59	Retain current CPUE >20 fish/hr of electrofishing. Maintain >10 % FS habitat, Combined gravel and cobble >30 %.	TPC reached if: - CPUE <5 fish/hr - <5% FS habitat - Combined gravel and cobble <20%
Anguilla mossambica	-10.45	Not common in this reach Use habitat as proxy. Maintain adequate depths for migration over the Transitional and Wet Seasons (minimum depth >0.2 m). Adequate SD habitat in pools.	TPC reached if: Depths over the Transitional and Wet Seasons: minimum depth <0.2 m.

10.1.8 EWR Site MA1 (Matigulu River)

The predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River) are provided in Table 10-8.

The most important flow-related metrics at EWR Site MA1 include:

- Velocity-depth classes: particularly Fast-Shallow (FS) for the euryhaline gobies represented by *G. callidus* and for eupotamonic lithophilic guild members represented by *L. natalenis*.
- Substratum: cobble and boulder size classes required for euryhaline gobies and for eupotamonic lithophilic guild members represented by *L. natalenis*.
- Migration: adequate depths for fish passage of large cyprinids and catadromous eels over the Transitional and Wet Seasons.

Table 10-8   Fish: Predicted percentage change from Baseline (2014), plus Ecospecs and TPCs for EWR Site MA1 (Matigulu River)

Indicator	Predicted change at % of Baseline	Ecospecs	TPC
Oreochromis mossambicus	2.57	*O. mossambicus* should comprise <10% of the catch. Current CPUE <5 fish/hr of electrofishing.	TPC reached if: - CPUE >10 fish/hr of electrofishing or >10% of the catch.
Labeobarbus natalensis	-38.53	Retain current CPUE >4 fish/hr of electrofishing. Maintain combined FS and FD flow-depth classes >10%. Maintain cobble-boulder substratum at >50%.	TPC reached if: - CPUE <1 fish/hr of electrofishing. - Combined FS and FD flow-depth classes <5%, Cobble-boulder substratum <25%.
Barbus paludinosus	-24.04	Not common in this reach. Use habitat as proxy. Inundation of at least 10 cm of marginal graminoids.	TPC reached if: - No inundation of marginal graminoids
Glossogobius callidus	-6.32	One of the gobies present in the catch (*G. callidus*, *G. giuris* or *Awaous aeneofuscus*). Maintain combined FS and FD flow-depth classes >10%. Maintain cobble-boulder substratum at >50%.	TPC reached if: - None of the gobies present in the sample. - Combined FS and FD flow-depth classes <5%, Cobble-boulder substratum <25%.
Anguilla mossambica	-23.33	Not common in this reach Use habitat as proxy. Maintain adequate depths for migration over the Transitional and Wet Seasons (>0.2 m). Adequate SD habitat in pools (>20%).	TPC reached if: Minimum depths over the Transitional and Wet Seasons <0.2 m. Loss of SD habitat.

10.2   Monitoring

Monitoring of Ecospecs should be undertaken bearing in mind that fish abundances are highly variable in space and time owing to their high mobility, patchy distribution and inter-annual variation in recruitment – all these factors being dependent on the environmental

conditions (hydrology, temperature) prevailing during and immediately preceding sampling events. It is suggested that annual monitoring be undertaken during the low flow season (June/July) – at the same time the EWR survey was undertaken when conditions in the rivers are suitable for sampling.

10.2.1 Fish sampling and processing

Electrofishing is recommended as the most effective, versatile and repeatable method for sampling a range of different fish species and habitat conditions. Electrofishing should be conducted at each site along the margins and thalweg of the active channel and side channels – moving diagonally from one back to the next, or from bank to thalweg if feasible. It is recommended that the electrofishing team consist of two people – the electrofisher and netter. The team should begin at the downstream end of the site and proceed in an upstream direction for a distance of 100 – 150 m, electrofishing for a period of between 45 and 60 minutes. The effort – the time taken to complete the transect – should be recorded. To replicate the methodology used during the EWR survey, it is recommended that the same electrofishing transects be used for monitoring. The coordinates for the start and end of each transect selected for the EWR survey at each site appear in **Table 10-9**.

Table 10-9   Geographical coordinates for the start and end of each electrofishing transect sampled during the course of EWR surveys in July 2014.

	Start		End	
	Lat	**Long**	**Lat**	**Long**
AS1	-27.062107°	30.988751°	-27.061269°	30.988127°
UP1	-27.363589°	30.969776°	-27.363938°	30.968806°
MK1	-27.591975°	32.219177°	-27.592290°	32.216176°
BM1	-27.939554°	31.211261°	-27.938856°	31.210312°
BM2	-28.013878°	31.324900°	-28.014305°	31.323721°
WM1	-28.231483°	31.188037°	-28.232142°	31.186380°
NS1	-28.634095°	31.931226°	-28.633805°	31.930787°
MA1	-29.021521°	31.470209°	-29.020225°	31.469921°

Captured fish should be held in a bucket or live well and at the end of the electrofishing period, the following information for each individual fish should be recorded:

- Species name
- Fork Length (FL, mm)
- Total Length (TL, mm)
- Weight (grams)
- Reproductive stage (i.e. whether it was ripe-and-running – note that no dissections were carried out)
- Fish health and condition (i.e. the presence of any externally visible anomalies such as parasites and lesions)

Where the taxon cannot be confirmed on-site, the sample should be fixed in a 40 % solution of formaldehyde for 24 hrs after which it can be transferred to the 96% alcohol and identified in the laboratory. The remaining fish should be returned to the river.

10.2.2 Fish habitat measurement and characterisation

The depth, substratum, velocity and cover characteristics of the transect should be recorded. Depth and velocity can be recorded by means of an electromagnetic current meter if one is available, or by means of a Transparent Velocity-Head Rod (TVHR) as described Fonstad et al. (2005). Full details for constructing and using a TVHR appear in the aforementioned paper. Substratum should be classified according to the size classed defined by Rowntree and Wadeson (1999) (silt, sand, gravel, cobble, boulder). Fish cover can be recorded according to the following categories: overhanging vegetation, aquatic macrophytes, marginal vegetation, woody debris and undercut banks (**Table 10-11**). Hydraulic habitat should be described in terms of depth, velocity (m.s^{-1}) and flow-depth classes outlined in **Table 10-10**. It is recommended that permanent transects be set up at each site and that these variables be measured at one or two meter intervals across the channel depending on the width of the river. Frequency histograms representing relative proportions of the different variables (Flow-depth, substratum and cover) can then be calculated and compared with the ecospecs for that site and against each other between years.

Table 10-10   Flow-Depth Classes for fish (Kleynhans et al. 2008)

Flow-Depth Class	Abbreviation	Velocity	Depth	Description
Slow Very Shallow	SVS	<0.3 m.s^{-1}	<0.1 m	Backwaters and slackwaters
Slow Shallow	SS	<0.3 m.s^{-1}	0.1-0.5 m	Backwaters and shallow pools
Slow Deep	SD	<0.3 m.s^{-1}	>0.5 m	Deep pools and backwaters
Fast Very Shallow	FVS	>0.3 m.s^{-1}	<0.1 m	Very shallow riffles and runs
Fast Shallow	FS	>0.3 m.s^{-1}	0.1-0.2 m	Shallow riffles and runs
Fast Intermediate	FI	>0.3 m.s^{-1}	0.2-0.3 m	Intermediate depth riffles and runs
Fast Deep	FD	>0.3 m.s^{-1}	>0.3 m	Deep riffles, runs and rapids

Table 10-11   Non-flow dependent Habitat Classes for fish (Jordanova et al. 2004)

Habitat Class	Description
Overhanging vegetation	Thick vegetation overhanging water by approximately 0.3 m and not more than 0.1 m above the water surface. This includes marginal vegetation
Undercut banks and root wads	Banks overhanging water by approximately 0.3 m and not more than 0.1 m above the water surface
Stream substrate	Various substrate components (rocks, boulders, cobbles, gravel, sand, fine sediment and woody debris "snags") that provide cover for fish
Aquatic macrophytes	Submerged and emergent water plants
Water column	Used to assess depth in relation to the size of fish

10.2.3 Interpretation of results

The data from the fish and habitat monitoring surveys should be compared with the Ecospecs and TPCs for each site and indicator species listed in this document. Utmost caution should be exercised when interpreting the results of monitoring surveys bearing in mind that fish catches are likely be highly variable between sampling events for the reasons indicated in the preceding section. Also, although every effort was made to select indicator species that were relatively abundant, this was not always possible. Some species may therefore be uncommon at the EWR Site. The absence of a species from a catch may therefore be spurious and greater reliance should then be placed on assessing habitat conditions at the site. Fish abundances and habitat should be interpreted together. Consistent trends in fish abundances and habitat variables observed in consecutive years are more reliable indicators of change, e.g. if FD conditions are consistently absent and numbers of *L. molybinus* are low in two consecutive years at EWR Site WM1, it is very likely that a TPC has been met or exceeded.

11   REFERENCES

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