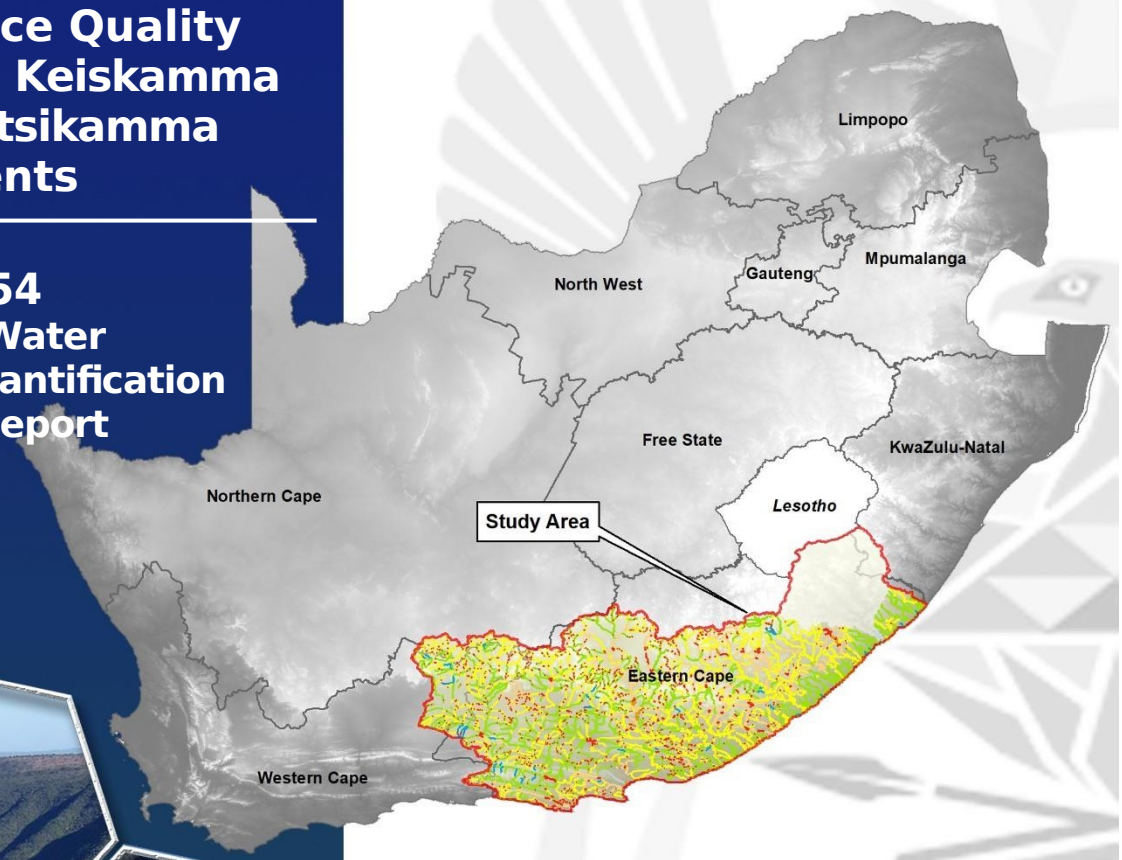
DEPARTMENT OF WATER AND SANITATION

Determination of Water Resource Classes, Reserve and the Resource Quality Objectives in the Keiskamma and Fish to Tsitsikamma Catchments

WP11354
Ecological Water Requirements Quantification for Rivers Report



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19.0	**WEM/WMA7/00/CON/RDM/1923**	**Ecological Water Requirements (EWR) quantification for rivers Report**

LIST OF ACRONYMS

CD: WEM	Chief Directorate: Water Ecosystems Management
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EcoRegions	Ecological Regions
EIS	Ecological Importance and Sensitivity
EI	Ecological Importance
ES	Ecological Sensitivity
EWR	Ecological Water Requirements
IEI	Integrated Ecological Index
IHI	Index of Habitat Integrity
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
RU	Resource Units
WMA	Water Management Area
WR2012	Water Resources 2012
WRCS	Water Resources Classification System
WWTW	Wastewater Treatment Work

EXECUTIVE SUMMARY

Background and Purpose

This Ecological Water Requirements (EWR) Quantification Report forms part of step 4 of the Reserve determination process and aligns with Step 3 of the integrated framework, DWS (2017) as part of the study to Determine the Water Resource Classes, Reserve and Resource Quality Objectives (RQOs) in the Keiskamma and Fish to Tsitsikamma catchment.

The results from this study will guide the Department of Water and Sanitation (DWS) to meet the objectives of maintaining, and if attainable, improving the ecological state of the water resources to facilitate sustainable use of the water resources while maintaining ecological integrity. The primary deliverable will be the preparation of the templates with the final Water Resource Classes and RQOs for gazetting.

This report draws on the results of the eco-categorisation that was undertaken for all selected Ecological Water Requirement (EWR) sites (see Report No. WEM/WMA7/00/CON/RDM/1723, Volume 1 and Volume 2). The focus of this report is the quantification of the EWRs using various approaches depending on the specific conditions and impacts at the EWR sites. These include:

- Habitat Flow Stressor Response (HFSR) for the **Intermediate** EWR sites;
- Verification of the Desktop Reserve Model (DRM)/ Revised DRM within SPATSIM for the integration of data produced from the surveys and eco-categorisation to quantify the EWRs for the **Rapid 3** EWR sites;
- **Desktop** EWRs for those EWR sites where little or no information was available from field surveys; and
- **Extrapolation** using the characteristics of Rapid 3 or Intermediate sites where Desktop/ Field Verification sites are in the same ecoregion level 2.

Study Area and location of EWR sites

The study area consists of the water resources of the Keiskamma, Fish to Tsitsikamma catchments and include large drainage areas as well as some smaller coastal systems, including:

- Mbhashe River (part of drainage region T which includes T11, T12 and T13),
- Great Kei River (drainage region S),
- Great Fish (drainage region Q),
- Sundays (drainage region N),
- Gamtoos River (drainage region L
- Mthatha River (drainage region T20),
- Small coastal rivers in the Pondoland area (drainage regions T60 to T90),
- Keiskamma, Buffalo, Nahoon and Gqunube Rivers (drainage region R),
- Kowie, Kariega and Boesmans Rivers (drainage region P),
- Koega and Swartkops Rivers (drainage region M),
- Krom and Seekoei Rivers (drainage region K90), and
- Tsitsikamma and small coastal rivers in drainage region K80.

Priority Resource Units (RUs) have been identified through an approach that considers both the water use, water quality impacts as well as ecological integrity and protection requirements for the rivers. See Resource Units prioritisation report (WEM/WMA7/00/CON/RDM/0422) for more detail on the approach and the final RU priorities.

Three levels of **priority RUs** were identified with associated level of detail required for the EWR assessment.

These priorities were:

(i) priority 1 – Intermediate level (at least 1 survey during high and low flow conditions);

(ii) priority 2 – Rapid level 3 (surveys during low flow conditions); and

(iii) priority 3 – Field Verification or desktop level (on site, and extrapolation from high confidence sites and expert opinion).

Hydraulic and hydrological data and modelling

Hydraulic information was obtained during both river surveys (September 2022 and May 2023) at the selected Intermediate and Rapid 3 sites. These included the selection and surveying of an appropriate cross-sectional profile of the river and longitudinal water slope and to measure the discharge. This data was used to develop the depth/discharge relationships for each EWR site. In addition, the hydraulics was further modelled using the HABFLO (HABitat FLOw) program to predict statistical distributions of hydraulic habitats for fish and macroinvertebrates. The results of the hydraulic modelling were used during the quantification of the EWRs.

Natural and present-day hydrology was obtained from several sources, including the data in the water resources yield planning models, WR2012 hydrology, and dam operating rules studies, reconsiliation strategies for the Algoa and Amathole systems and the Algoa Water Assessment and Allocation Study for the Kouga, Baviaans, Gamtoos and Krom Rivers. The flow time series obtained from these studies were used and adjusted by catchment area to obtain the flows at the EWR sites.

EWR results

The final EWR quantification results for all Intermediate and Rapid 3 EWR sites for the Recommended Ecological Category (REC) is presented in **Table 1-1** below. These EWR results will be used in the next steps during the evaluation of ecological consequences of management scenarios, trade-offs with socio-economic considerations to determine the Watter Resource Classes per IUA and for the setting of RQOs.

Table 1-1: Summary of the EWR quantification results for the study

IUA	EWR site	River	Quat*	REC	Total EWR as %nMAR for REC	nMAR ($10^6 m^3$)
INTERMEDIATE SITES						
IUA_T03	MTHA01_I	Mthatha (Lower)	T20G	B/C	37.81	389.2
IUA_T02	MBAS01_I	Mbhashe (Middle)	T13C	C/D	38.02	673.8
IUA_S02	BKEI01_R	Black Kei	S32K	D	32.03	187.9
IUA_S03	GKEI01_I	Great Kei	S70A	C	24.97	897.2
IUA_S01	TSOM01_I	Tsomo	S50G	C/D	37.48	196.7

IUA	EWR site	River	Quat*	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)
IUA_R02	BUFF01_I	Buffalo (Middle)	R20F	D	34.46	83.8
IUA_R01	KEIS01_I	Keiskamma (Upper)	R10E	D	34.31	58.8
IUA_Q03	KAT01_I	Kat (Upper)	Q94B	B/C	43.53	23.9
IUA_Q02	FISH03_I	Great Fish (Lower)	Q91B	C	29.73	331.8
IUA_M01	SWAR01_I	Swartkops	M10C	B/C	39.97	27.3
IUA_KL01	GAMT01_I	Gamtoos	L90A	D	10.80	427.0
RAPID 3 SITES						
IUA_T04	MNGA01_R	Mngazi	T70B	B/C	25.94	78.2
IUA_T04	NQAB01_R	Nqabarha	T90A	C	34.51	9.8
IUA_T04	MTEN01_R	Mtentu	T60C	B/C	44.33	89.6
IUA_T01	MBHA02_R	Mbhashe (Upper)	T11H	B/C	22.05	373.4
IUA_S03	GCUW01_R	Gcuwa	S70D	D	14.86	67.6
IUA_S01	INDW01_R	Indwe	S20D	C/D	24.69	61.9
IUA_S01	WKEI01_R	White Kei	S10J	C	26.16	155.7
IUA_S03	KUBU03_R	Kubusi (Lower)	S60E	B/C	20.38	98.1
IUA_R01	KEIS02_R	Keiskamma (Lower)	R10L	B/C	27.85	107.8
IUA_R01	TYUM01_R	Tyume	R10H	B/C	34.15	32.6
IUA_Q03	KOON01_R	Koonap	Q92G	D	17.14	76.9
IUA_Q03	KAT02_R	Kat (Lower)	Q94F	C/D	15.16	61.8
IUA_N01	SUND02_R	Sundays (Lower)	N40C	D	5.42	214.0
IUA_L01	KOUG01_R	Kouga	L82D	B/C	15.78	155.1
IUA_K01	KROM01_I	Kromme	K90A	C	36.66	27.6

* Quaternary catchment

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1. INTRODUCTION

1.1 Background

The National Water Act, 1998 (No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without affecting the functioning of water resource systems. To achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of Resource Directed Measures (RDM). These measures are protection-based and include Water Resource Classification, determination of the Reserve and setting the associated Resource Quality Objectives (RQOs). These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources, while allowing economic development.

The provision of water required for the maintenance of the natural functionality of the ecosystem and provision of Basic Human Needs (BHN) is the only right to water in the National Water Act (No. 36 of 1998) (NWA). The other water users from a strategic use who are second in line to other water users are subject to formal gazetted General Authorization and water use authorization as per Section 21 of the NWA.

The Department of Water and Sanitation, through the Chief Directorate: Water Ecosystems Management (CD: WEM), has initiated a study for the determination of Water Resource Classes, Reserve and associated Resource Quality Objectives for the identified significant water resources in the Keiskamma and Fish to Tsitsikamma catchments. The water resource components included for this study are surface water (rivers, wetlands and estuaries) and groundwater. The Reserve determination include both the water quantity and quality of the Ecological Water Requirements (EWR) and Basic Human Needs (BHN). This will assist the process of ensuring the availability of water required to protect aquatic systems and to secure water that is essential for the needs of individuals that are directly dependent on these water resources for their daily lifelihood.

1.2 Purpose of this study

The Keiskamma and Fish to Tsitsikamma catchments within the Mzimvubu to Tsitsikamma Water Management Area (WMA 7) are amongst many water stressed catchments in South Africa. These areas are important for conservation and have recognisable protected areas, natural heritage, cultural and historical sites that require protection. However, water use from surface as well as groundwater for agricultural and domestic purposes are high, especially in the more arid catchments, impacting on the availability of water resources for the protection of the aquatic ecosystems. Industrial practices and domestic water use are on the rise in some of these catchments, especially around the major towns and cities. Water transfers into the study area from adjacent WMAs (i.e. transfer from Gariep Dam on Orange River to the Great Fish River) and within the study area and numerous storage dams changes the flow patterns, impacting on the aquatic biota.

Thus, the main purpose of the study is to determine the Water Resource Classes, the Reserve and associated RQOs for all significant water resources in the study area to facilitate sustainable use of the water resources while maintaining ecological integrity.

The aim is to:

- implement the Water Resource Classification System (WRCS) (Regulation 810, 2010) to determine the Water Resource Classes;
- follow the integrated framework steps (DWS, 2017);
- undertake the 7-step process within the integrated framework context to determine and set RQOs; and
- determine the Reserve (EWR and BHN) for the selected water resources in the study area.

The above mentioned will ultimately assist the DWS in the management of the water resources in the study area from source to sea as far as practicably possible, to allow for the making of informed decisions regarding the authorisation of future water use and the magnitude of the impacts of current and proposed developments in the study area.

1.3 Purpose of this report

The purpose of this report is to document the results of the quantification of the Ecological Water Requirements (EWR) within the study area (Keiskamma and Fish to Tsitsikamma). This forms part of step 4 of the Reserve determination process and aligns with Step 3 of the integrated framework, DWS (2017) (see **Figure 1-1**).

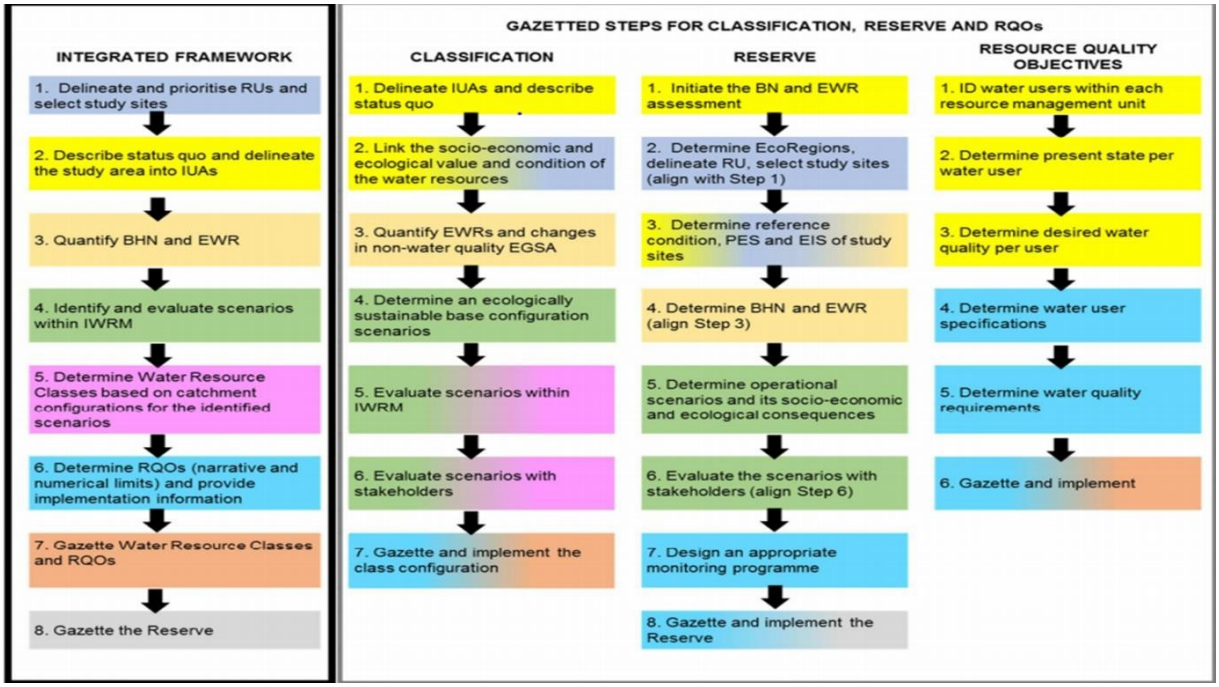


Figure 1-1: Integrated framework for the determination of Water Resource Classes, Reserve and RQOs.

The quantification is based on surveys that were undertaken as part of the current study (September 2022 and May 2023) together with information and data that is available through various previous studies and the surveys that were then undertaken.

The quantification of the Ecological Water Requirements (EWR) was determined using the following:

- Information collected during the field surveys;
- Results from the Eco-categorisation process (Present Ecological State (PES), Ecological Importance (EI), Ecological Sensitivity (ES) and Recommended Ecological Category (REC));
- Habitat Flow Stressor Response (HFSR) method and the Desktop Reserve Model (DRM)/ Revised DRM within SPATSIM were used for the integration of data produced from the surveys and Eco-categorisation to quantify the EWRs. The most applicable approach was selected depending on the specific conditions at the EWR site and impacts in the upper catchments;
- Results from the hydraulic modelling (cross-sectional profile and discharge) to evaluate the requirements; and
- Baseflow separation undertaken for the Intermediate and Rapid 3 sites using the approach as developed by Smakhtin (2001). This provides an indication as to the groundwater contribution to surface flows without the influence of high flows (freshets and floods) and assist the ecologists with the setting of baseflows (maintenance low) for the rivers.

This report describes the approaches, methods and models used to determine the EWRs for the priority river reaches (priority Resource Units) at selected EWR sites. These determinations are on various levels of detail as described in volume 3 of the RDM methodology of 1999 (DWAF, 1999) and include Intermediate, Rapid 3, field verification and Desktop assessments. This report draws on the results from:

- The Eco-categorisation process and report (see Report No. WEM/WMA7/00/CON/RDM/1723 Volume 1 and Volume 2 (a, b respectively);
- HFSR approach or Revised/DRM within SPATSIM for the integration of data produced from the surveys to quantify the EWRs; and
- Results from the hydraulic modelling (cross-sectional profile and discharge) to evaluate the requirements.

2. OVERVIEW OF STUDY AREA

The study area forms part of the Mzimvubu to Tsitsikamma WMA7 with the main catcahments and rivers indicated in **Table 2-1** and **Figure 2-1.** The water resources of the Mzimvubu River (T31 – T36) are not included as part of the study area as the resources have already been classified, RQOs determined and gazetted. Secondary catchments T40 (Mtamvuna) and T50 (Mzimkhulu) form part of WMA 4. A detailed overview and status quo of the study area in terms of the rivers, wetlands, estuaries and groundwater, water resource infrastructure and socio-economics has been presented in the delineation of IUAs report (Report Number: WEM/WMA7/00/CON/RDM/0322).

The rivers in the study area ranges from large perennial to semi-ephemeral systems and there are also small coastal rivers that all drains towards the Indian Ocean. The study area consists of five large drainage basins with several smaller rivers in-between. The larger drainage basins are the:

- Mbhashe River (part of drainage region T which includes T11, T12 and T13),
- Great Kei River (drainage region S),
- Great Fish (drainage region Q),
- Sundays (drainage region N), and
- Gamtoos River (drainage region L).

The small drainage regions include the:

- Mthatha River (drainage region T20),
- Small coastal rivers in the Pondoland area (drainage regions T60 to T90),
- Keiskamma, Buffalo, Nahoon and Gqunube Rivers (drainage region R),
- Kowie, Kariega and Boesmans Rivers (drainage region P),
- Koega and Swartkops Rivers (drainage region M),
- Krom and Seekoei Rivers (drainage region K90), and
- Tsitsikamma and small coastal rivers in drainage region K80.

Table 2-1: Main catchments and rivers in the study area.

Catchment	Major Rivers
K80	Tsitsikamma and small coastal rivers
K90	Krom and small coastal rivers
L10 - L90	Gamtoos with main tributaries Groot, Baviaanskloof and Kouga
M10 - M30	Koega, Swartkops and small coastal rivers
N10 - N40	Sundays
P10 - P40	Kowie, Kariega, Boesmans and small coastal rivers

Catchment	Major Rivers
Q10 - Q90	Fish River with main tributaries of Little Fish, Koonap and Kat
R10 - R50	Keiskamma and small coastal rivers
S10 - S70	Great Kei River with main tributaries of Klipplaats, Indwe, White Kei, Black Kei
T10	Mbhashe
T20	Mthatha
T60	Small coastal rivers (Mtentu, Msikaba, Mzintlava)
T70	Small coastal rivers (Mtakatye, Mngazi)
T80 & T90	Small coastal rivers

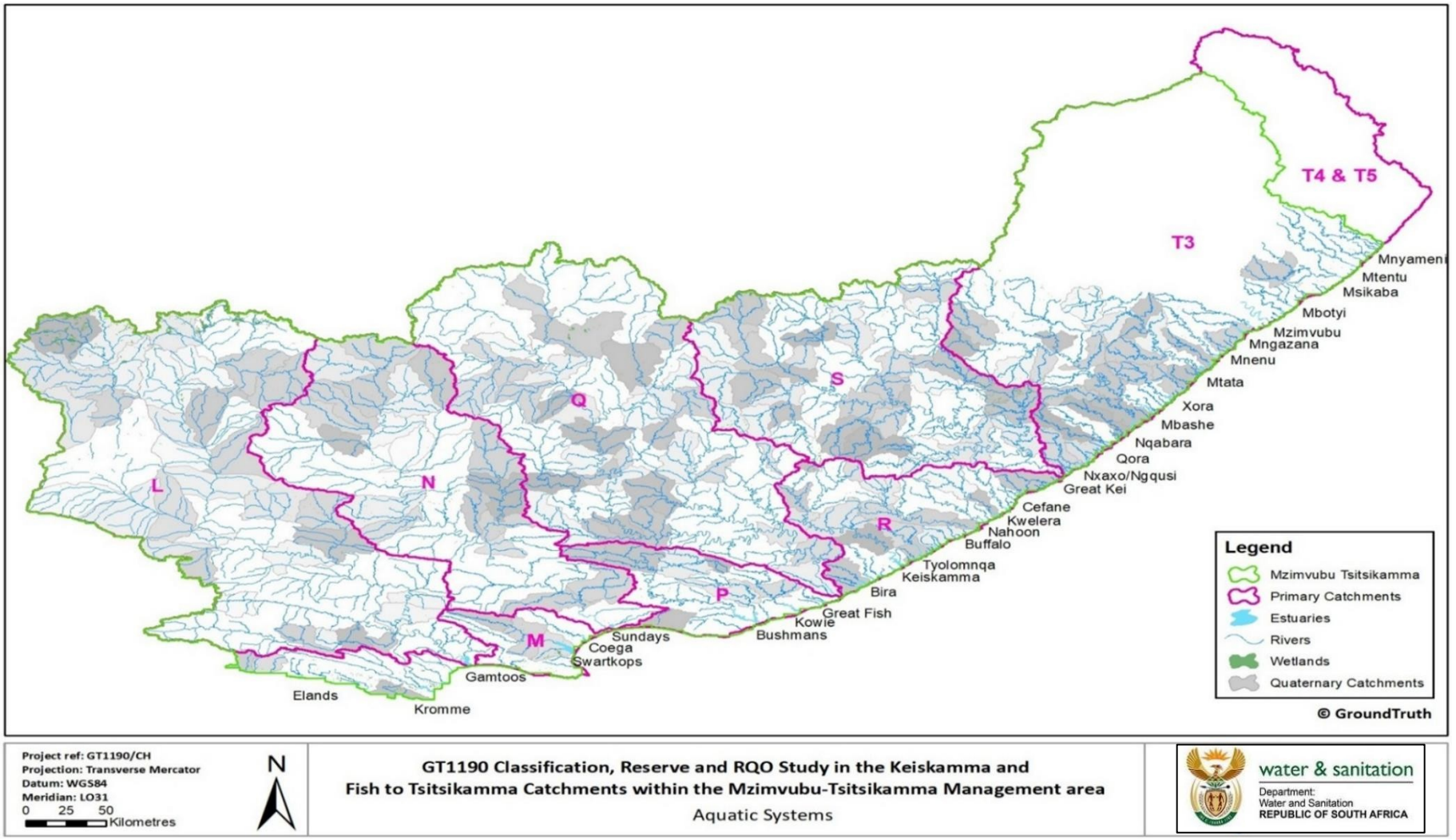


Figure 2-1: Map illustrating the study area for the Keiskamma, Fish to Tsitsikamma

3. FINAL EWR SITES

As part of the approach followed for the the classification of the water resources in the study area, determination of the Reserve and setting of Resource Quality Objectives (RQOs), priority resource units were identified per delineated Integrated Unit of Assessment (IUA). The level of assessment to quantify the EWRs were based on the priority, with priority 1 on an Intermediate level, priority 2 a Rapid level 3 and priority 3 on a Desktop level using information from the field verification to inform the ecostatus of the rivers (see Resource Units Report, WEM/WMA7/00/CON/RDM/0422 for further information).

The aim was alo to select EWR sites on an Intermediate level for the five major river basins and for the more impacted smaller systems (e.g., Mthatha, Keiskamma, etc.) and Rapid 3 sites for larger tributaries and smaller coastal systems, depending on the priority RUs. Desktop assessments to quantify the EWR for selected field verification sites were undertaken at those sites that were identified as Rapid 3, but due to no flows during the sites visits, inaccessibility or where the selected EWR sites were not close to the outlet of an IUA.

Refer to **Table 3-1** and Figure 3-1 for the final selected Intermediate, Rapid 3 and Field Verification/ Desktop sites as identified for the study within each IUA. The aim was to select EWR sites as close as possible to the outlet of the IUAs to provide high confidence results during the scenario evaluation and trade-offs with the socio-econoics of the IUA.

Table 3-1: Final Intermediate, Rapid 3 and Field Verification sites per IUA for the Keiskamma, Fish to Tsitsikamma study area.

IUA	IUA Description	EWR site code	River	Quat*	Co-ordinates	
INTERMEDIATE						
IUA_T03	Lower Mthatha	MTHA01_I	Mthatha (Lower)	T20G	-31.92622055	29.13647331
IUA_T02	Lower Mbhashe	MBAS01_I	Mbhashe (Middle)	T13C	-31.95809842	28.47223807
IUA_S02	Black Kei	BKEI01_R	Black Kei	S32K	-32.11819532	27.06884273
IUA_S03	Lower Great Kei	GKEI01_I	Great Kei	S70A	-32.50811888	27.96629455
IUA_S01	Upper Great Kei	TSOM01_I	Tsomo	S50G	-32.04397654	27.82105224
IUA_R02	Buffalo/ Nahoon	BUFF01_I	Buffalo (Middle)	R20F	-32.99151874	27.64057286
IUA_R01	Keiskamma	KEIS01_I	Keiskamma (Upper)	R10E	-32.80233328	27.02430956
IUA_Q03	Koonap and Kat	KAT01_I	Kat (Upper)	Q94B	-32.56964523	26.72185233
IUA_Q02	Great Fish	FISH03_I	Great Fish (Lower)	Q91B	-33.08373323	26.22527359
IUA_M01	M primary catchment	SWAR01_I	KwaZungu/ Swartkops	M10C	-33.72216489	25.30087336
IUA_KL01	Kromme from Kromme Dam to estuary and Gamtoos	GAMT01_I	Gamtoos	L90A	-33.76097595	24.69384012
RAPID 3						
IUA_T04	Pondoland coastal	MNGA01_R	Mngazi	T70B	-31.608958	29.405132
		NQAB01_R	Nqabarha	T90A	-32.091927	28.400234
		MTEN01_R	Mtentu	T60C	-31.130483	29.757179
IUA_T01	Upper Mbhashe , Upper Mthatha	MBHA02_R	Mbhashe (Upper)	T11H	-31.807857	28.346994
IUA_S03	Lower Great Kei	GCUW01_R	Gcuwa	S70D	-32.319770	28.136094
		KUBU03_R	Kubusi (Lower)	S60E	-32.507220	27.731348
IUA_S01	Upper Great Kei	INDW01_R	Indwe	S20D	-31.897077	27.409825
		WKEI01_R	White Kei	S10J	-32.003057	27.351052
IUA_R01	Keiskamma	KEIS02_R	Keiskamma (Lower)	R10L	-33.075316	27.218534
		TYUM01_R	Tyume	R10H	-32.910291	26.932242

IUA	IUA Description	EWR site code	River	Quat*	Co-ordinates	
IUA_Q03	Koonap and Kat	KOON01_R	Koonap	Q92G	-33.042856	26.658506
		KAT02_R	Kat (Lower)	Q94F	-32.890965	26.68407
IUA_N01	Sundays downstream Darlington Dam	SUND02_R	Sundays (Lower)	N40C	-33.404384	25.407919
IUA_L01	Kouga to Kouga Dam, Baviaanskloof	KOUG01_R	Kouga	L82D	-33.788449	24.025821
IUA_K01	Tsitsikamma and headwaters of Kromme to Kromme Dam	KROM01_R	Kromme	K90A	-33.9370951	24.2690587
FIELD VERIFICATION/ DESKTOP						
IUA_T04	Pondoland coastal	XORA01_D	Xora	T80D	-32.135524	28.973139
IUA_T01	Upper Mbhashe , Upper Mthatha	MTHA02_D	Upper Mthatha	T20A	-31.475254	28.605656
IUA_R02	Buffalo/ Nahoon	BUFF02_FV	Lower Buffalo	R20G	-32.991768	27.775910
IUA_Q02	Great Fish	TARK01_FV	Tarka	Q44C	-32.283315	25.759280
		FISH02_FV	Middle Great Fish	Q50B	-32.604885	25.751772
		LFIS02_FV	Lower Little Fish	Q80G	-33.09345	25.82152
IUA_Q01	Upper Fish	FISH01_FV	Upper Great Fish	Q21B	-31.919527	25.390974
		LFIS01_FV	Upper Little Fish	Q80B	-32.50617	25.42683
IUA_P01	P primary catchment	BOES01_D	Boesmans	P10G	-33.543899	26.391105
IUA_LN01	Groot to Kouga confluence, Upper Sundays to Darlington Dam	SUND01_FV	Upper Sundays	N22E	-33.07812	25.01548
		GRT01_D	Groot	L70G	-33.743359	24.613965
IUA_L01	Kouga to Kouga Dam, Baviaanskloof	BAVI01_D	Baviaanskloof	L81D	-33.664914	24.388605
		KOUG02_D	Kouga	L82H	-33.739983	24.587785
IUA_K01	Tsitsikamma and headwaters of Kromme to Kromme Dam	GROO01_FV	Groot (coastal)	K80D	-34.032134	24.195684

* Quaternary catchment

Figure 3-1: Map illustrating the final EWR sites assessed for the Keiskamma, Fish to Tsitsikamma catchment.

The results of the eco-categorisation process to determine the PES, EI, ES and final Recommended Ecological Category (REC) were used to quantify the EWRs at each of the selected sites. A summary of the eco-categorisation results is presented in **Table 3-2.**

Table 3-2: Summary of results from the eco-categorisation process.

IUA	EWR site code	River	Quat*	PES	EI-ES	REC
INTERMEDIATE						
IUA_T03	MTHA01_I	Mthatha (Lower)	T20G	C	High-High	B/C
IUA_T02	MBAS01_I	Mbhashe (Middle)	T13C	C/D	Moderate-Moderate	C/D
IUA_S02	BKEI01_R	Black Kei	S32K	D/E	Moderate-Moderate	D
IUA_S03	GKEI01_I	Great Kei	S70A	C/D	High-Moderate	C
IUA_S01	TSOM01_I	Tsomo	S50G	D	Moderate-Moderate	C/D
UA_R02	BUFF01_I	Buffalo (Middle)	R20F	D	Moderate-Moderate	D
IUA_R01	KEIS01_I	Keiskamma (Upper)	R10D	D	Moderate-Moderate	D
IUA_Q03	KAT01_I	Kat (Upper)	Q94B	C	Moderate-High	B/C
IUA_Q02	FISH03_I	Great Fish (Lower)	Q91B	C	Moderate-Moderate	C
IUA_M01	SWAR01_I	KwaZungu/ Swartkops	M10C	C	Moderate-High	B/C
IUA_KL01	GAMT01_I	Gamtoos	L90A	D	Moderate-Moderate	D
RAPID 3						
IUA_T04	MNGA01_R	Mngazi	T70B	C	High-High	B/C
IUA_T04	NQAB01_R	Nqabarha	T90A	D	Moderate-Moderate	C
IUA_T04	MTEN01_R	Mtentu	T60C	C	High-High	B/C
IUA_T01	MBHA02_R	Mbhashe (Upper)	T11H	B/C	High-Moderate	B/C
IUA_S03	GCUW01_R	Gcuwa	S70D	D	Moderate-Moderate	D
IUA_S01	INDW01_R	Indwe	S20D	C/D	Moderate-Moderate	C/D
IUA_S01	WKEI01_R	White Kei	S10J	C/D	Moderate-Moderate	C
IUA_S03	KUBU03_R	Kubusi (Lower)	S60E	C	High-High	B/C
IUA_R01	KEIS02_R	Keiskamma (Lower)	R10L	C	High-High	B/C
IUA_R01	TYUM01_R	Tyume	R10H	C	High-High	B/C
IUA_Q03	KOON01_R	Koonap	Q92G	D	Moderate-Moderate	D
IUA_Q03	KAT02_R	Kat (Lower)	Q94F	C/D	Moderate-Moderate	C/D
IUA_N01	SUND02_R	Sundays (Lower)	N40C	D	Low-Moderate	D
IUA_L01	KOUG01_R	Kouga	L82D	C	High-High	B/C
IUA_K01	KROM01_I	Upper Kromme	K90A	D	High-High	C
FIELD VERIFICATION/ DESKTOP						
IUA_T04	XORA01_D	Xora	T60D	B	Moderate-High	B
IUA_T01	MTHA02_D	Upper Mthatha	T20A	C	Low-Moderate	C
IUA_R02	BUFF02_FV	Buffalo (Lower)	R20G	D/E	High-Moderate	D
IUA_Q02	TARK01_FV	Tarka	Q44C	D	Moderate-Moderate	D
	FISH02_FV	Great Fish (Middle)	Q50B	D	Moderate-Moderate	D
	LFIS02_FV	Little Fish (Lower)	Q80G	C	High-Moderate	C
IUA_Q01	LFIS01_FV	Little Fish (Upper)	Q80B	C	High-Moderate	B/C
IUA	**EWR site code**	**River**	**Quat***	**PES**	**EI-ES**	**REC**

	FISH01_FV	Great Fish (Upper)	Q21B	D	Moderate-Moderate	D
IUA_P01	BOES01_D	Boesmans	P10G	B	High-Moderate	B
IUA_LN01	SUND01_FV	Sundays (Upper)	N22E	C	Moderate-Moderate	C
	GRT01_D	Groot	L70G	B	High-Moderate	B
IUA_L01	BAVI01_D	Baviaanskloof	L81D	B	High-Moderate	B
	KOUG02_D	Kouga	L82H	C	Moderate-Moderate	B/C
IUA_K01	GROO01_FV	Groot (coastal)	K80D	C	Moderate-High	B/C

* Quaternary catchment

4. DATA COLLECTION AND MODELLING

4.1 Hydraulics

During the site visits, the following activities were undertaken:

- EWR site cross sections were selected;
- A survey of the cross-sectional profile of the EWR site was conducted;
- Longitudinal water slope was surveyed;
- Discharge was measured;
- GPS co-ordinates of the site were captured; and
- EWR site photographs were taken.

The hydraulic data collected during the site visit is listed in **Table 4-1**.

Table 4-1: Hydraulic data measured for the Keiskamma, Fish to Tsitsikamma catchment EWR sites.

EWR site	Survey date	River	Discharge Q (m^3/s)	Maximum flow depth (m)
INTERMEDIATE SITES				
MTHA01_I	7 September 2022	Lower Mthatha	0.96	0.43
	14 May 2023		Not measured(1)	Not Measured
MBAS01_I	8 September 2022	Middle Mbashe	5.809	0.95
	13 May 2023		20.832	1.44
BKEI01_I	11 September 2022	Black Kei	1.1	0.42
	10 May 2023		3.758	0.84
GKEI01_I	15 September 2022	Great Kei	3.84	0.76
	12 May 2023		17.37	0.95
TSOM01_I	10 September 2022	Tsomo	0.48	0.37
	11 May 2023		1.348	0.45
BUFF01_I	16 September 2022	Middle Buffalo	0.111	0.26
	9 May 2023		0.118	0.29
KEIS01_I	13 September 2022	Upper Keiskamma	0.368	0.24
	8 May 2023		0.525	0.26
KAT01_I	13 September 2022	Upper Kat	0.028	0.19
	7 May 2023		0.047	0.21
FISH01_I	20 September 2022	Lower Great Fish	3.466	0.62
	4 May 2023		5.728	0.8
SWAR01_I	24 September 2022	Swartkops	0.069	0.23
	6 May 2023		0.096	0.27
GAMT01_I	25 September 2022	Gamtoos	0.059	0.19
	5 May 2023		0 (2)	0 (2)
RAPID 3 SITES				
MNGA01_R	7 September 2022	Mngazi	0.389	0.5

EWR site	Survey date	River	Discharge Q (m^3/s)	Maximum flow depth (m)
NQAB01_R	9 September 2022	Nqabarha	0.024	0.13
MTEN01_R	6 September 2022	Mtentu	0.954	0.58
MBHA02_R	9 September 2022	Upper Mbashe	1.822	0.73
GCUW01_R	11 May 2023	Gcuwa	0.043	0.185
KUBU03_R	10 May 2023	Lower Kubusi	0.291	0.2
INDW01_R	10 September 2022	Indwe	0.134	0.27
WKEI01_R	10 September 2022	White Kei	0.931	0.39
KEIS02_R	19 September 2022	Lower Keiskamma	0.568	0.285
TYUM01_R	14 September 2022	Tyume	0.198	0.42
KOON01_R	12 September 2022	Koonap	0.23	0.21
KAT02_R	12 September 2022	Lower Kat	0.025	0.12
SUND02_R	23 September 2022	Lower Sundays	0.141	0.18
KOUG01_R	26 September 2022	Kouga	2.138	0.62
KROM01_R	5 May 2023	Kromme	1.156	1.17

(1) In flood
(2) No flows, just pools

Modelling was conducted using the measured data, as well as two modelled points to develop stage discharge curves. The following data was required in the use of the modelling: y (maximum flow depth), n (resistance coefficient), S (slope), Q (discharge), A (area) and WP (wetted perimeter). The measured and modelled data are shown in **Table 4-2**.

Table 4-2: Hydraulic data used to extend observed rating data at the EWR sites.

EWR site	River	Discharge Q (m^3/s)	Maximum flow depth (m)	Manning's resistance, n	Surface Slope, S (m/m)	Ave. Velocity, V (m/s)
INTERMEDIATE SITES						
MTHA01_I	Lower Mthatha	0.96	0.43	0.1360	0.008	0.224
MBAS01_I	Middle Mbashe	5.809	0.95	0.4198	0.011	0.144
		20.832	1.44	0.1644	0.002	0.242
BKEI01_I	Black Kei	1.1	0.42	0.1042	0.01	0.399
		3.758	0.84	0.1697	0.014	0.487
GKEI01_I	Great Kei	3.84	0.76	0.2518	0.013	0.252
		17.37	0.95	0.0896	0.013	0.729
TSOM01_I	Tsomo	0.48	0.37	0.2009	0.004	0.119
		1.348	0.45	0.1376	0.006	0.245
BUFF01_I	Middle Buffalo	0.111	0.26	0.2760	0.015	0.106
		0.118	0.29	0.3907	0.017	0.089
KEIS01_I	Upper Keiskamma	0.368	0.24	0.2916	0.02	0.155
		0.525	0.26	0.2938	0.03	0.2
KAT01_I	Upper Kat	0.028	0.19	0.6832	0.029	0.046
		0.047	0.21	0.5807	0.029	0.061
FISH01_I	Lower Great Fish	3.466	0.62	0.0950	0.009	0.567
		5.728	0.8	0.0720	0.005	0.613
SWAR01_I	Swartkops	0.069	0.23	0.3526	0.021	0.119
		0.096	0.27	0.2761	0.014	0.13

EWR site	River	Discharge Q (m^3/s)	Maximum flow depth (m)	Manning' s resistance, *n*	Surface Slope, S (m/m)	Ave. Velocity, V (m/s)
GAMT01_I	Gamtoos	0.059	0.19	0.3102	0.006	0.055
RAPID 3 SITES						
MNGA01_R	Mngazi	0.389	0.5	0.2063	0.009	0.155
NQAB01_R	Nqabarha	0.024	0.13	0.1129	0.015	0.185
MTEN01_R	Mtentu	0.954	0.58	0.1359	0.003	0.216
MBHA02_R	Upper Mbhashe	1.822	0.73	0.1704	0.004	0.203
GCUW01_R	Gcuwa	0.043	0.185	0.3198	0.011	0.075
KUBU03_R	Lower Kubusi	0.291	0.2	0.1000	0.023	0.327
INDW01_R	Indwe	0.134	0.27	0.2275	0.006	0.094
WKEI01_R	White Kei	0.931	0.39	0.1017	0.004	0.223
KEIS02_R	Lower Keiskamma	0.568	0.285	0.0998	0.014	0.298
TYUM01_R	Tyume	0.198	0.42	0.2084	0.014	0.182
KOON01_R	Koonap	0.23	0.21	0.2219	0.008	0.105
KAT02_R	Lower Kat	0.025	0.12	0.2643	0.025	0.096
SUND02_R	Lower Sundays	0.141	0.18	0.1494	0.021	0.217
KOUG01_R	Kouga	2.138	0.62	0.0857	0.008	0.498
KROM01_R	Kromme	1.156	1.17	0.1531	0.005	0.307

The depth/discharge relationship (Hirschowitz, *et al*., 2007) was determined using the following equation:

$$y = aQ^b + c \qquad (1)$$

Where: Y is the maximum depth, Q is the discharge (m^3/s) and a, b and c coefficients. The coefficients used in equation (1) are shown in **Table 4-3**.

Table 4-3: Regression coefficients in equation (1).

EWR site	River	Regression coefficients		
		A	b	c
INTERMEDIATE SITES				
MTHA01_I	Lower Mthatha	0.4341	0.3192	0
MBAS01_I	Middle Mbashe	0.5552	0.3022	0
BKEI01_I	Black Kei	0.5427	0.3301	0
GKEI01_I	Great Kei	0.3539	0.3441	0
TSOM01_I	Tsomo	0.4704	0.3179	0
BUFF01_I	Middle Buffalo	0.5954	0.3678	0
KEIS01_I	Upper Keiskamma	0.3498	0.3947	0
KAT01_I	Upper Kat	0.4707	0.258	0
FISH01_I	Lower Great Fish	0.3882	0.3799	0
SWAR01_I	Swartkops	0.675	0.4026	0
GAMT01_I	Gamtoos	0.4797	0.3248	0

EWR site	River	Regression coefficients		
		A	b	c
RAPID 3 SITES				
MNGA01_R	Mngazi	0.6515	0.2816	0
NQAB01_R	Nqabarha	0.5796	0.3916	0
MTEN01_R	Mtentu	0.5864	0.3392	0
MBHA02_R	Upper Mbhashe	0.6066	0.3108	0
GCUW01_R	Gcuwa	0.6606	0.4031	0
KUBU03_R	Lower Kubusi	0.3177	0.3738	0
INDW01_R	Indwe	0.5516	0.3539	0
WKEI01_R	White Kei	0.3998	0.3632	0
KEIS02_R	Lower Keiskamma	0.3469	0.3686	0
TYUM01_R	Tyume	0.66	0.2793	0
KOON01_R	Koonap	0.3977	0.4259	0
KAT02_R	Lower Kat	0.4206	0.3335	0
SUND02_R	Lower Sundays	0.3301	0.3096	0
KOUG01_R	Kouga	0.4687	0.3699	0
KROM01_R	Kromme	1.1295	0.285	0

The cross-sectional views of the EWR sites per river, stage discharge relationships developed from the modelling and the detailed output tables are available electronically and will be included in the final deliverables.

The confidence rating in the hydraulic modelling results for the EWR sites ranges from 0=none to 5=high and is indicated in **Table 4.4**.

Table 4-4: Confidence in the hydraulic modelled results.

EWR site	River	Limits of measured discharge range (m^3/s)	Confidence rating for discharge range		Comments
		Q measured	Q< Q measured	Q> Q measured	
INTERMEDIATE SITES					
MTHA01_I	Lower Mthatha	0.96	3	2	One set of data captured. Upstream bridge may influence hydraulics under high flow conditions.
MBAS01_I	Middle Mbashe	5.809	4	2	Side channel will activate under high flow conditions which will affect the confidence.
BKEI01_I	Black Kei	3.758	3	2	One set of measured data used for modelling.
GKEI01_I	Great Kei	17.37	3.5	2	One set of measured data used for modelling. Side channel will activate under high flow conditions.
TSOM01_I	Tsomo	0.48	3.5	2	Measured flows are similar.
BUFF01_I	Middle Buffalo	0.111	3.5	2	Measured flows are similar. Weir located upstream of the site may

EWR site	River	Limits of measured discharge range (m^3/s)	Confidence rating for discharge range		Comments
		Q measured	Q< Q measured	Q> Q measured	
					affect hydraulics under high flow conditions.
KEIS01_I	Upper Keiskamma	0.368	3.5	2	Measured flows are similar. Road crossing located upstream of the site is likely to affect hydraulics.
KAT01_I	Upper Kat	0.047	4	2	Measured flows are similar. Braided section may cause unpredictable hydraulics under high flow conditions.
FISH01_I	Lower Great Fish	3.466	4	2.5	Site located close to bridge which might affect hydraulics under high flow conditions.
SWAR01_I	Swartkops	0.096	3.5	2	Measured flows are similar.
GAMT01_I	Gamtoos	0.059	3	2	One set of data captured.
RAPID 3 SITES					
MNGA01_R	Mngazi	0.389	3	2	One set of data captured.
NQAB01_R	Nqabarha	0.024	3.5	1	One set of data captured.
MTEN01_R	Mtentu	0.954	3.5	2	One set of data captured. Site located close to bridge which might affect hydraulics under high flow conditions.
MBHA02_R	Upper Mbhashe	1.822	2.5	2	One set of data captured.
GCUW01_R	Gcuwa	0.043	3	2	One set of data captured. Hydraulics of the site are influenced by the dam located upstream.
KUBU03_R	Lower Kubusi	0.291	3.5	2	One set of data captured. Bridge located upstream of the site may affect hydraulics under high flow conditions.
INDW01_R	Indwe	0.134	3.5	2	One set of data captured.
WKEI01_R	White Kei	0.931	3	2	One set of data captured. High flows may be unpredictable as the site is located downstream of a bend.
KEIS02_R	Lower Keiskamma	0.568	3	2	One set of data captured.
TYUM01_R	Tyume	0.198	3	2	One set of data captured.
KOON01_R	Koonap	0.23	3	2	One set of data captured. Site located close to bridge which might affect hydraulics under high flow conditions.

EWR site	River	Limits of measured discharge range (m^3/s)	Confidence rating for discharge range		Comments
		Q measured	Q< Q measured	Q> Q measured	
KAT02_R	Lower Kat	0.025	3.5	2	One set of data captured. Weir located upstream of the site may affect hydraulics under high flow conditions.
SUND02_R	Lower Sundays	0.141	3	1	One set of data captured. Dense vegetation will activate under high flow conditions.
KOUG01_R	Kouga	2.138	2	1	One set of data captured. Bridge located upstream of the site may affect hydraulics under high flow conditions.
KROM01_R	Kromme	1.156	2	1	One set of data captured. Site located upstream of bridge and in slow moving water, therefore hydraulics under varying conditions may be unpredictable.

The final hydraulic model and HABFLOW output per EWR site will be provided electronically to DWS.

4.2 Hydrological data

The natural hydrology for the study area was sourced from several previous and current studies. These include data from:

- WR2012 hydrology, mainly for the smaller, less impacted river systems;
- Water Resources Yield and Planning models for the larger river systems;
- Development of dam operating rules for stand-alone dams (updated present day demands);
- Reconsiliation strategies for the rivers in the Algoa and Amathole systems with updated hydrology and present-day water use demands; and
- Algoa Water Assessment and Allocation Study (WAAS) for the Kouga, Baviaans, Gamtoos and Krom Rivers.

The natural flow time series obtained from these studies were used and adjusted by catchment area to obtain the natural flows at the selected EWR sites. Thus, during the generation of the natural hydrology for Reserve determination studies, the position of the EWR sites is determined in relation to the natural hydrology timeseries' representative catchment areas. The natural hydrology timeseries are then scaled by area to approximate the natural flows at the sites. Care was taken to ensure that existing infrastructure in the model network were considered in determining the area scaling to be consistent with the current configuration and to ensure that Present Day flows to be generated are representative.

Where available, daily data from gauging weirs were used during the setting of floods and freshets at the EWR sites.

The table below provides the natural MAR (nMAR) for the EWR sites. The final natural time series per EWR site will be provided electronically to DWS.

Table 4-5: Natural MAR per EWR site in the Keiskamma, Fish to Tsitsikamma catchment.

EWR site	River	Latitude	Longitude	Quat*	nMAR ($10^6 m^3$)
INTERMEDIATE					
MTHA01_I	Lower Mthatha	-31.92622055	29.13647331	T20G	389.2
MBAS01_I	Middle Mbashe	-31.95809842	28.47223807	T13C	673.8
BKEI01_I	Black Kei	-32.11819532	27.06884273	S32K	187.9
GKEI01_I	Great Kei	-32.50811888	27.96629455	S70A	897.2
TSOM01_I	Tsomo	-32.04397654	27.82105224	S50G	196.7
BUFF01_I	Middle Buffalo	-32.99151874	27.64057286	R20F	83.8
KEIS01_I	Upper Keiskamma	-32.80233328	27.02430956	R10E	58.8
KAT01_I	Upper Kat	-32.56964523	26.72185233	Q94B	23.9
FISH01_I	Lower Great Fish	-33.08373323	26.22527359	Q91B	331.8
SWAR01_I	Swartkops	-33.72216489	25.30087336	M10C	27.3
GAMT01_I	Gamtoos	-33.76097595	24.69384012	L90A	427.0
RAPID 3					
MNGA01_R	Mngazi	-31.608958	29.405132	T70B	78.2
NQAB01_R	Nqabarha	-32.091927	28.400234	T90A	9.8
MTEN01_R	Mtentu	-31.130483	29.757179	T60C	89.6
MBHA02_R	Upper Mbhashe	-31.807857	28.346994	T11H	373.4
GCUW01_R	Gcuwa	-32.319770	28.136094	S70D	67.6
INDW01_R	Indwe	-31.897077	27.409825	S20D	61.9
WKEI01_R	White Kei	-32.003057	27.351052	S10J	155.7
KUBU03_R	Lower Kubusi	-32.50722	27.731348	S60E	98.1
KEIS02_R	Lower Keiskamma	-33.075316	27.218534	R10L	107.8
TYUM01_R	Tyume	-32.910291	26.932242	R10H	32.6
KOON01_R	Koonap	-33.042856	26.658506	Q92G	76.9
KAT02_R	Lower Kat	-32.890965	26.68407	Q94F	61.8
SUND02_R	Lower Sundays	-33.404384	25.407919	N40C	214.0
KOUG01_R	Kouga	-33.788449	24.025821	L82D	155.1
KROM01_R	Kromme	-33.9370951	24.2690587	K90A	27.6
FIELD VERIFICATION/ DESKTOP					
XORA01_D	Xora	-32.135524	28.973139	T60D	83.0
MTHA02_D	Upper Mthatha	-31.475254	28.605656	T20A	122.5

EWR site	River	Latitude	Longitude	Quat*	nMAR ($10^6 m^3$)
BUFF02_FV	Lower Buffalo	-32.991768	27.775910	R20G	91.9
TARK01_FV	Tarka	-32.283315	25.759280	Q44C	63.3
FISH02_FV	Middle Great Fish	-32.604885	25.751772	Q50C	201.9
LFIS02_FV	Little Fish (Lower)	-33.09345	25.82152	Q80G	88.9
FISH01_FV	Upper Great Fish	-31.919527	25.390974	Q21B	18.0
LFIS01_FV	Upper Little Fish	-32.50617	25.42683	Q80B	24.3
BOES01_D	Boesmans	-33.543899	26.391105	P10G	32.7
SUND01_FV	Upper Sundays	-33.07812	25.01548	N22C	148.0
GRT01_D	Groot	-33.743359	24.613965	L70G	185.7
BAVI01_D	Baviaanskloof	-33.664914	24.388605	L81D	48.1
KOUG02_D	Kouga	-33.739983	24.587785	L82H	229.3
GROO01_FV	Groot (coastal)	-34.032134	24.195684	K80D	47.6

* Quaternary catchment

4.3 Quantification of EWRs

The quantification of the EWRs used the following approaches to calculate the requirements for the REC at the EWR sites:

i. Habitat Flow Stressor Response (HFSR) for Intermediate sites
ii. Verification of the Desktop Reserve Model (DRM) (SPATSIM, version 2.12) for the rapid 3 sites. These EWR flow data were converted to hydraulic conditions (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model and evaluated by the ecologists through the verification of the drought and base flows (maintenance flows). Where the modelled requirements were ecologically judged not to be adequate to provide the envisaged protection, the model was adjusted to satisfy such requirements; and
iii. Desktop Reserve Model (DRM)/ Revised DRM for the field verification/ desktop sites.

The HFSR is based on the approach as developed by IWR, 2004 and O'Keeffe *et al.*, 2002 and is a modification of the Building Block Methodology (BBM) from King and Louw, 1998 and was used to determine the baseflows. The approach to set freshets and floods is a combination of the downstream Response to Imposed Flow Transformation (DRIFT; Brown and King, 2001) approach and BBM and was used in several high confidence Reserve determination studies.

The HFSR approach is to set stress indices for the aquatic biota namely fish and macroinvertebrates. The stress index describes the effects of flow reduction on flow dependant biota (semi-rheophilic fish species (refers to a species that requires fast flowing water habitat during their particular life stage(s)) or guilds and macroinvertebrates), or life stages and is determined by first assessing the response of habitat to a flow reduction. The habitat flow index is described separately for fish and macroinvertebrates as an instantaneous response of habitat to flow in terms of a stress of 0 to 10. The

0 stress represents optimum habitat with the maximum natural base flow, while a stress of 10 is indicative of zero/no flow. Various habitat types are used during this assessment and includes the following:

SIC – Stones-in-Current
SOOC – Stones-out-of-Current
GSM – Gravel, Sand and Mud
VFCS – Very Fast Coarse Substrate
FCS – Fast Coarse Substrate
FD – Fast Deep
SD – Slow Deep
FS – Fast Shallow
FI – Fast Intermediate

The second step is to determine the biota stress index which describes the instantaneous response of biota to change in habitat (and therefore flow) in terms of the 0 to 10 stress index. Important to note the change of critical habitat at each stress level (as described in the habitat stress index) and which is then related to the response of biotic indicator species/taxon. Similarly, a stress of a 0 represents optimum critical habitat (for that indicator species/taxon), therefore providing no stress to the biota and which assemblage abundances are high under these conditions. A stress of 10 is where there is zero critical habitat thus negatively responded to by the indicator species/taxon. Thus, the stress index therefore describes the habitat conditions and biota response at a range of low flows. The stress-flow relationship for the fish and macroinvertebrates will obviously differ owing to their differences in their responses/requirements/preferences/tolerances to the same flows.

The fish and macroinvertebrate stress indices are then used to convert natural, present-day and EWR flow time series to a stress time series. The stress time series is converted to a stress duration curve for the highest (wet) and lowest (dry) flow months. This subsequently provides the specialists with the information of how much the stress has changed from natural to present conditions due to changes in flow. It would follow that if flow has decreased from natural, stress would increase and vice versa. If specialists did not agree with the levels of stress under present conditions based on their knowledge of the indicator species, the stress indices were further refined. Essentially, the aim is to ensure the persistence of the indicator species/taxon, as the rest of the biotic community will then persist.

Additionally, freshets and annual floods were specified for the Intermediate and Rapid 3 sites taking the release capacities of dams (where available) into consideration. The freshets/ floods specified by the ecologists were evaluated using information from a nearby gauge (if available) with daily data to determine whether they are realistic. Without daily data from a nearby gauge, the results of the hydraulic modelling and cross-section of the river were used to guide the ecologists.

These freshets were adjusted where required, when higher than the release capacities of the dams. The ecolocical consequences will be determined (next step of study) at the sites where the freshets/ floods could not be released. If these lower releases result in a lower ecological category, the Target

Ecological Category will be set for the site.

These EWR results for the recommended ecological categories were then used to produce the final EWR results in the format of an assurance table or EWR rule curves. These curves specify the frequency of occurrence relationships of the flow requirements for each month of the year. The tables thus specify the % of time that defined flows should equal or exceed the flow regime required to satisfy the ecological Reserve.

The final total EWR results (summary tables, rule tables and long-term requirements) per EWR site will be provided to DWS electronically.

5. EWR RESULTS: INTERMEDIATE SITES

The results of the quantification of the EWRs of the various rivers in the Keiskamma, Fish to Tsitsikamma catchment at the selected EWR sites are presented in this section. These include the intermediate, rapid 3 and field verification/ desktop sites.

The HFSR approach (as described in Chapter 4.3 above), was followed for the Intermediate EWR sites and include the specification of stress indices that describe the consequences of flow reductions on flow dependant biota, or life stages, and were selected for fish and macroinvertebrates to determine baseflow requirements. Thus, it describes the available habitat conditions for indicator fish species or guilds and macroinvertebrates taxon at various flow conditions. These habitat conditions at different flows and the ecologically derived habitat conditions required by the indicator species and taxa, are rated at a scale ranging from 0 to 10. Refer to Chapter 4.3 for further detail on these stress indices.

Additionally, due to the extent of the detection of **blackfly larvae** (family ***Simuliidae***), a macroinvertebrate taxon in this study area, constant baseflows (releases from upstream dams) were adjusted to provide some flow variability. Refer to **Chapter 8** for additional information.

5.1 MTHA01_I: Lower Mthatha River

Sample Date	7 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	MTHA01_I	**IUA**	IUA_T03
River	Mthatha	**IUA description**	Lower Mthatha
Altitude (m.a.s.l.)	6m	**Prioritised RU**	R_RU15_I
Latitude	-31.92622055	**Longitude**	29.13647331
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**T20G**
Level 2 EcoRegion	31.01	**SQ Reach**	T20G-06794
Geomorphological zone	E (0.003)	**PES (DWS, 2014)**	C
Ecological Importance	High	**Ecological Sensitivity**	High

MAP ILLUSTRATION (Figure 5-1) AND SITE PHOTOGRAPHS (Figure 5-2)

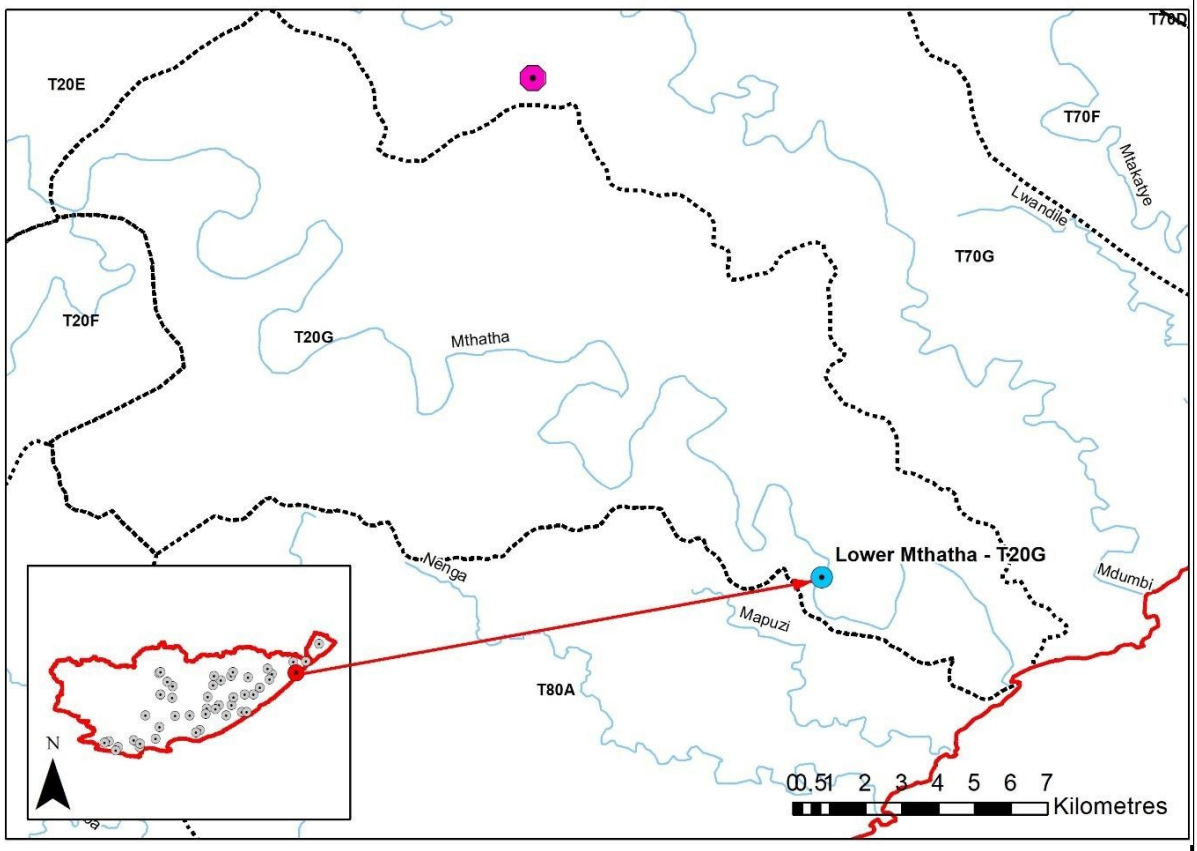


Figure 5-1: Location of site MTHA01_I (Lower Mthatha) in relation to the study area.
(pink icon indicates WWTW in relation to the EWR site)

Site Photographs: Survey 1 (September 2022)

Figure 5-2: Site photographs of the lower Mthatha EWR site.

The EWR for the Lower Mthatha River was determined for a REC of a B/C and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Lower Mthatha River were Perlidae (stonefly) and *Anguilla mossambica* (African Longfin Eel, semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: A diversity of good availability of biotopes (SIC, SOOC, marginal vegetation and GSM) and hydraulic features were present for macroinvertebrates at this site on the lower Mthatha. Perlidae were not recorded during the September 2022 survey, and the river was in flood in May 2023 and thus could not be surveyed. However, Perlidae's form part of the reference conditions, and they have previously been recorded in both A and B abundances at the REMP site (T2MTHA-MDUMB) located within the same EcoRegion Level 2. Therefore, Perlidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. They prefer cobbles and high velocities of >0.6 m/s, although appear optimally at flows between 0.3 and 0.6 m/s. If flows fall below this target, Perlidaes will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS. They are further very sensitive to any water quality change.

Fish: Although various fish species present, no true rheophilics expected, thus semi-rheophilic *Anguilla mossambica* was selected. The species inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep and fast-shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (40-60 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 30th percentile for March (8.297 m^3/s) and a minimum dry flow or 95th percentile for August (1.848 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats, and velocities. The selected stress values and associated flows are provided in **Table 5-1** and the final integrated stress curve is shown in **Figure 5-3**.

Table 5-1: Selected stress values, flows and rationale for the Lower Mthatha EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	8.4	Both critical habitats are in excess and very high quality (29% and 31% for FCS and VFCS respectively) with an average flow velocity of 0.5 m/s. The average depth is 51 cm, which is around the target flow for this indicator group - Perlidae. The wetted perimeter is 32 m of the full cross-section.	8.4	Critical habitats present in abundance, with fast-deep habitat present at 57% and slow-deep present at 17%.
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	5.03	Although the critical habitat of FCS and VFCS remains in excess and good quality (33% and 20% respectively), the average depth and velocity has reduced to 40 cm and 0.4 m/s. Although these still remain within the preference range for the family Perlidae, should these velocities and average depth further reduce, stress will set in. The wetted perimeter is 30 m of the full cross-section.	3.498	Fast-deep habitat starts to decrease significantly relative to wetted perimeter (39%), with slow-deep down to 7%. Average depth will still facilitate movement through cross-section
4		No assessment undertaken		No assessment undertaken
5	0.892	The average flow of 0.2 m/s is where the stress will set in for Perlidae as the velocity slows down. Furthermore, even though there is still 19% of FCS, there is a considerable reduction in the availability of the VFCS habitat (4%), thus the	0.96	Fast-deep velocity-depth class greatly reduced (3%; 0.648 m in width), with no slow-deep class present. Fast-intermediate class starts to decrease significantly (now at 11%)

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		community will be in less abundances and at risk. Other habitats moderate to low quality. The wetted perimeter has also reduced to 21 m of the full cross-section which will be of a concern.		
6		No assessment undertaken		No assessment undertaken
7	0.075	Very shallow habitat (average depth of 6 cm and an average velocity of 0.2 m/s) will not support the Perlidae family and their abundances will diminish. Habitat quality is expected to deteriorate. TheFCS and VFCS habitat availability has decreased considerably to only 11% and 2% available at these flows. A more resilient invertebrate community will colonise instead.	0.118	Critical habitat extremely limited, with only 1% of cross-section being fast-intermediate class. Average depth of 0.07 m will limit movement across the cross-section.
8		No assessment undertaken		No assessment undertaken
9	0	No flow, only standing water, 0% critical habitats.		No assessment undertaken
10	0	Average depth is 0 cm, with no critical habitat (0% for FCS and VFCS and many other habitats), pooled in-stream. Only specialists will persist.	0	No flowing water present

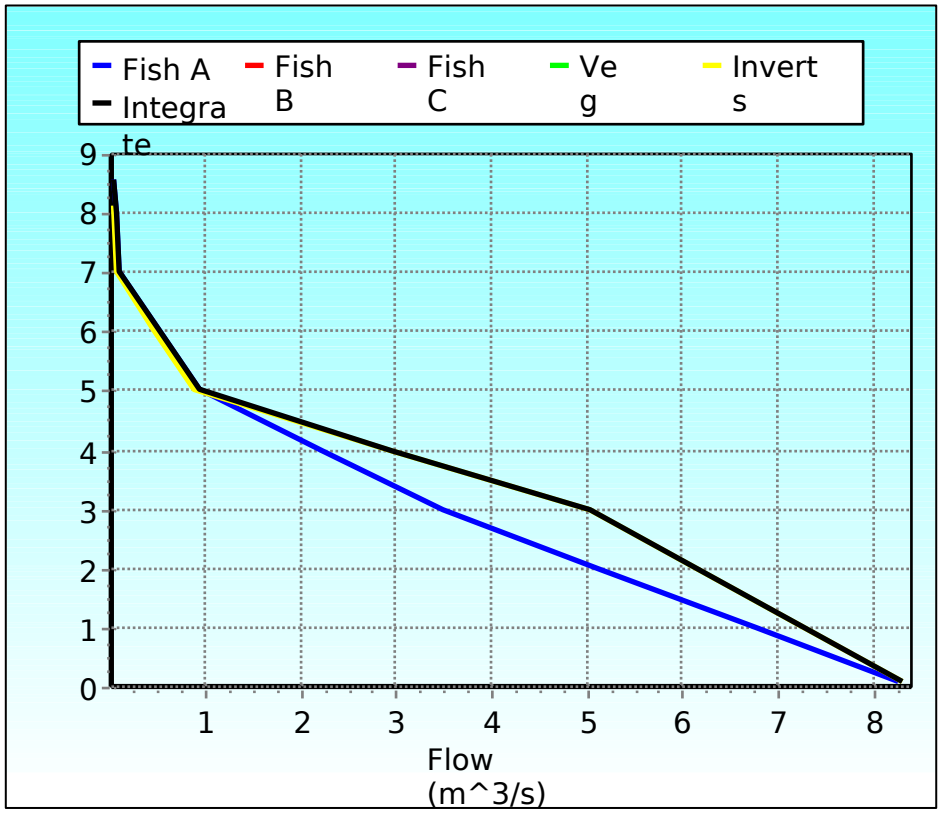


Figure 5-3: Final integrated stress curve for the Lower Mthatha EWR site (MTHA01_I)

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (August) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-4** and **Figure 5-5** below. The adjustments made to the DRM results are as follows:

Increase August drought flows from 0.483 m^3/s to 1.442 m^3/s.

Increase March maintenance low flows from 2.875m^3/s to 4.049 m^3/s.

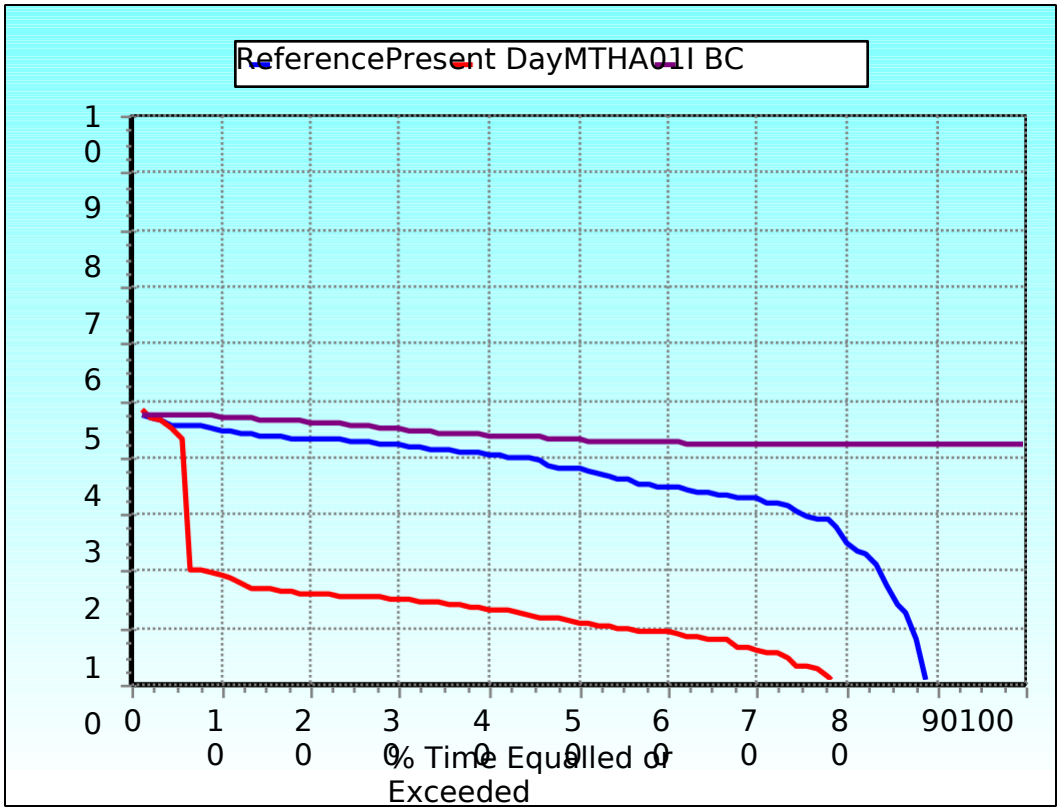


Figure 5-4: Final stress duration curves – dry season (August)

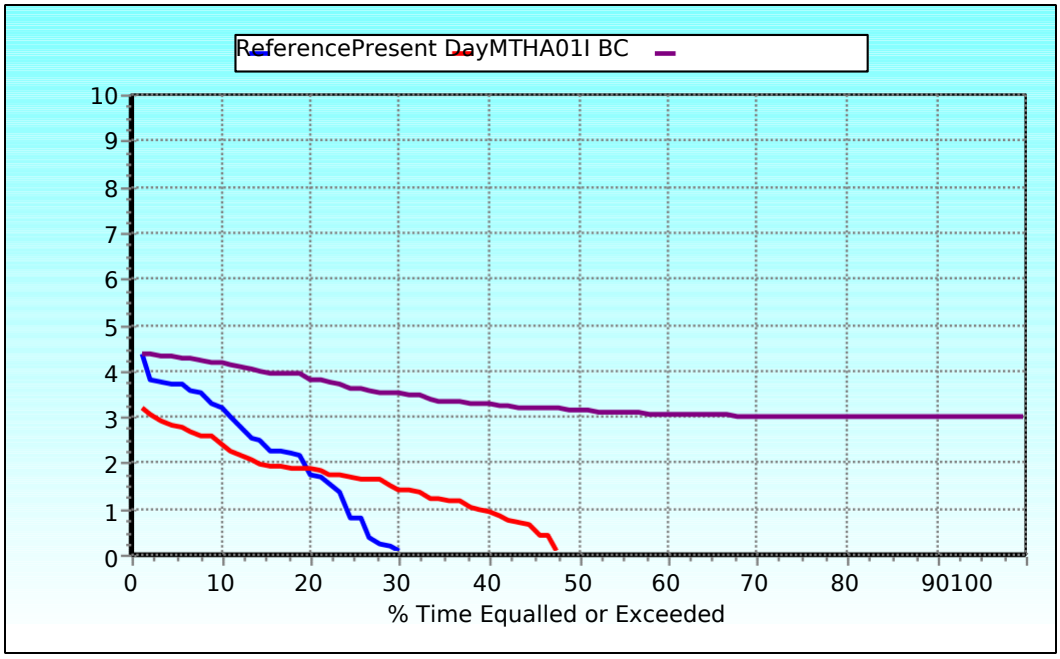


Figure 5-5: Final stress duration curves – wet season (March)

The flood requirements for the Lower Mthatha EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river

channel. The individual

requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-2.** The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-2: Flood requirements for the Lower Mthatha at the EWR site (MTHA01_I).

Floods	Flood size (range)	FINAL
Class 1 (10-20 m^3/s)	m^3/s	15
	# days	4
	Months	Oct, Nov, Jan, Feb, Mar, Apr
	Type	Daily average
Class 2 (20-40 m^3/s)	m^3/s	30
	# days	5
	Months	Nov, Dec, Jan, Feb, Mar
	Type	Daily average
Class 3 (41-50 m^3/s)	m^3/s	50
	# days	5
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-3**.

Table 5-3: Lower Mthatha - Summary of the EWR results (flows in Mm^3 per annum)

Quaternary Catchment	T20G
Site name	MTHA01_I
River	Lower Mthatha
EWR Site Co-ordinates	-31.9262; 29.1364
Recommended Ecological Category	B/C
nMAR at EWR site	389.2
Total EWR	147.157 (37.81 %MAR)
Maintenance Low flows	89.925 (23.11 %MAR)
Drought Low flows	51.337 (13.19 %MAR)
Maintenance High flows	57.231 (14.71 %MAR)
Overall confidence	Moderate

5.2 MBAS01_I: Middle Mbhashe River

Sample Date	8 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	MBAS01_I	**IUA**	IUA_T02
River	Mbhashe	**IUA description**	Lower Mbhashe
Altitude (m.a.s.l.)	392	**Prioritised RU**	R_RU14_I
Latitude	-31.95809842	**Longitude**	28.47223807
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**T13C**
Level 2 EcoRegion	31.01	**SQ Reach**	T13C-06941
Geomorphological zone	E (Slope 0.003)	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-6) AND SITE PHOTOGRAPHS (Figure 5-7)

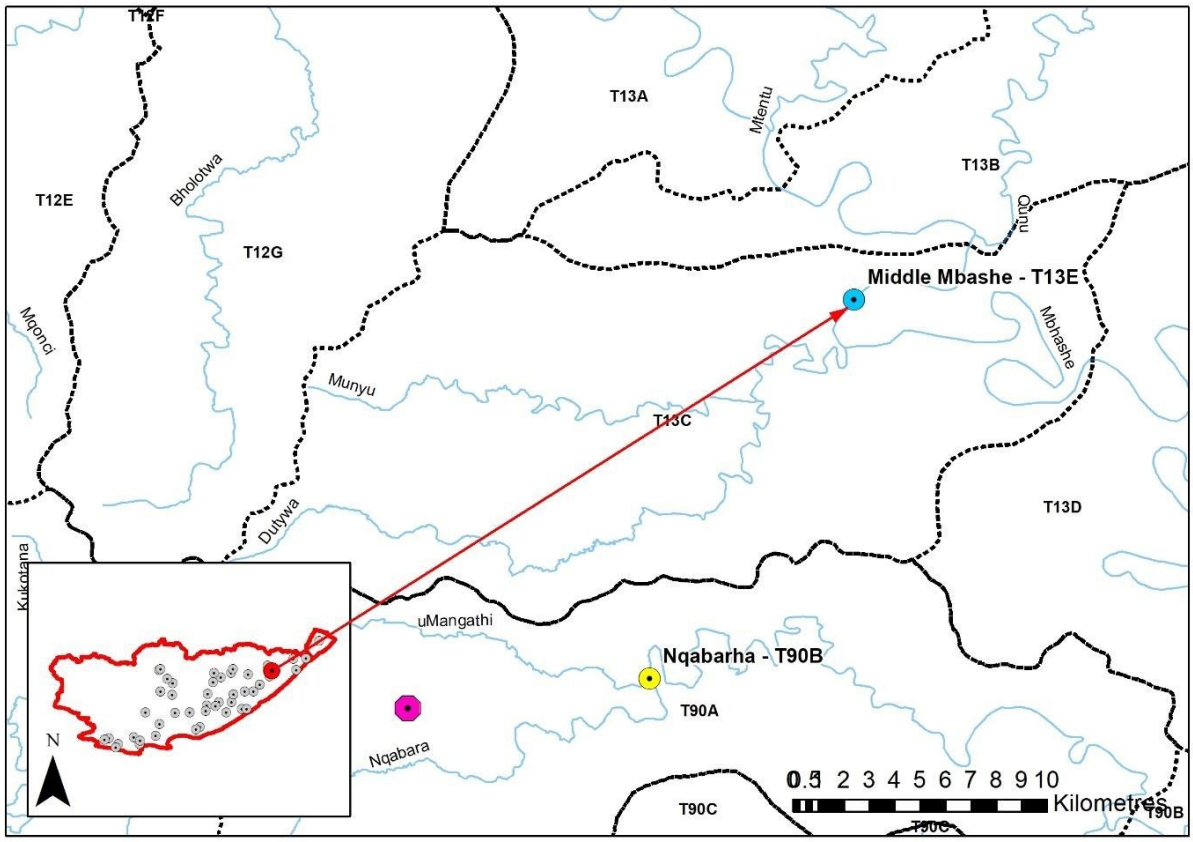


Figure 5-6: Location of site MBAS01_I (Middle Mbhashe) in relation to the study area.
(pink icon indicates a WWTW and yellow dot a Rapid 3 EWR site)

Site Photographs: Survey 1 (September 2022)

Figure 5-7: Site photographs of the middle Mbhashe EWR site.

The EWR for the Middle Mbashe River was determined for a REC of a C/D and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Middle Mbashe River were Perlidae (Stonefly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Good availability of SIC (although dominated by large boulders) and SOOC and GSM, including within the interstitial spaces in the SIC/SOOC biotope. The marginal vegetation was limited to none, primarily due to scoured banks, or boulders dominating the right bank. Perlidae were recorded in abundances during the May 2023 survey, although they weren't recorded during the REMP monitoring in 2023, even though they were part of the reference list. Therefore, Perlidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. They prefer cobbles and high velocities of >0.6 m/s, although appear optimally at flows between 0.3 and
0.6 m/s. If flows are below this target, Perlidaes will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS. They are further very sensitive to any water quality change. Furthermore, a single Oligoneuridae (Brushlegged mayfly) was recorded at this site during the May 2023 survey, and although part of the reference list, have not often been recorded but clearly still are present. However, when the Oligoneuridae were recorded, the discharge was measured at 20.8 m^3/s, which only occur 1% of the time in accordance with the hydrology. Thus, although Oligoneuridae would be a great indicator taxon, for the purpose of this study and realistic flows, Perlidaes will remain the indicator taxon for this site.

Fish: Natural fish species within the reach expected to be limited with no true rheophilics expected,

thus semi-rheophilic *Anguilla mossambica* selected as indicator taxa. The species inhabits both quiet

and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep, and fast- shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (40-60 mm) due to proximity to estuary, with upstream migration taking place during high-flow period and during receding limb of freshets and floods. The indicator species was noted to occur during the various surveys undertaken.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 30th percentile for March (12.894 m^3/s) and a minimum dry flow or 95th percentile for June (2.381 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats, and velocities. The selected stress values and associated flows are provided in **Table 5-4** and the final integrated stress curve is shown in **Figure 5-8**.

Table 5-4: Selected stress values, flows and rationale for the Middle Mbashe EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	12.745	The 7.9 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology. The critical habitats along the cross section were FCS and VFCS, which comprised 16% and 4% and in very high quality. The average flow velocity at this discharge is 0.2 m/s with a maximum velocity of 0.7 m/s, which is the optimal velocity preference for Perlidae. The average depth is 68 cm and the wetted perimeter 93 m of the full cross-section. Some of the cobbles along the right bank will become activated at this maximum velocity and depths, providing additional cobble habitat for Perlidae.	7.831	Based on maximum baseflow expected. Slow-deep class dominant (47%) with slow-shallow also dominant. Fast-deep class respresented at 13%.
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	9.188	The maximum velocity at a discharge of 9.1 m^3/s is 0.6 m/s, with the average velocity being 0.2 m/s. Perlidae will persist, despite the slightly reduced critical habitat of 13% and 3% for FCS and VFCS respectively. The average depth of 57 cm will activate the cobbles	5.752	Fast-intermediate class decreases significantly, but fast-deep class still present at 10%. Will allow for boulders on the outer edges to be activated and provide cover for indicator species.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		along the outer edge thus provide additional FCS critical habitat for the Perlidae.		
4		No assessment undertaken		No assessment undertaken
5	4.784	The wetted perimeter at this discharge has only slightly decreased to 88 m of the cross section, while the average depth has decreased considerably to 40 cm. The maximum velocity is 0.5m/s, thus still within the velocity preference for Perlidae being 0.3 and 0.6 (although optimally at >0.6 m/s). This further would explain the deactivation of the VFCS critical habitat. Overall, only 10% remains of the FCS for Perlidae to persist.	2.027	Critical habitat greatly reduced, with slow-deep class the most prominent of the critical habitat classes present (10%). Ability of boulders at outer edges to provide cover for indicator species reduced.
6		No assessment undertaken		No assessment undertaken
7	0.296	Very shallow habitat (average depth of 13 cm) and a a maximum velocity of 025 m/s, will not support the Perlidae family and their abundances will diminish. Habitat quality is expected to deteriorate. The FCS habitat availability has decreased considerably to only 1% and 0% available at these flows along the cross-section respectively. A more resilient invertebrate community will colonise instead.	0.596	No critical habitats remaining. Only limited fast-flowing habitat available (1% for fast-shallow and fast-very shallow) with the slow-shallow habitat being dominant (68%) and limited water depth (0.17 cm average).
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	No flowing water present

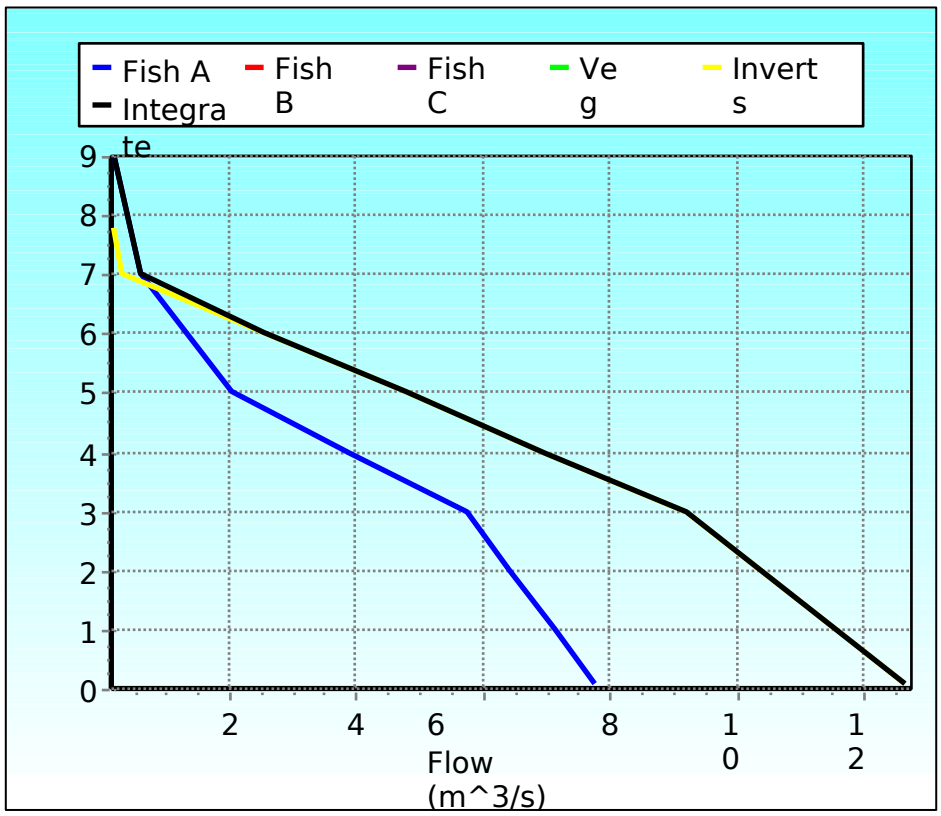


Figure 5-8: Final integrated stress curve for the Middle Mbashe EWR site (MBAS01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (June) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-9** and **Figure 5-10** below. The adjustments made to the DRM results are as follows:

Increase June drought flows from 0.777 m^3/s to 1.279 m^3/s.

Increase March maintenance low flows from 2.240 m^3/s to 6.178 m^3/s.

The 'High flow shape' for the months November to April was adjusted to 6.

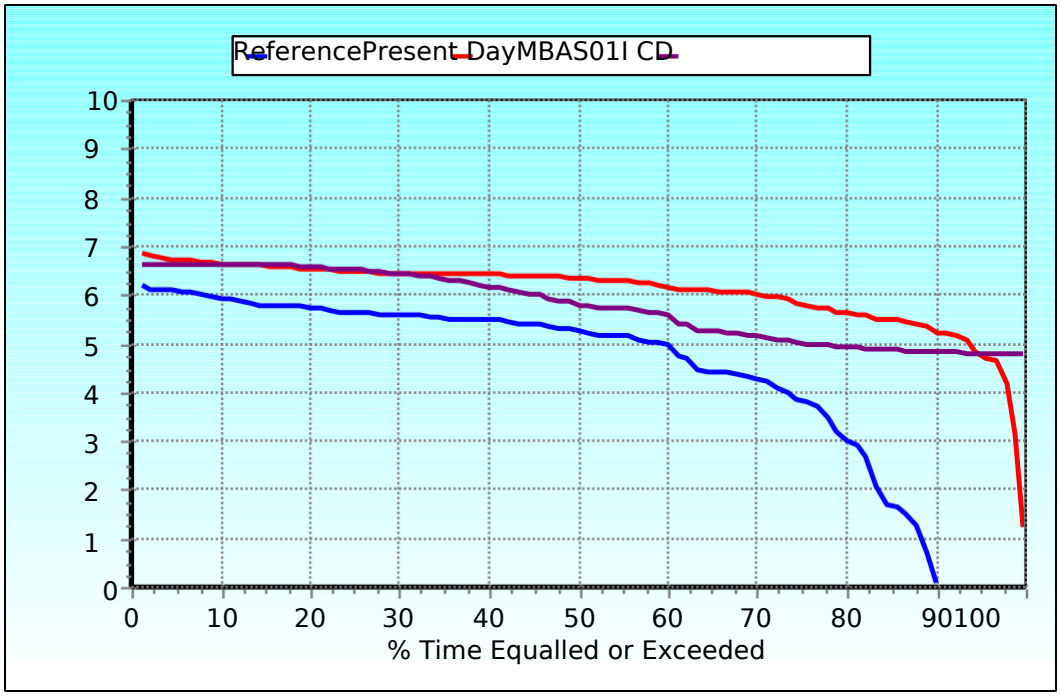


Figure 5-9: Final stress duration curves – dry season (June).

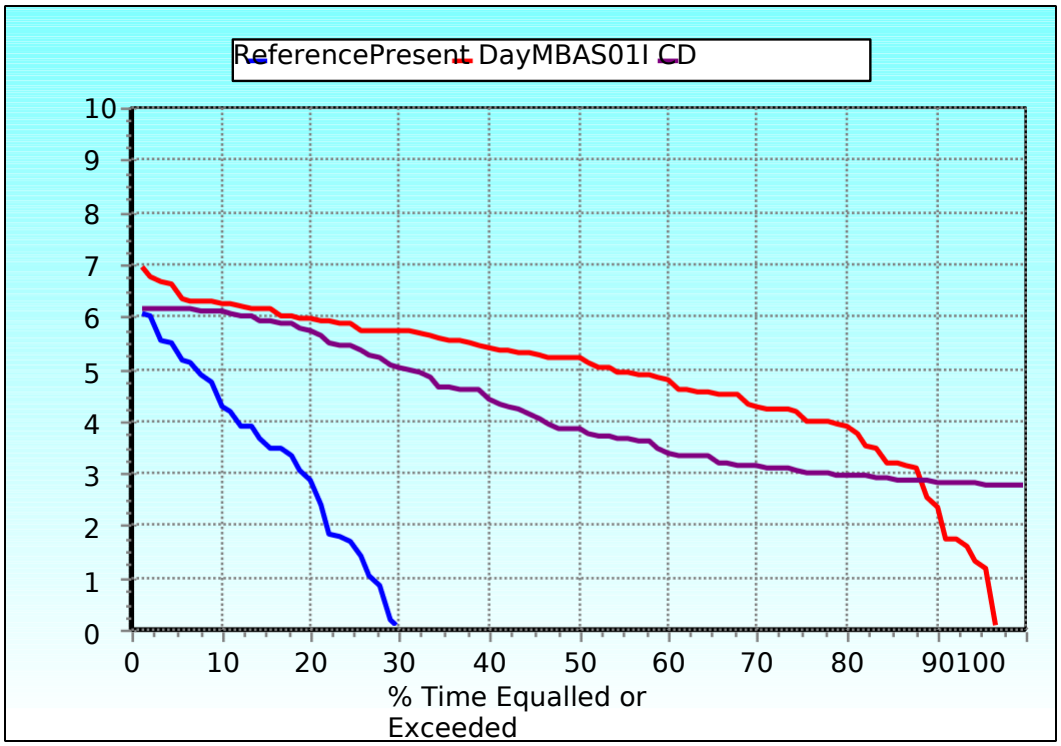


Figure 5-10: Final stress duration curves – wet season (March).

The flood requirements for the Middle Mbashe EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel.

The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-5**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-5: Flood requirements for the Middle Mbashe at the EWR site (MBAS01_I).

Floods	Flood size (range)	FINAL
Class 1 (20-40 m^3/s)	m^3/s	37
	# days	5
	Months	Oct, Nov, Feb, Mar, Apr
	Type	Daily average
Class 2 (40-55 m^3/s)	m^3/s	50
	# days	5
	Months	Nov, Dec, Jan, Feb
	Type	Daily average
Class 3 (200-370 m^3/s)	m^3/s	200
	# days	5
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-6**.

Table 5-6: Middle Mbashe - Summary of the EWR results (flows in Mm^3 per annum)

Quaternary Catchment	T13C
Site name	MBAS01_I
River	Middle Mbashe
EWR Site Co-ordinates	-31.958; 28.472
Recommended Ecological Category	C/D
nMAR at EWR site	673.8
Total EWR	256.156 (38.02 %MAR)
Maintenance Low flows	136.367 (20.24 %MAR)
Drought Low flows	47.185 (7.00 %MAR)
Maintenance High flows	119.789 (17.78 %MAR)
Overall confidence	Moderate to high

5.3 BKEI01_I: Black Kei River

Sample Date	11 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	BKEI01_I	**IUA**	IUA_S02
River	Black Kei	**IUA description**	Black Kei
Altitude (m.a.s.l.)	872	**Prioritised RU**	R_RU24_I
Latitude	-32.11819532	**Longitude**	27.06884273
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**S32K**
Level 2 EcoRegion	18.02	**SQ Reach**	S32K-07057
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-11) AND SITE PHOTOGRAPHS (Figure 5-12)

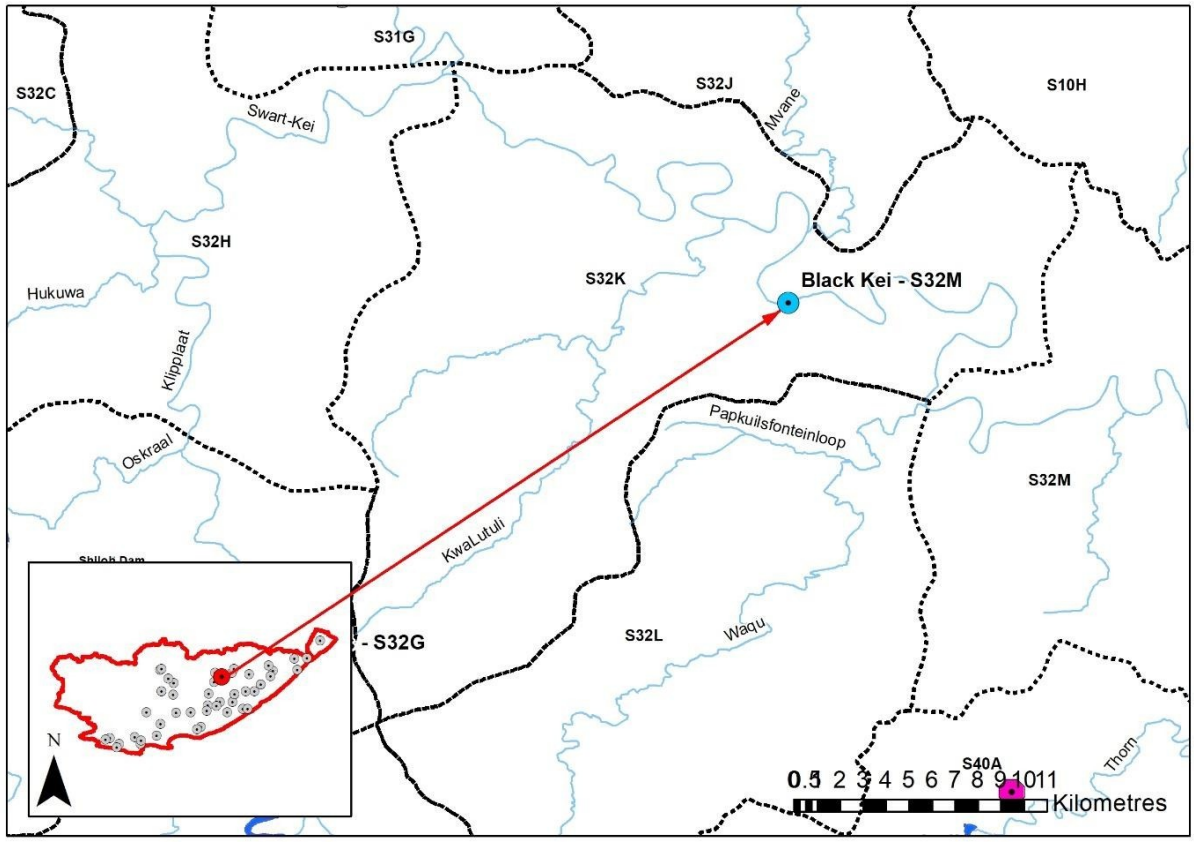


Figure 5-11: Location of site BKEI01_I (Black Kei) in relation to the study area.

(pink icon indicates a WWTW in relation to the EWR site)

Figure 5-12: Site photographs of the Black Kei EWR site.

The EWR for the Black Kei River was determined for a REC of a D and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Black Kei River were Hydropsychidae (Tube case netspinning caddisfly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Biotope availability within the Black Kei comprised SIC (including boulders), some SOOC and GSM. Marginal vegetation was limited to no vegetation owing to scoured and eroded banks. The indicator taxon selected for this site is Hydropsychidae, being a flow dependent taxon. They have a high preference for fast currents of >0.6 m/s, although optimal speeds are approximatley
0.4 m/s, along cobble substrate. The minimum depth requirements for Hydropsychidae are 10 cm, and maximum depths are about 30cm. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the FCS and VFCS. The Hydropschyidae family are not sensitive to deterioration in water quality and are expected to tolerate wide fluctuations in flow and water quality conditions. An additonal motivation for this selected indicator taxon, is that this system is driven by impaired water quality, opposed to flow. Thus, the fact that Hydropschyidae can tolerate a wide range of water quality conditions, and flow dependent taxa, means that they should still occur despite the water quality.

Fish: Only two native fish species expected within the system, notably *Anguilla mossambica* and

Enteromius anoplus (Chubbyhead Barb). Although not collected during the present study or during

REMP studies, *Anguilla mossambica* selected as an indicator species as the species is a better flow-dependent indicator than *Enteromius anoplus* due to higher flow requirements. The species inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep, and fast-shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (60-120 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods. Critical breeding habitat for *Enteromius anoplus* within the cross section is considered but does not form the primary basis as the species prefers slow-flowing habitat and can breed in pools should there be marginal vegetation. Bank collapse present at the cross section will impact marginal vegetation presence. Reach is also noted to be dominated by non-native fish species, notably *Labeobarbus aeneus* (Vaal-Orange Smallmouth Yellowfish).

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 40th percentile for March (2.997 m^3/s) and a minimum dry flow or 95th percentile for July (1.054 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitat and velocities. The selected stress values and associated flows are provided in **Table 5-7** and the final integrated stress curve is shown in **Figure 5-13**.

Table 5-7: Selected stress values, flows and rationale for the Black Kei EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	2.356	The 2.4 m^3/s was the selected maxium natural Baseflow for this site (50% percentile) in accordance with the hydrology. Thus, the stress of 0 was based on this. Critical habitats along the cross sectionis in excess and high quality (34% and 14% for FCS and VFCS respectively). The average flow velocity at this discharge is 0.4 m/s with a maximum velocity of 1.09 m/s, which is where the Hydropsychidae will occur on the cobbles (their preferece being >0.6 m/s). The average depth is 5 cm and the wetted perimeter 1.26 m of the full cross-section.		No assessment undertaken
1		No assessment undertaken		No assessment undertaken

2		No assessment undertaken	1.357	Limit of marginal vegetation contact at the cross section for breeding of *Enteromius anoplus*. Sufficient fast-flowing habitat for movement of *Anguilla*

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
				mossambica, with 32% of the cross section falling within the fast-deep class, and 2% falling within the fast-intermediate class.
3	1.499	At this discharge of 1.499 m^3/s, the VFCS critical habitat has reduced, although 30% of the VFC critical habitat persists. Furthermore, the maximum velocity of 0.9 m/s is still suitable for the indicator species Hydropschydiae, although the average velocity is decreasing over the cobble biotope. Overall, the indicator taxon will still persist despcite the reduced critical habitat and quality (VFCS).		No assessment undertaken
4		No assessment undertaken		No assessment undertaken
5	0.607	The critical habitat at this flow has drastically decreased for the indicator taxon (14% and 3% for FCS and VFCS respectively). Maximim velocity is 0.6 m/s, with an average velocity of 0.2 m/s, thus the velocities too have reduced, with Hydropschyidae have optimal preference to 0.4 m/s, but also thrive in >0.6 m/s. Thus, a level of stress will set in at these flows for the indicator taxon.	0.266	Residual fast-deep and fast-intermediate class present.
6		No assessment undertaken		No assessment undertaken
7	0.108	The maximum depth is 26 cm and average depth 15 cm, not suitable for Hydropschyidae, the flows have drastically reduced with maximum velocity being 0.3 m/s and both critical habitats comproised with only 2% of VFCS and no availability of the VFCS critical habitat. Thus, the flows or lack of habitat availble will not support the Hydropschyidae family and their abundances will diminish, as the biotopes also become exposed and thus habitat quality is expected to deteriorate. A more resilient invertebrate community will colonise instead that are not so	0.108	Loss of critical habitat, with no slow-deep, fast-deep or fast-intermediate class present. Some movement between upstream and downstream reaches likely possible.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		flow dependent and prefer the pools.		
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	No flow across cross section - only hyperheic refugia present.

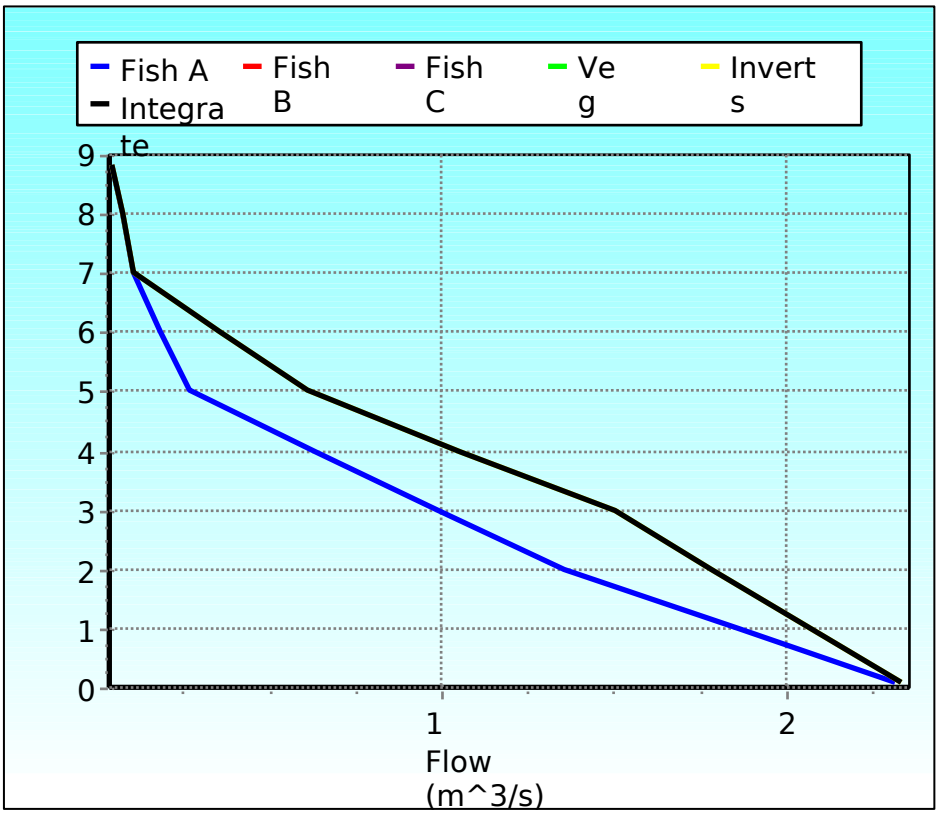


Figure 5-13: Final integrated stress curve for the Black Kei EWR site (BKEI01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-14** and **Figure 5-15** below. The adjustments made to the DRM results are as follows:

Increase July drought flows from 0.293 m^3/s to 0.602 m^3/s.

Increase March maintenance low flows from 0.413 m^3/s to 1.232 m^3/s.

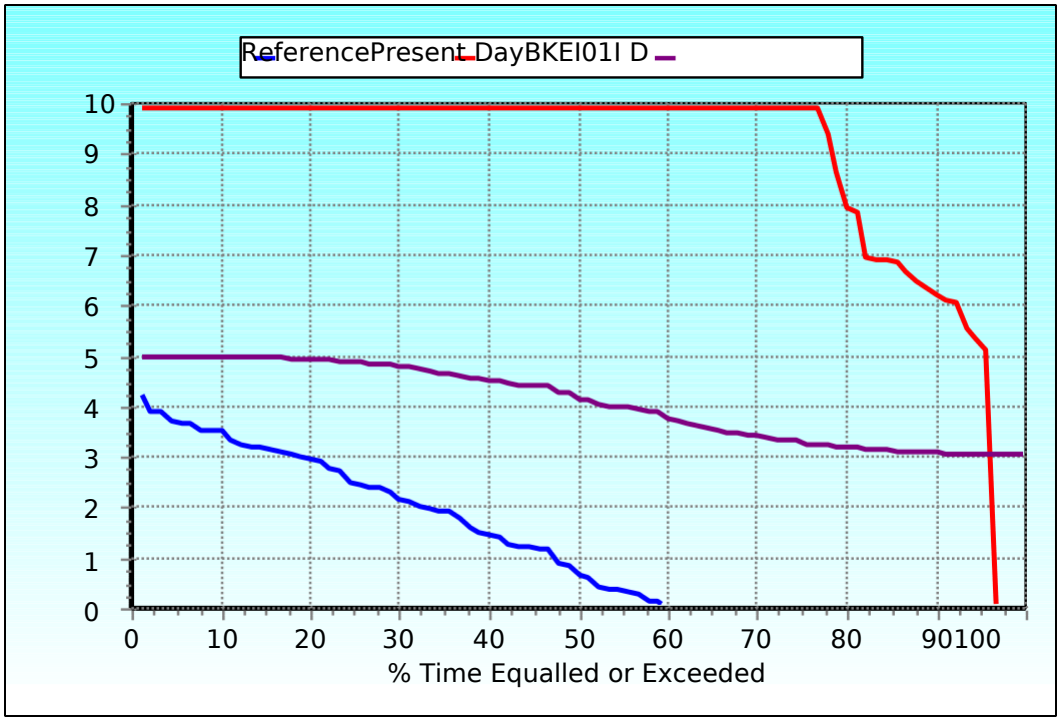


Figure 5-14: Final stress duration curves – dry season (July).

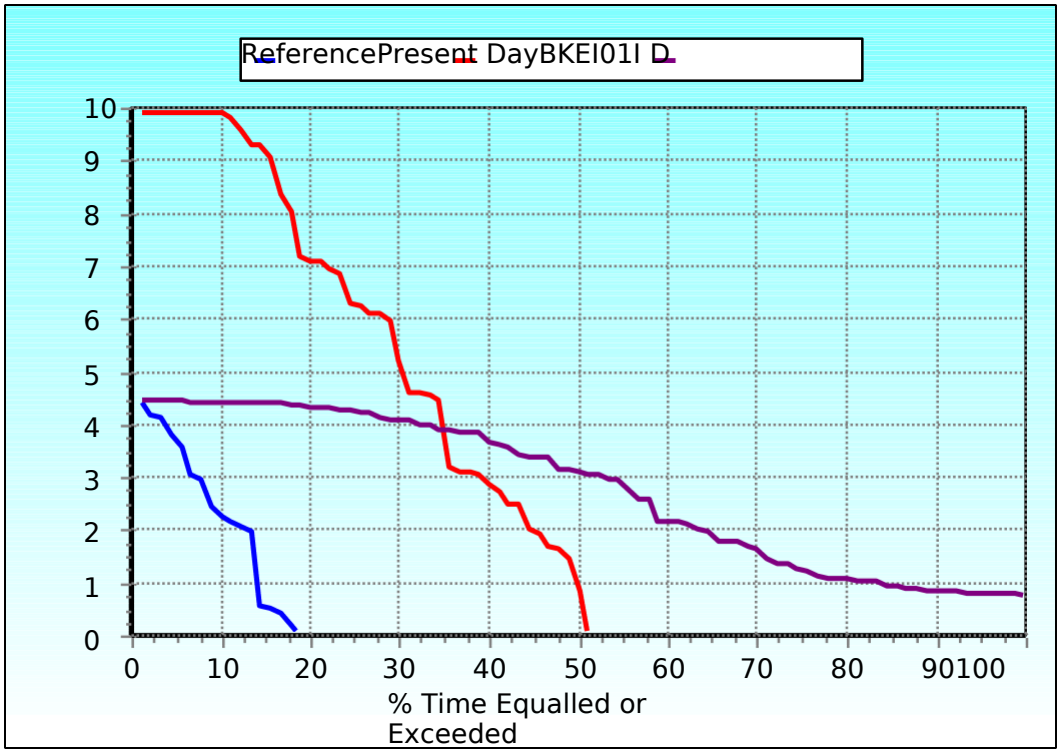


Figure 5-15: Final stress duration curves – wet season (March).

The flood requirements for the Black Kei EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual

requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-8**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-8: Flood requirements for the Black Kei at the EWR site (BKEI01_I).

Floods	Flood size (range)	FINAL
Class 1 (4-9 m^3/s)	m^3/s	7
	# days	5
	Months	Oct, Dec, Jan, Feb, Apr
	Type	Daily average
Class 2 (28-32 m^3/s)	m^3/s	30
	# days	3
	Months	Nov, Feb
	Type	Daily average
Class 3 (90 m^3/s)	m^3/s	60
	# days	5
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5.9.**

Table 5-9: Black Kei - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S32K
Site name	KEI01_I
River	Black Kei
EWR Site Co-ordinates	-32.118; 27.069
Recommended Ecological Category	D
nMAR at EWR site	197.9
Total EWR	60.189 (32.03 %MAR)
Maintenance Low flows	31.387 (16.70 %MAR)
Drought Low flows	20.882 (11.11 %MAR)
Maintenance High flows	28.802 (15.33 %MAR)
Overall confidence	Moderate to high

5.4 GKEI01_I: Great Kei River

Sample Date	15 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	GKEI01_I	**IUA**	IUA_S03
River	Great Kei	**IUA description**	Lower Great Kei
Altitude (m.a.s.l.)	159m	**Prioritised RU**	R_RU13_I
Latitude	-32.50811888	**Longitude**	27.966289
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	**S70A**
Level 2 EcoRegion	16.06	**SQ Reach**	S70A-07524
Geomorphological zone	E (slope 0.003)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-16) AND SITE PHOTOGRAPHS (Figure 5-17)

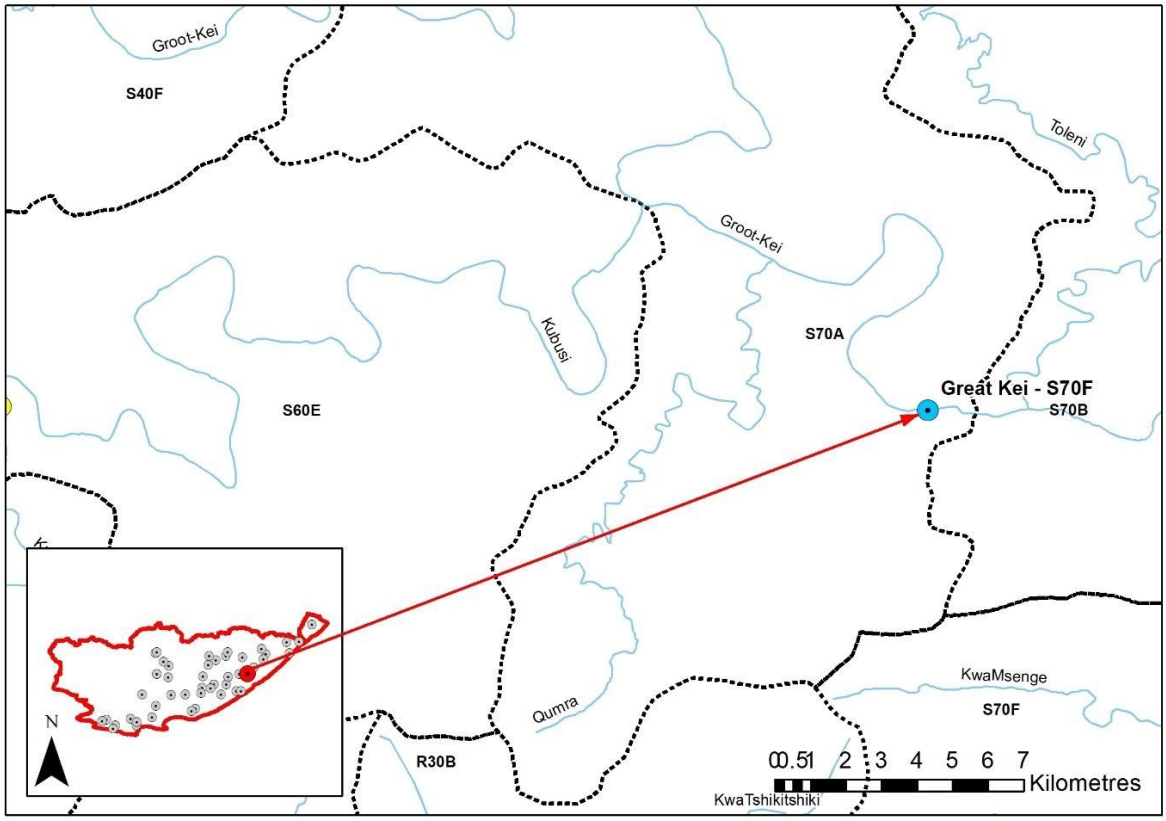


Figure 5-16: Location of site GKEI01_I (Great Kei) in relation to the study area.

Figure 5-17: Site photographs of the Great Kei EWR site.

The EWR for the Great Kei River was determined for a REC of a C and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Great Kei River were Heptageniidae (Flatheaded mayfly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Biotope availability within the Great Kei River comprised SIC (including boulders), SOOC and GSM. Marginal vegetation was limited due to eroded and undercut banks. Varying hydraulic features at this site as well. Heptageniidae were recorded in A and B abundances during the September 2022 and May 2023 surveys respectively, including being recorded during the REMP biomonitoring located just downstream of this site. Therefore, Heptageniidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. Heptageniidae are widespread throughout the catchment and wider throughout South Africa. They have a high preference for moderate to fast flowing water (0.1 - 0.3 m/s and 0.3 - 0.6 m/s respectively) over the cobble biotope. Their preferred water depths are 10 - 30 cm depth range. In addition, although Perlidae were not recorded, they do form part of the reference list and have previously been recorded within the same Ecoregion Level 2 (also flow dependent taxon and very sensitive to water quality changes). They prefer cobbles and high velocities of >0.6 m/s (VFCS), although they appear optimally at flows between 0.3 and 0.6 m/s.

Fish: Although various fish species are present, no true rheophilics expected. Only a single species noted to prefer faster flowing velocity-depth classes, namely *Anguilla mossambica*. While *Pseudomyxus capensis* (Freshwater Mullet) was noted to have the highest intolerance to no-flow conditions, its cover prefence was noted as being the water coloumn and slow-deep velocity-depth class, thus not suitable as an indicator species. Thus, large semi-rheophilic *Anguilla mossambica* selected. The species inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep, and fast-shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (40-60 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods. Consideration also given to smaller cohorts since they are likely to also utilise fast-shallow habitats. River reach was

however

dominated by non-native fish species, with no native fish species collected. Based on communication with regional DWS officials, REMP site for fish monitoring is likely to be more downstream, below the low-level weir.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 60th percentile for March (10.799 m^3/s) and a minimum dry flow or 95th percentile for July (3.513 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats, and velocities. The selected stress values and associated flows are provided in **Table 5-10** and the final integrated stress curve is shown in **Figure 5.17**.

Table 5-10: Selected stress values, flows and rationale for the Great Kei EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	10.687	The 10.79 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology. Thus, the stress of 0 was based on this. Critical habitats along the cross section at a discharge of 10.687 m^3/s was selected for 0 stress owing to both critical habitats being in excess and high quality (23% and 43% for FCS and VFCS respectively). The average flow velocity ais 0.6 m/s, which is suitable for the Heptageniidae to occur on the cobble's biotope. The average depth is 42 cm and the wetted perimeter 40 m of the full cross-section.	10.687	The 10.79 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology. Critical habitat dominated by fast-deep class, with slow-deep class at 9%, fast-shallow class at 4% and fast-intermediate at 7%.
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	3.781	The VFCS critical habitat has reduced by 50% compaired to 0 stress (sitting at 20%), while the FCS habitat has increased to 33%. Although the average and maximum velocities have decreased to 0.4 m/s and 1.25 m/s respectively, the Heptageniidae indicator taxon will still occur at these flows and still enough critical habitat for persistence. The wetted perimeter has slightely reduced to	2.562	Critical habitat regarded as sufficient to allow for movement of indicator species through the reach, with fast-shallow, fast-intermediate, and fast-deep classes present at a cumulative 43%.

		29 m of the cross section.		

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
4		No assessment undertaken		No assessment undertaken
5	0.502	The critical habitat is reduced with moderate to low quality (16% and 4% for VFCS and FCS respectively). The wetted perimeter has drastically reduced at only 16m of the cross section. Maximum depth is 28 cm, with average depth at 15 cm, thus the cobbles and boulder biotopes will become exposed. The average and maximum velocities are 0.2 m/s and 0.6 m/s respectivley, thus most times, the velociites are not meeting the indicator taxons prference of 0.6 m/s. The wetted perimeter has also reduced to 16 m of the cross section. Thus, a level of stress will set in at these flows for the indicator taxon.	0.404	Critical habitat greatly reduced, with perimeter at 15.5 m and fish habitat dominated by slow-shallow and slow-very shallow classes, and fast-shallow and fast-intermediate being the only faster flowing critical habitat classes present.
6		No assessment undertaken		No assessment undertaken
7	0.025	No critical habitat available for the indicator taxon, and instream biotopes fully exposed with maximum depth at 10 cm and maximum velocity at 0.2 m/s. The wetted perimeter has become narrow at 6m of the cross section. A more resilient invertebrate community will colonise instead that are not so flow dependent and prefer the isolated pools.	0.033	Loss of all critical flow classes, with perimeter down to 7.3 m and habitat dominated by slow-very shallow class.
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	Only hyperheic (sub-surface) refugia present, thus not supportive of fish.

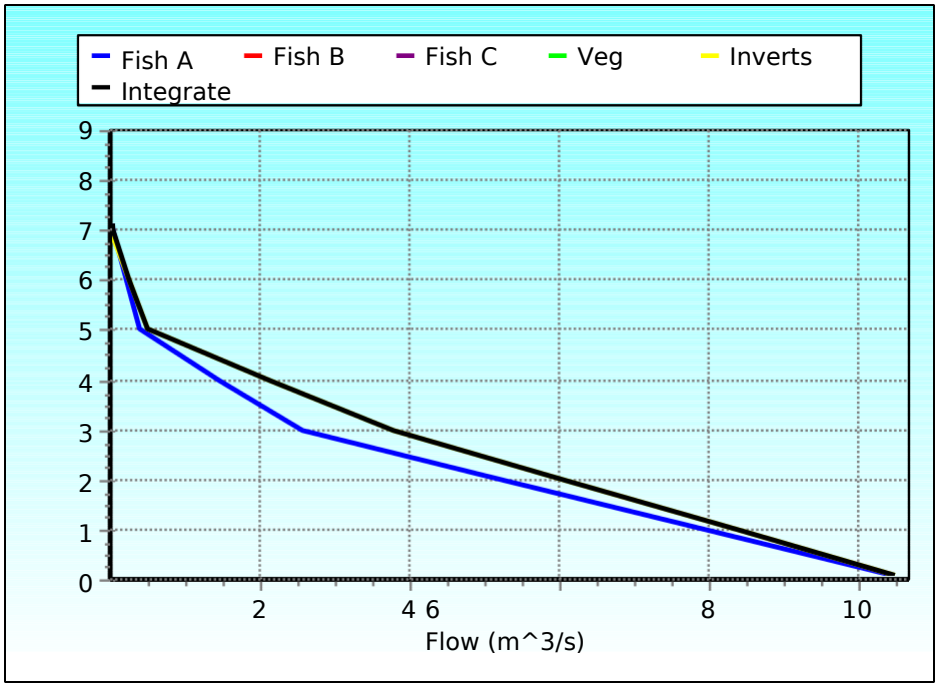


Figure 5-18: Final integrated stress curve for the Great Kei EWR site (GKEI01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-19** and **Figure 5-20** below. The adjustments made to the DRM results are as follows:

Increase July drought flows from 0.954 m^3/s to 1.062 m^3/s.

Increase March maintenance low flows from 4.089 m^3/s to 6.073 m^3/s.

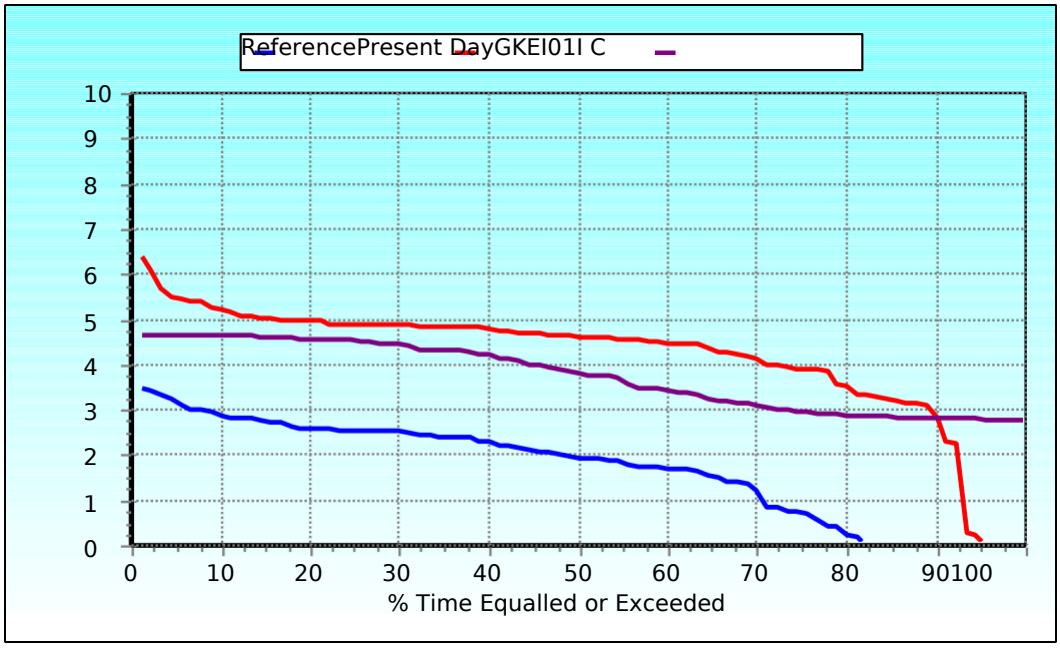


Figure 5-19: Final stress duration curves – dry season (July).

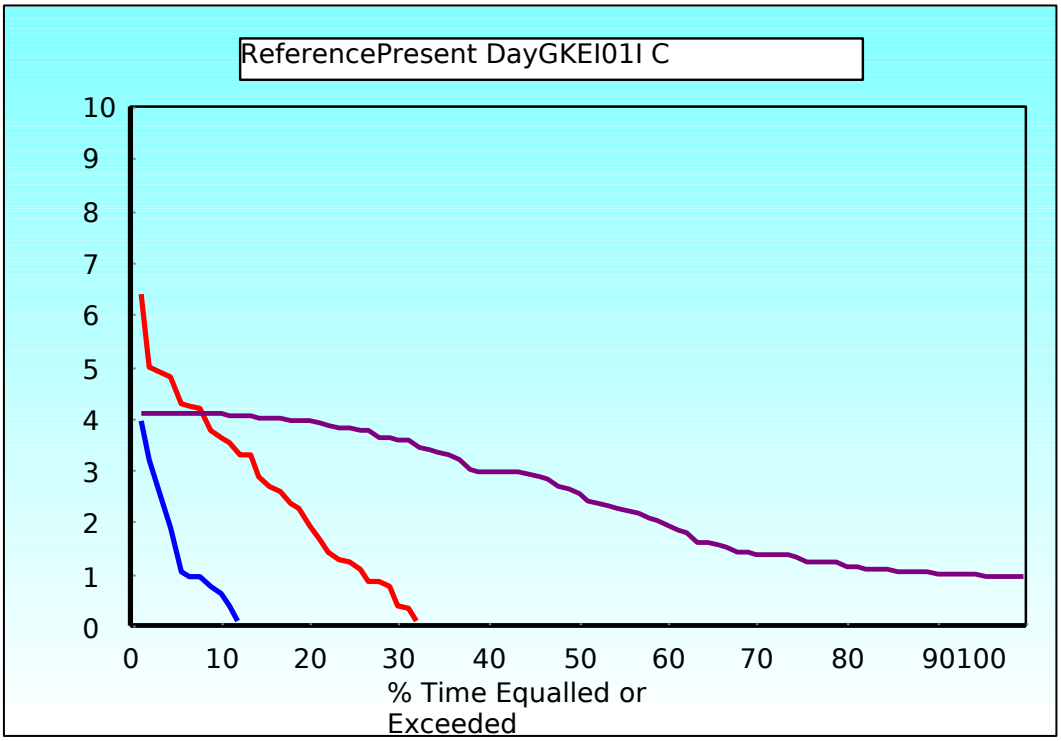


Figure 5-20: Final stress duration curves – wet season (March).

The flood requirements for the Great Kei EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-11**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-11: Flood requirements for the Black Kei at the EWR site (BKEI01_I).

Floods	Flood size (range)	FINAL
Class 1 (25-45 m^3/s)	m^3/s	30 & (45)
	# days	Sep, Oct & (Nov – Apr)
	Months	5
	Type	Daily average
Class 2 (95-120 m^3/s)	m^3/s	120
	# days	5
	Months	Mar
	Type	Daily average

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-12**.

Table 5-12: Great Kei - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S70A
Site name	KEI01_I
River	Great Kei
EWR Site Co-ordinates	-32.508; 27.966
Recommended Ecological Category	C
nMAR at EWR site	897.2
Total EWR	223.993 (24.97 %MAR)
Maintenance Low flows	131.847 (14.70 %MAR)
Drought Low flows	44.287 (4.94 %MAR)
Maintenance High flows	92.146 (10.27 %MAR)
Overall confidence	High

5.5 TSOM01_I: Tsomo River

Sample Date	10 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	TSOM01_I	**IUA**	IUA_S01
River	Tsomo	**IUA description**	Upper Great Kei
Altitude (m.a.s.l.)	769m	**Prioritised RU**	R_RU11_I
Latitude	-32.04397654	**Longitude**	27.82105224
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	**S50G**
Level 2 EcoRegion	16.06	**SQ Reach**	S50J-07011
Geomorphological zone	E (slope 0.004)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-21) AND SITE PHOTOGRAPHS (Figure 5-22)

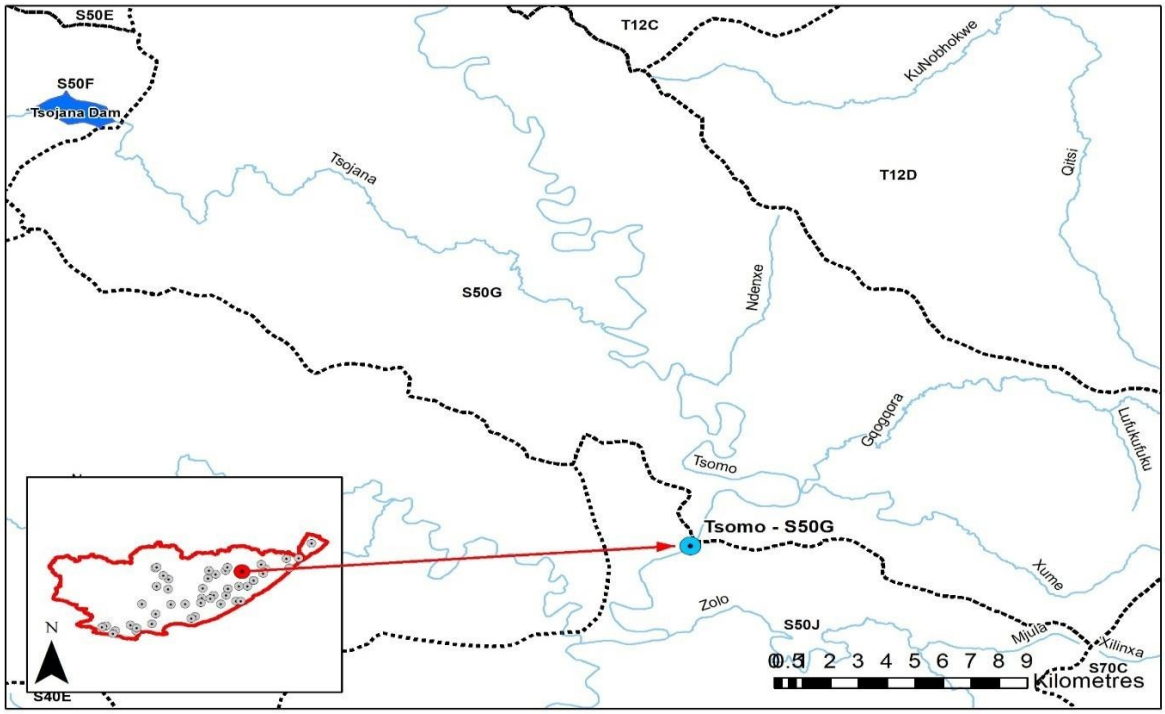


Figure 5-21: Location of site TSOM01_I (Tsomo) in relation to the study area.

Figure 5-22: Site photographs of the Tsomo EWR site.

The EWR for the Tsomo River was determined for a REC of a C/D and the HFSR approach was used to determine the EWRs. The indicator species for macro-invertebrate taxa and fish species selected for the Tsomo River were Perlidae (Stonefly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Biotope availability within the Tsomo for macroinvertebrates included SIC, boulders, SOOC and GSM. The marginal vegetation was highly limiting due to scoured banks and undercutting of banks. Perlidae were recorded in abundances during the May 2023 survey and have also previously been recorded during the REMP monitoring within the same EcoRegion Level 2. Therefore, Perlidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. They prefer cobbles and high velocities of >0.6 m/s, although they appear optimally at flows between 0.3 and 0.6 m/s. If flows fall below this target, Perlidaes will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS. They are further very sensitive to any water quality change. Thus, even if the flow is available, should the water quality be highly compromised, this indicator taxon will not occur due to its high requirement for unmodified physico-chemical conditions changed.

Fish: Only two native fish species expected within the system, notably *Anguilla mossambica* and *Enteromius anoplus*. Although not collected during the present study or during REMP studies, *Anguilla mossambica* selected as an indicator species as the species is a better flow-dependent indicator than *Enteromius anoplus* due to higher flow requirements. The species inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep, and fast-shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (60-120 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods. Critical breeding habitat for *Enteromius anoplus* within the cross section is considered but does not form the primary basis as the species has a preference for slow-flowing habitat and can breed in pools should there be marginal vegetation. Reach is also noted to be dominated by non-native fish species, notably *Labeobarbus aeneus* (small mouth yellow fish). Although the river reach is assessed on the basis of fish movement through cross section, the presence of a weir upstream of the cross section that limits upstream migration suggests emphasis on flow should be given to invertebrates.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 60th percentile for March (2.015 m^3/s) and a minimum dry flow or 95th percentile for July (0.394 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats and velocities. The selected stress values and associated flows are provided in **Table 5-13** and the final integrated stress curve is shown in **Figure 5-23**.

Table 5-13: Selected stress values, flows and rationale for the Tsomo EWR site

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	2.009	The 2.009 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology. Thus, the stress of 0 was based on this. Critical habitats along the cross section at a discharge of 2.009 m^3/s was selected for 0 stress owing to both critical habitats available (20% and 5% for FCS and VFCS respectively). The average flow velocity is 0.24 m/s although maximum velocity is 0.8 m/s, thus suitable for the Perlidae to occur on the cobbles biotope. The average depth is 37 cm and the wetted perimeter 23 m of the full cross-section.	2.009	The 2.009 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology. Critical habitat dominated by fast-deep class, with slow-deep class at 17%, fast-shallow class at 3% and fast-intermediate at 2%. Slow-shallow calss at 41% providing good velocity-depth classes for the two fish species expected.
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	1.439	The critical habitat fpr Perlidae have been reduced (15% and 3% for VFCS and FCS respectively). The average and maximum velocity is 0.2 m/s and 0.7 m/s respecitvely, thus still suitable for the indicator taxon to occur (Perlidae appear optimally at flows between 0.3 and 0.6 m/s). The wetted perimeter is slightly reduced at 20 m of the cross section.	0.865	No assessment undertaken
4		No assessment undertaken		No assessment undertaken
5	0.75	The critical habitat is reduced with moderate to low quality (9% and 1% for VFCS and FCS respectively). Maximum depth is 43 cm, with average depth at 28 cm. The wetted perimeter has further reduced to 18 m of the cross section, and the average and maximum velocities are 0.15 m/s and 0.5 m/s respectivley, thus the average velocity are below the preferences of the indicator taxon.	0.361	No assessment undertaken

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		Thus, a level of stress will set in at these flows for the indicator taxon.		
6		No assessment undertaken		No assessment undertaken
7	0.157	No critical habitat available for the indicator taxon, and instream biotopes becoming fully exposed with maximum depth at 26 cm and maximum velocity at 0.2 m/s, way below the preferences for Perlidae. The wetted perimeter has become narrow at 16m of the cross section. A more resilient invertebrate community will colonise instead that are not so flow dependent and prefer the isolated pools.	0.011	No assessment undertaken
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water, and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	Only hyperheic refugia present, thus not supportive of fish.

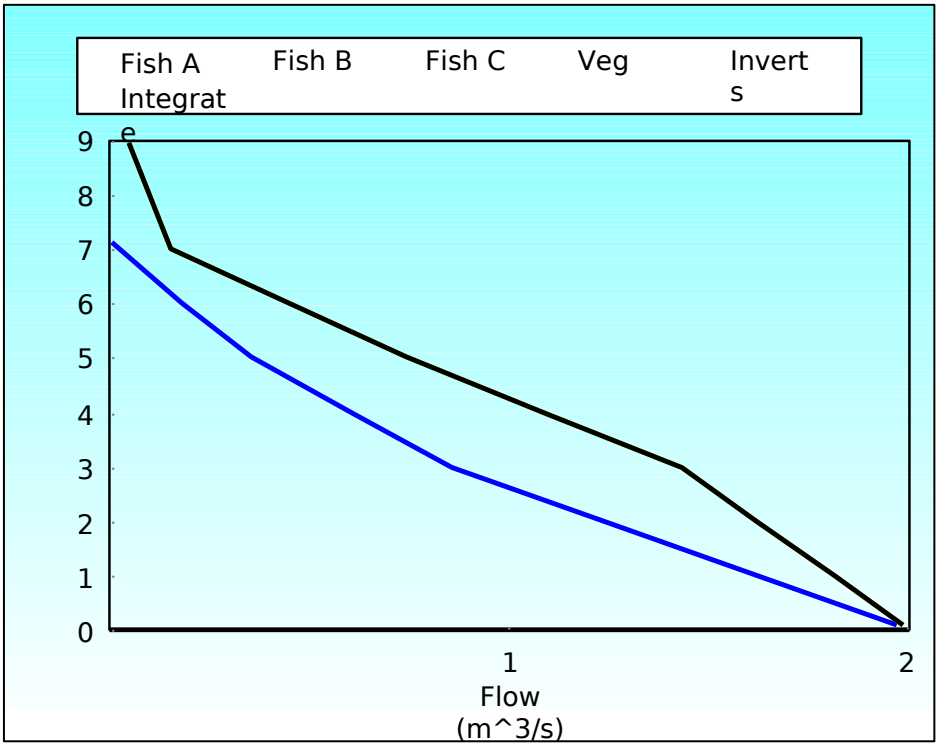


Figure 5-23: Final integrated stress curve for the Tsomo EWR site (TSOM01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-24** and **Figure 5-25** below. The adjustments made to the DRM results are as follows:

Increase July drought flows from 0.120 m^3/s to 0.214 m^3/s.

Increase March maintenance low flows from 0.674 m^3/s to 1.116 m^3/s.

The 'High flow shape' for the months March and November was adjusted to 7 and for December to February to 6.

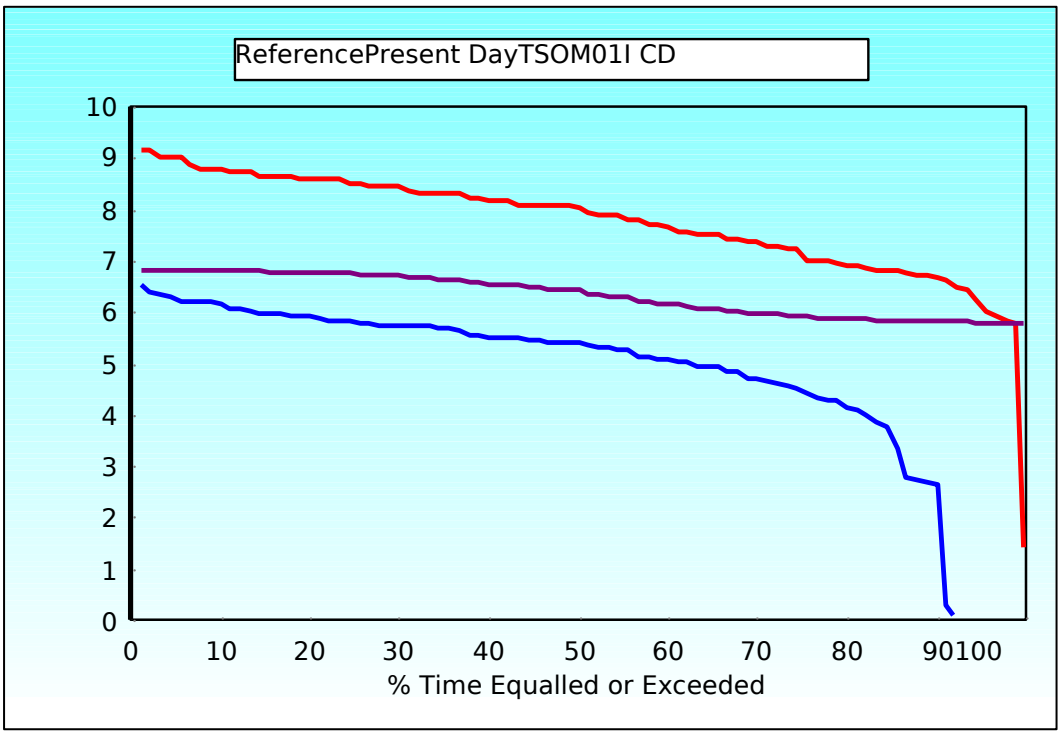


Figure 5-24: Final stress duration curves – dry season (July).

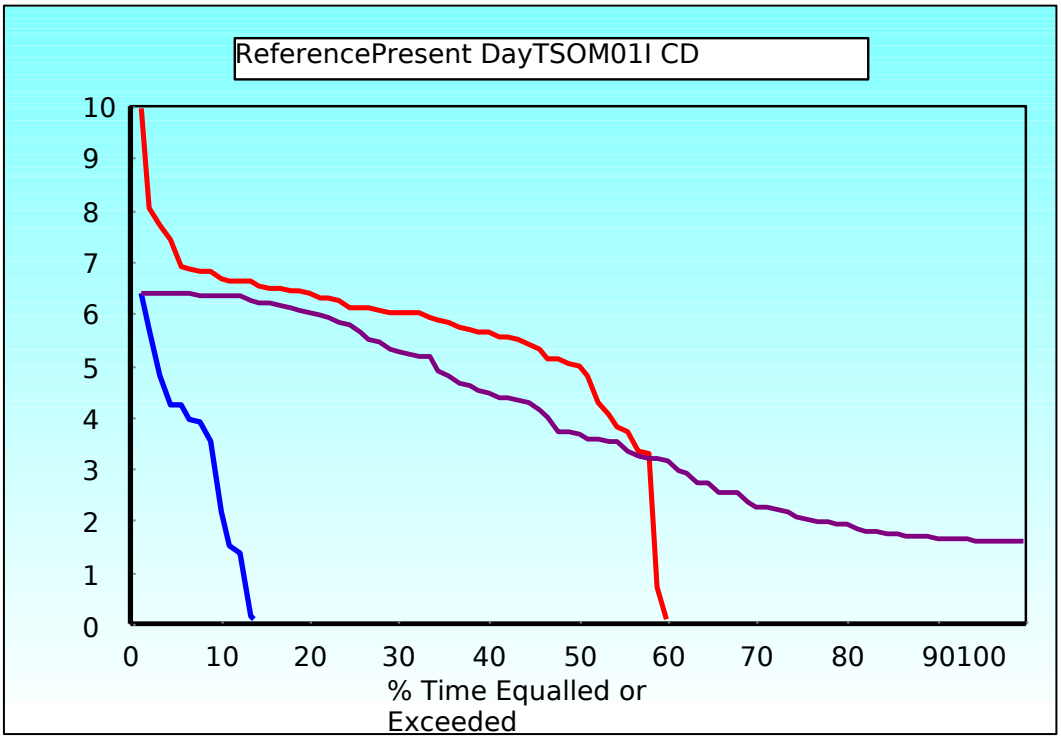


Figure 5-25: Final stress duration curves – wet season (March).

The flood requirements for the Tsomo EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-14**. The detailed requirements and motivations per component are presented in **Appendix A.**

Table 5-14: Flood requirements for the Tsomo at the EWR site (TSOM01_I).

Floods	Flood size (range)	FINAL
Class 1 (8-20 m^3/s)	m^3/s	10 (20)
	# days	5
	Months	Sep, Oct, Apr (Dec, Jan, Feb)
	Type	Daily average
Class 2 (30-40 m^3/s)	m^3/s	35
	# days	4
	Months	Nov, Jan, Feb
	Type	Daily average
Class 3 (80 m^3/s)	m^3/s	80
	# days	5
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in Table 5-15.

Table 5-15: Tsomo - Summary of the EWR results (flows in Mm^3 per annum)

Quaternary Catchment	S50G
Site name	TSOM01_I
River	Tsomo
EWR Site Co-ordinates	-32.045; 27.822
Recommended Ecological Category	C/D
nMAR at EWR site	196.7
Total EWR	73.744 (37.48 %MAR)
Maintenance Low flows	19.882 (10.11 %MAR)
Drought Low flows	8.340 (4.24 %MAR)
Maintenance High flows	53.862 (27.38 %MAR)
Overall confidence	Moderate to high

5.6 BUFF01_I: Middle Buffalo River

Sample Date	16 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	BUFF01_I	**IUA**	IUA_R02
River	Buffalo	**IUA description**	Buffalo/ Nahoon
Altitude (m.a.s.l.)	162	**Prioritised RU**	R_RU10_I
Latitude	-32.99151874	**Longitude**	27.64057286
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**R20F**
Level 2 EcoRegion	31.02	**SQ Reach**	R20F-08045
Geomorphological zone	E (slope 0.004)	**PES (DWS, 2014)**	D
Ecological Importance	High	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-26) **AND SITE PHOTOGRAPHS** (Figure 5-27)

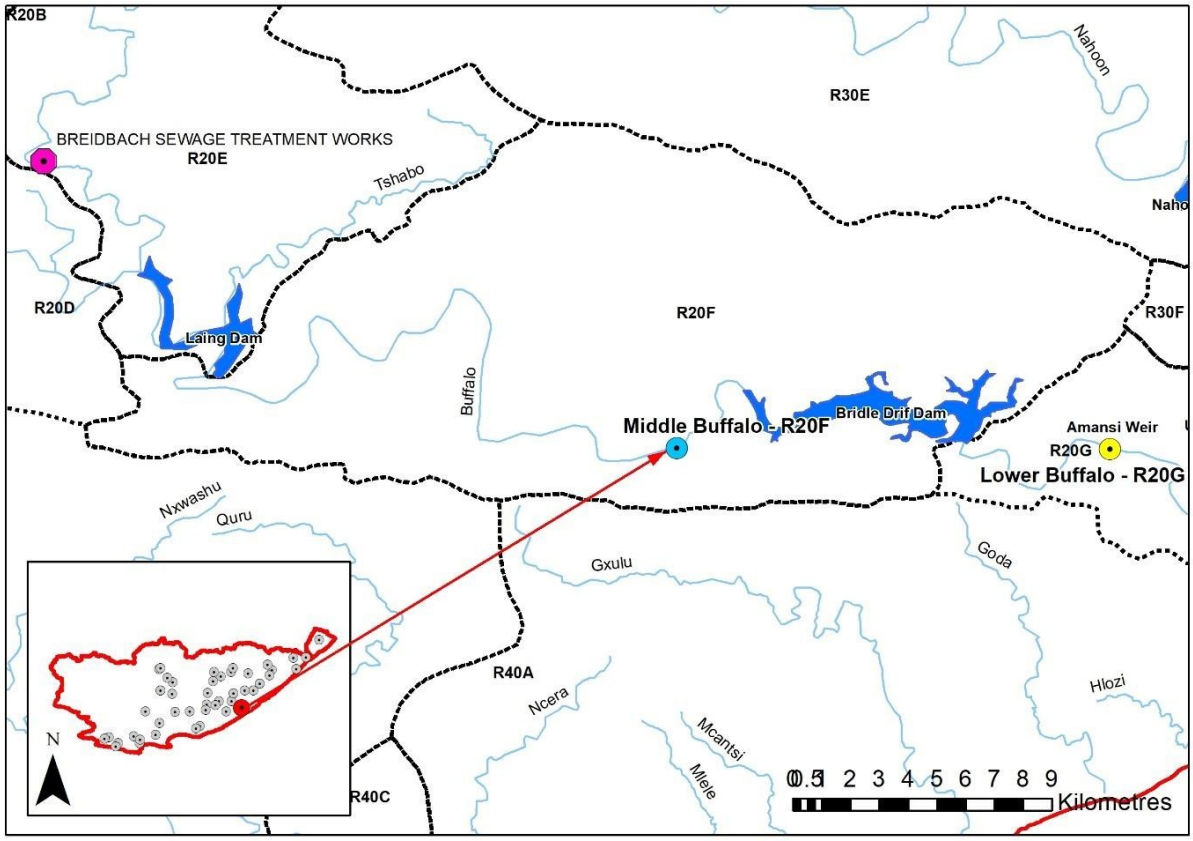


Figure 5-26: Location of site BUFF01_I (Middle Buffalo) in relation to the study area.
(pink icon indicates a WWTW and the yellow dot a Rapid 3 EWR site)

Figure 5-27: Site photographs of the Middle Buffalo EWR site.

The EWR for the Middle Buffalo River was determined for a REC of a D and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Tsomo River were Hydropschyidae (Tube case netspinning caddisfly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Biotope availability within the Middle Buffalo River comprised SIC (including boulders), SOOC and GSM. Marginal vegetation was limited due to eroded and undercut banks. Varying hydraulic features at this site as well and a large weir just upstream of the site. The Hydropschyidae was recorded during both surveys, including being dominated by the Simuliidae outbreak in September 2022 although subsequently being scoured and re-set from the floods in February 2023. During previous REMP sampling, Hydropschyidae have also been recorded along this reach. Consequently, the indicator taxon selected for this site is Hydropschyidae, being a flow dependent taxon. They have a high preference for fast currents of >0.6 m/s, although optimal speeds are approximately 0.4 m/s, along cobble substrate. Their greatest response to depth is between 15 and 40 cm. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the FCS and VFCS. The Hydropschyidae family further tolerate a wide fluctuation in water quality.

Fish: Although various fish species present, no true rheophilics expected. In addtion, the site is located immediately below a weir and upstream of a large dam (Bridle Drift Dam) that will limit movement from downstream reaches as well as result in a species assemblage that is able to tolerate no-flow or limited flow conditions. As such, the large semi-rheophilic *Anguilla mossambica* was selected as an indicator species. The species inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-deep, slow-deep and fast-shallow (including fast-intermediate). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (40-60

mm), with upstream

migration taking place during high-flow period and during receding limb of freshets and floods. Althought Bridle Drift Dam would impact upstream migration and create an energy burden for extensive upstream migration, the presence of smaller *Anguilla mossambica* cohorts at the site does indicate that at least some individuals are able to migrate over the dam wall (likely with great effort).

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 60th percentile for March (0.865 m^3/s) and a minimum dry flow or 95th percentile for June (0.234 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats and velocities. The selected stress values and associated flows are provided in **Table 5-16** and the final integrated stress curve is shown in **Figure 5-28**.

Table 5-16: Selected stress values, flows and rationale for the Middle Buffalo EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	0.817	The 0.817 m^3/s was the selected maxium natural Baseflow for this site (70% percentile) in accordance to the hydrology. Thus the stress of 0 was based on this. Critical habitats along the cross section at a discharge of 0.817 m^3/s was selected for 0 stress as there is 11% FCS, although 2% of the VFCS. However, this is the nature of this system, highly stressed, high abstraction and water use, along with highly compromised water quaity. However, the maximim velocities of 0.6 m/s is suitable for the indicator taxon selected for this site, as well as the maximum depth of 54 cm. The average flow velocity is 0.2 m/s although maximum velocity is 0.6 m/s, thus suitable for Hydropsychidae to occur on the cobbles biotope. The average depth is 30cm and the wetted perimeter 15 m of the full cross-section.	0.817	The 0.817 m^3/s was the selected maxium natural Baseflow for this site in accordance to the hydrology. Thus the stress of 0 was based on this. Critical habitats from a fish perspective provides a good representation of a variety of fast- flowing habitat, with the greatest extent being fast-deep class with a total extent of fast-flowing water noted at 2.52 m (of which fast- shallow and fast-intermediate extent is 1.04 m).
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	0.591	The velocity is moderate at 0.2 m/s on average to a maximum of 0.5 m/s, thus still suitable for Hydropschyidae to persist.	0.312	Critical habitat reduced, with fast-flowing water extent at 1.08 m, with fast-shallow and fast-intermediate exent being 0.84 m.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		However, the VFCS critical habitat has reduced to 1% and thus reduced critical quality.		
4		No assessment undertaken		No assessment undertaken
5	0.163	The critical habitat are reduced with moderate to low quality (7% and 0% for VFCS and FCS respectively). Maximum depth is 30 cm, with average depth at 15 cm, thus on the boundary of the depth preferences for this indicator taxon. The wetted perimeter has further reduced to 9 m of the cross section, and the average and maximum velocities are 0.1 m/s and 0.4 m/s respectivley. Therefore, the average velocity is below the preferences of the indicator taxon. Thus a level of stress will set in at these flows for the indicator taxon.	0.178	Loss of fast-deep habitat, with fast-shallow and fast-intermediate now at 0.58 m in extent across cross-section.
6		No assessment undertaken		No assessment undertaken
7	0.034	No critical habitat available at this discharge of 0.034 m^3/s. Thus tvery shallow habitat (average depth of 9 cm) and an average velocity of 0.08m/s. This will not support the Hydopsychidae family and their abundances will diminish. Habitat quality is expected to deteriorate at this measurement. A more resilient invertebrate community will colonise instead.	0.029	No critical habtiat remaining, with only slow-shallow and slow-very shallow habitat present, with maximum depth being 0.16 m and an average depth of 0.09 m. Velocities insufficient to allow for migration of fish over weir.
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	Only hyperheic refugia present, thus not supportive of fish.

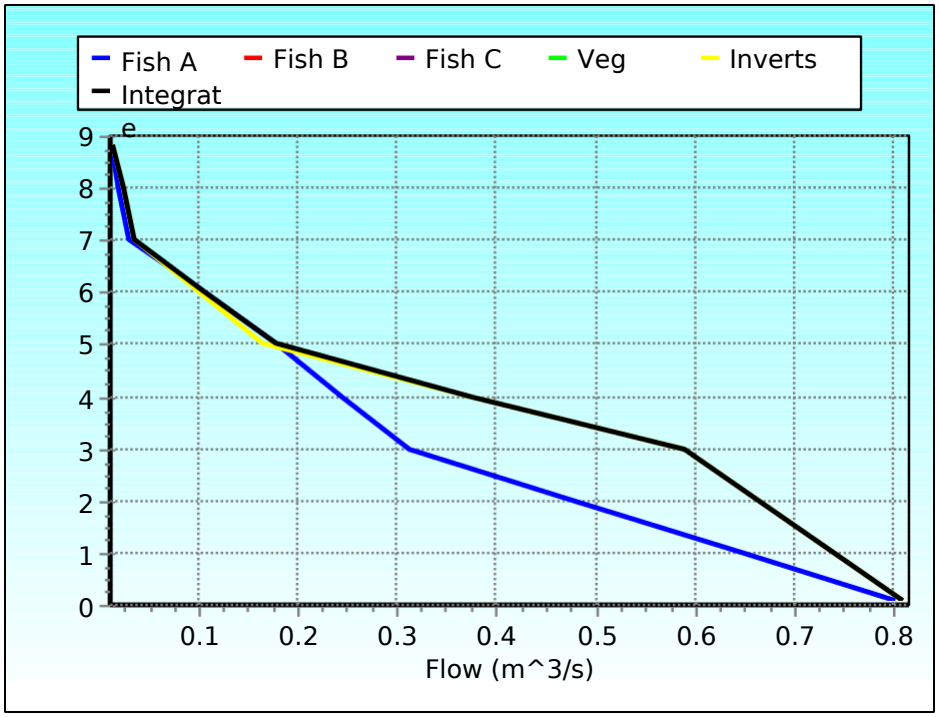


Figure 5-28: Final integrated stress curve for the Middle Buffalo EWR site (BUFF01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (June) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-29** and **Figure 5-30** below. The adjustments made to the DRM results are as follows:

Increase June drought flows from 0.086 m^3/s to 0.147 m^3/s.

Increase March maintenance low flows from 0.120 m^3/s to 0.505 m^3/s.

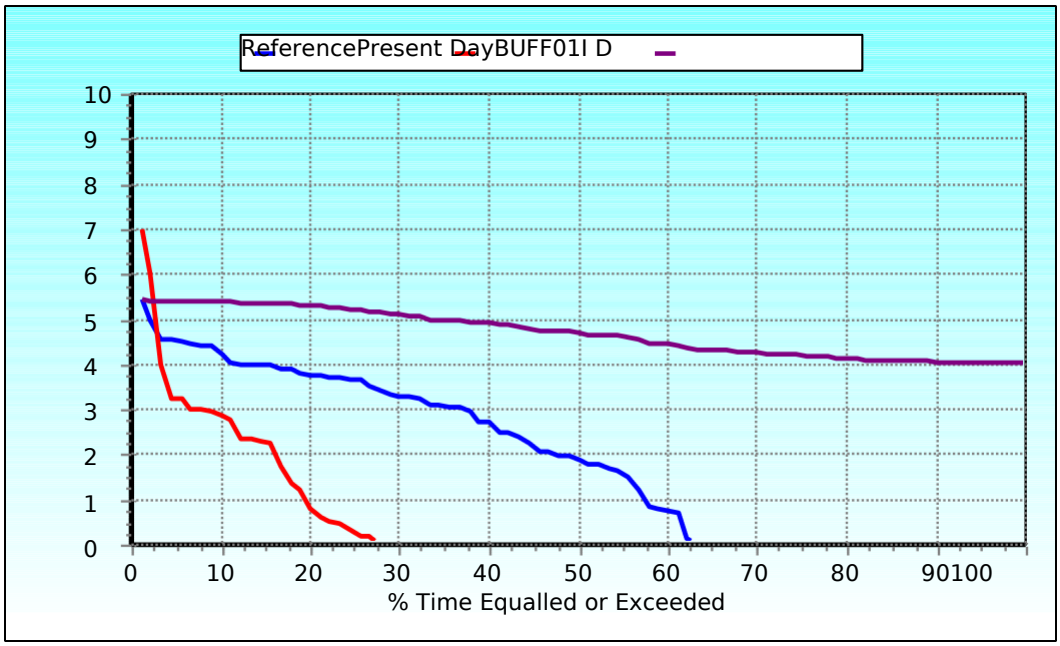


Figure 5-29: Final stress duration curves – dry season (June).

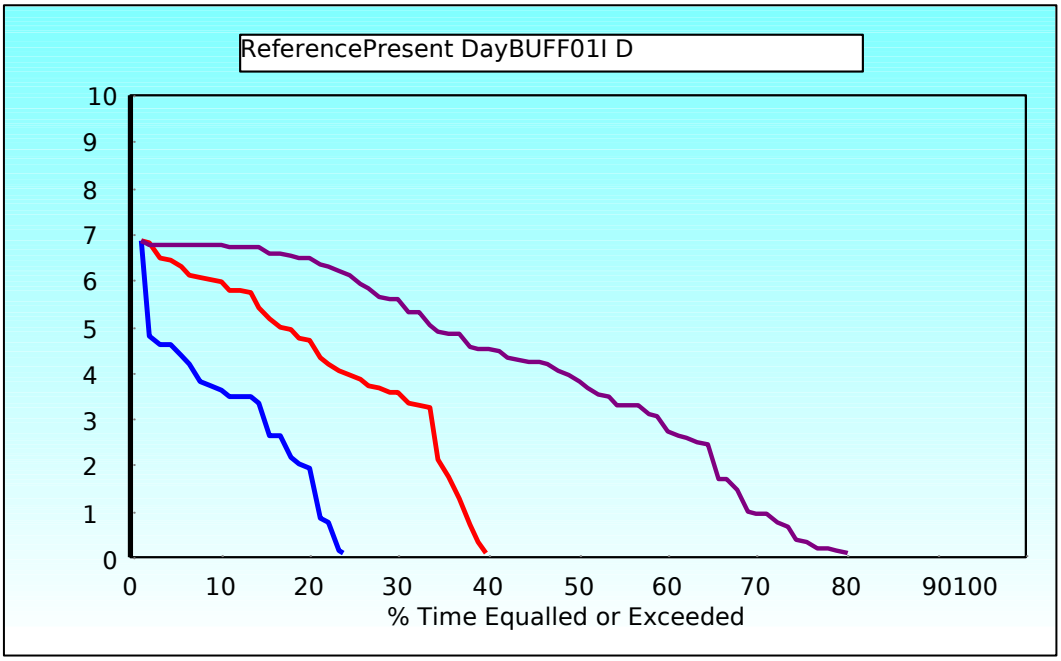


Figure 5-30: Final stress duration curves – wet season (March).

The flood requirements for the Middle Buffalo EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-17**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-17: Flood requirements for the Middle Buffalo at the EWR site (BUFF01_I).

Floods	Flood size (range)	FINAL
Class 1 (0-5.5 m^3/s)	m^3/s	4
	# days	4
	Months	Oct, Dec, Jan, Apr
	Type	Daily average
Class 2 (10-30 m^3/s)	m^3/s	20
	# days	3
	Months	Nov, Feb
	Type	Daily average
Class 3 (80-100 m^3/s)	m^3/s	40
	# days	3
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in Table 5-18.

Table 5-18: Middle Buffalo - Summary of the EWR results (flows in Mm^3 per annum)

Quaternary Catchment	R20F
Site name	BUFF01_I
River	Middle Buffalo
EWR Site Co-ordinates	-32.992; 27.641
Recommended Ecological Category	D
nMAR at EWR site	83.8
Total EWR	28.866 (34.46 %MAR)
Maintenance Low flows	13.521 (16.14 %MAR)
Drought Low flows	4.621 (5.52 %MAR)
Maintenance High flows	15.345 (18.32 %MAR)
Overall confidence	Moderate to high

5.7 KEIS01_I: Upper Keiskamma River

Sample Date	13 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	KEIS01_I	**IUA**	IUA_R01
River	Keiskamma	**IUA description**	Keiskamma
Altitude (m.a.s.l.)	437m	**Prioritised RU**	R_RU09_I
Latitude	-32.80233328	**Longitude**	27.02430956
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**R10E**
Level 2 EcoRegion	18.02	**SQ Reach**	R10E-07844
Geomorphological zone	E (0.002)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-31) AND SITE PHOTOGRAPHS (Figure 5-32)

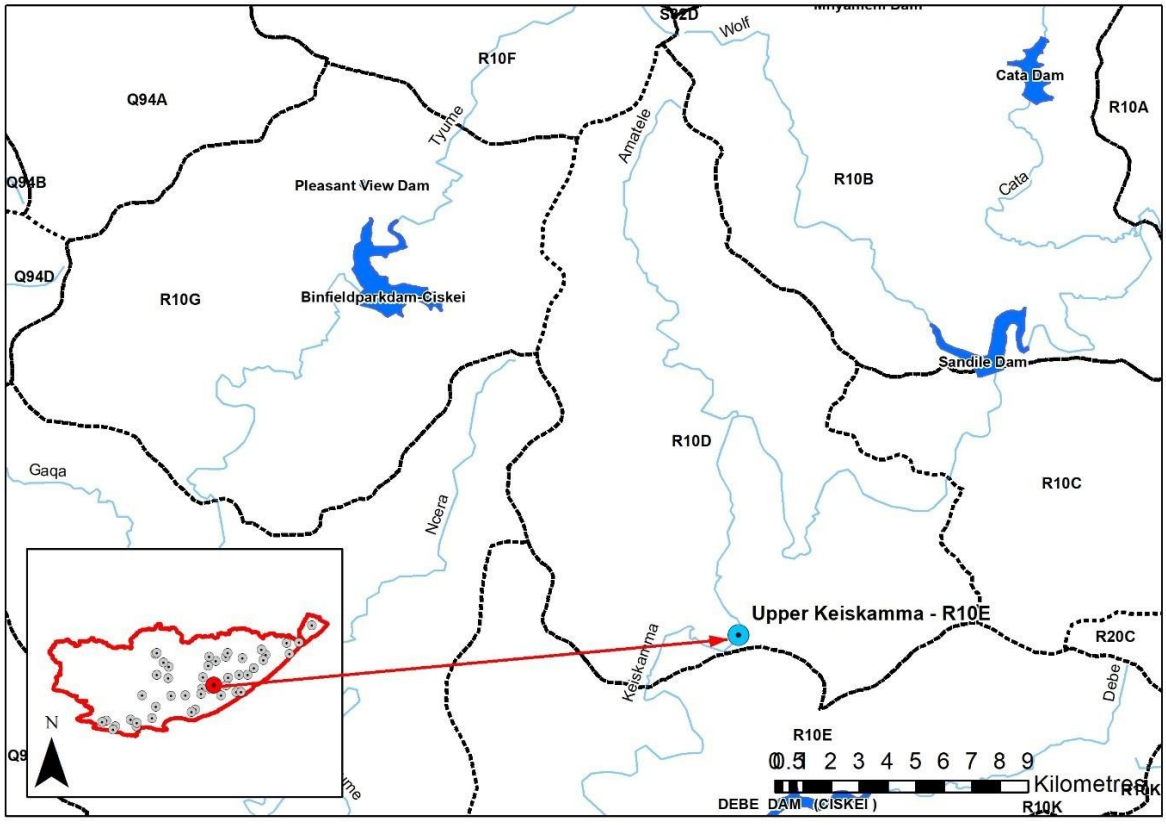


Figure 5-31: Location of site KEIS01_I (Upper Keiskamma) in relation to the study area.

Site Photographs: Survey 1 (September 2022)

Figure 5-32: Site photographs of the Upper Keiskamma EWR site.

The EWR for the Upper Keiskamma River was determined for a REC of a D and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Upper Keiskamma River were Heptageniidae (Flathead mayfly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: A diversity of good availability of biotopes (SIC, SOOC, GSM and marginal and overhanging vegetation) were present for macroinvertebrates at this site on the upper Keiskamma. Heptageniidae were recorded in B abundances during the May 2023 survey, but not during the September 2022 survey, although are part of the reference list. They are further not often recorded at the downstream REMP site, however lower downstream site is primarily driven by severe water quality issues because of sewage inputs from the town of Alice, thus the absence of this indicator and sensitive taxon. Nonetheless, Heptageniidae have been identified to be the indicator taxon for this upstream selected EWR site, as they are a flow dependent taxon. Heptageniidae are widespread throughout the catchment and wider throughout South Africa. They have a high preference for moderate to fast flowing water (0.1 - 0.3 and 0.3 - 0.6 m/s respectively) over the cobble biotope. Their preferred water depths are 10 - 30 cm depth range. In addition, although Perlidae were not recorded, they do form part of the reference conditions and have previously been recorded within the same Ecoregion Level 2 and which are also flow dependent taxon and very sensitive to water quality changes. They prefer cobbles and high velocities of >0.6 m/s (VFCS), although they appear to be optimal at flows between 0.3 and 0.6 m/s. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS.

Fish: Although various fish species present, no true rheophilics expected. Two species with preferences for fast flowing water expected, namely *Anguilla mossambica* and *Amatolacypris*

trevelyani (Border Barb). *Amatolacypris trevelyani* has a broad habitat preference, with the species occurring in pools and riffles and breeding in spring/early summer. Habitat preference for the species is regarded as high for fast-shallow, fast-intermediate, and fast-deep. *Anguilla mossambica* inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-shallow (medium preference), fast-intermediate (high preference), fast-deep (very high preference). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus, critical life stage regarded as elvers (60-120 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods. As such, the large semi-rheophilic *Anguilla mossambica* was selected as an indicator species. Althought sewage input from downstream area is expected to discourage upstream migration, the presence of *Anguilla mossambica* cohorts at the site does indicate that at least some individuals do migrate into the reach. Critical habitat for *Amatolacypris trevelyani* still considered.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 40th percentile for March (0.983 m^3/s) and a minimum dry flow or 95th percentile for July (0.356 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats, and velocities. The selected stress values and associated flows are provided in **Table 5-19** and the final integrated stress curve is shown in **Figure 5-33**.

Table 5-19: Selected stress values, flows and rationale for the Upper Keiskamma EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	0.93	The 0.983 m^3/s was the selected maxium natural Baseflow for this site (40% percentile) in accordance with the hydrology. Thus, the stress of 0 was based on this. Critical habitats along the cross section at a discharge of 0.93 m^3/s was selected for 0 stress as there is 37%, 26% and 5% of SCS, FCS and VFCS respectively.The average and maximum velocities are 0.25 m/s and 0.8 m/s respectively, thus within the indicator taxons preference range for velocity and will occur in high abundances within the cobble biotope, barring the water quality is not compromised. The average and maximum depth is 26 cm and 34 cm, also withn the depth range, with a wetted perimeter of 15 m.	0.93	All critical habitat available, with fast-deep class most abundant (2.18 m/15% of cross section), with fast-intermediate class also prevalent (1.89 m/13% of cross section). Fast-shallow present in relevatively small proportions.

1		No assessment undertaken		No assessment undertaken

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
2		No assessment undertaken		No assessment undertaken
3	0.736	The FCS critical habitat has slightly reduced from 26% at a stress of 0 to 20% at a stress of 3, with the discharge measured at 0.7 m^3/s along the cross section. However, the average and maximum velocities remain within the preference range for Heptageniidae's. They will still be present in high abundances, barring the water quality is not compromised.	0.622	Loss of fast-deep class, but fast-intermediate (2.2 m width) and fast-shallow (0.69 m width) classes still present. Critical habitat still present that will support both *Anguilla mossambica* (high) and Amatolcypris trevelyani (high), with maximum velocity of 0.67 m/s and average velocity of 0.2 m/s.
4		No assessment undertaken		No assessment undertaken
5	0.309	The critical habitats of FCS and VFCS have reduced drastically, 50% compared to a stress of a 3, thus only 10% and 1% of FCS and VFCS available respectively. However, the SCS critical habitat for Heptageniidae continues to be preset and avaialble at 41% (0.1-0.3 m/s). The average and maximum velocity (0.1 m/s and 0.5 m/s respectively) have also reduced, compromising the quality and availability of the critical habitat for the indicator taxon.	0.275	Loss of fast-intermediate class, with only fast-shallow class remaining across 1.14 m width. Medium preference for *Anguilla mossambica* but still high preference for *Amatolacyrpis trevelyani*. Maxiumum velocity of 0.48 m/s and average velocity of 0.14 m/s with sufficient depth (0.16 m average).
6		No assessment undertaken		No assessment undertaken
7	0.042	The VFCS and FCS critical habitat availabilit is zero at this discharge of 0.042 m^3/s. Thus, very shallow habitat (average depth of 7 cm) and an average velocity of 0.06 m/s. This will not support the Heptageniidae family, and their abundances will diminish. Habitat quality is expected to deteriorate at this measurement. A more resilient invertebrate community will colonise instead.	0.067	Loss of all fast-deep, fast-intermediate, and fast-shallow class across cross section, with *Anguilla mossambica* and *Amatolacypris trevelyani* only likely to be present wihtin the pools below and upstream of cross section. Movement between pools likely compromised.
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water, and no critical habitat (0% for FCS and VFCS, including other	0	Only hyperheic refugia present, thus not supportive of fish within cross section

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		habitats), pooled in-stream. Only specialists will persist.		

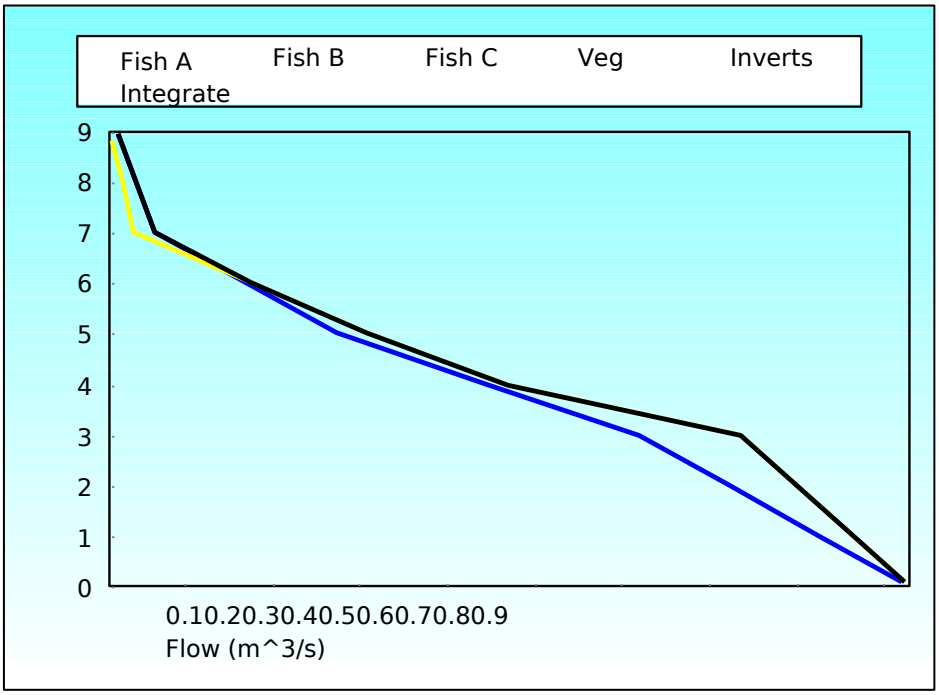


Figure 5-33: Final integrated stress curve for the Upper Keiskamma EWR site (KEIS01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-34** and **Figure 5-35** below. The adjustments made to the DRM results are as follows:

Increase July drought flows from 0.072 m^3/s to 0.147 m^3/s.

Increase March maintenance low flows from 0.121 m^3/s to 0.311 m^3/s.

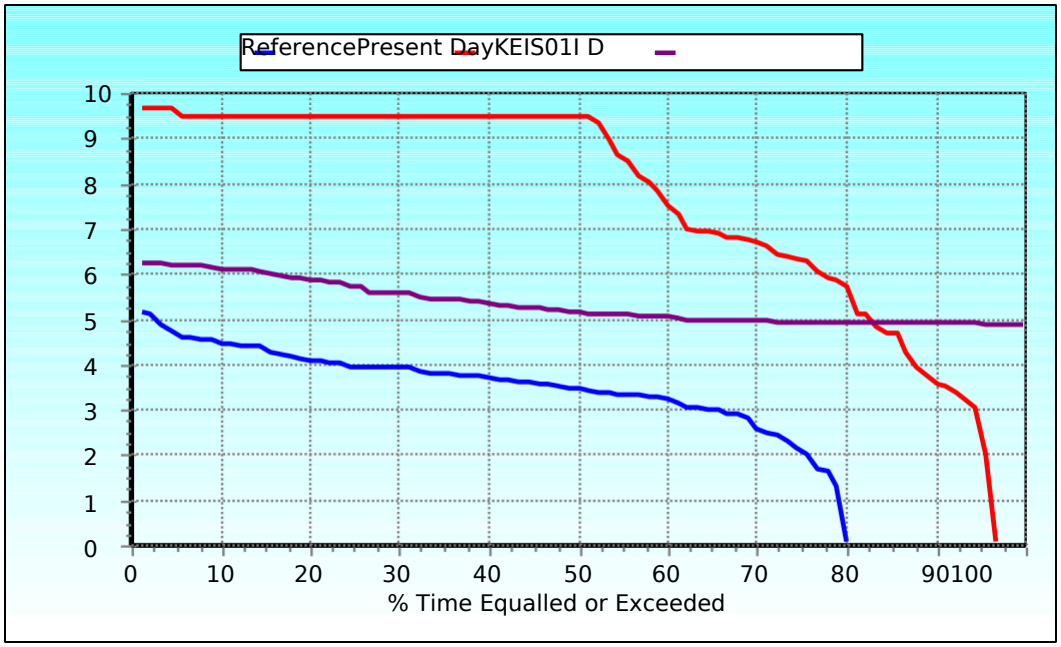


Figure 5-34: Final stress duration curves – dry season (July).

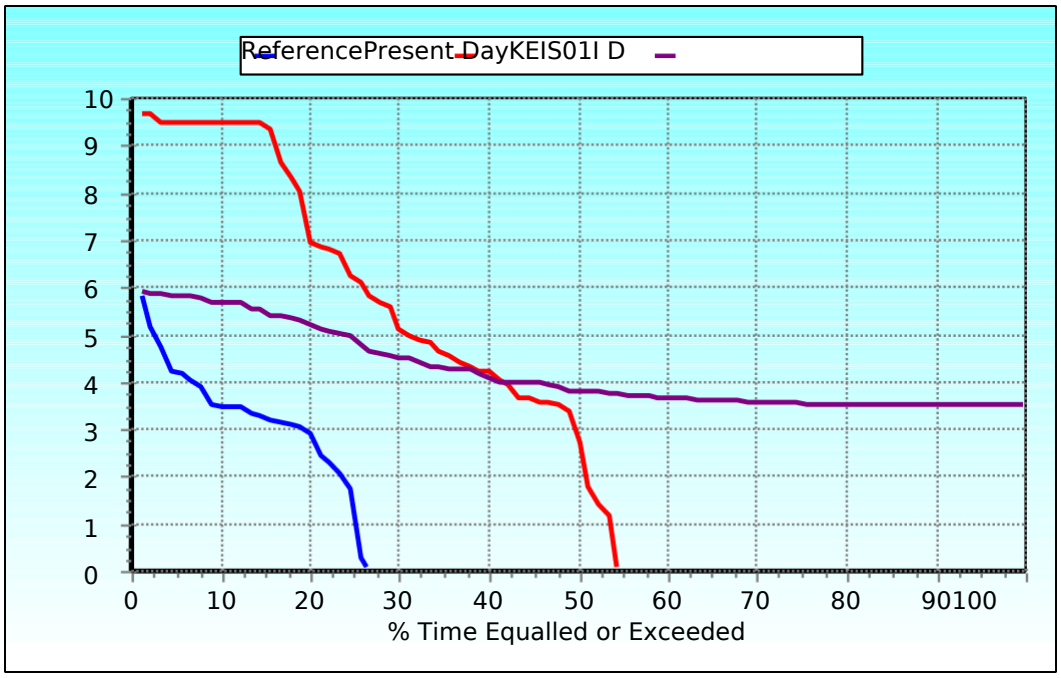


Figure 5-35: Final stress duration curves – wet season (March).

The flood requirements for the Upper Keiskamma EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised

in **Table 5-20**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-20: Flood requirements for the Upper Keiskamma at the EWR site (KEIS01_I).

Floods	Flood size (range)	FINAL
Class 1 (7-10 m^3/s)	m^3/s	5 (8)
	# days	3
	Months	Oct, Apr (Dec, Jan)
	Type	Daily average
Class 2 (11-25 m^3/s)	m^3/s	14
	# days	3
	Months	Nov, Feb
	Type	Daily average
Class 3 (25-35 m^3/s)	m^3/s	25
	# days	3
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in Table 5-21.

Table 5-21: Upper Keiskamma - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	R10D
Site name	KEIS01_I
River	Upper Keiskamma
EWR Site Co-ordinates	-32.80233; 27.02431
Recommended Ecological Category	D
nMAR at EWR site	58.8
Total EWR	20.158 (34.31 %MAR)
Maintenance Low flows	7.872 (13.40 %MAR)
Drought Low flows	5.990 (10.19 %MAR)
Maintenance High flows	12.286 (20.91 %MAR)
Overall confidence	High

5.8 KAT01_I: Upper Kat River

Sample Date	13 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	KAT01_I	**IUA**	IUA_Q03
River	Kat	**IUA description**	Koonap and Kat
Altitude (m.a.s.l.)	634	**Prioritised RU**	R_RU08_I
Latitude	-32.56964523	**Longitude**	26.72185233
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**Q94B**
Level 2 EcoRegion	18.02	**SQ Reach**	Q94B-07623
Geomorphological zone	D (slope 0.007)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	High

MAP ILLUSTRATION (Figure 5-36) AND SITE PHOTOGRAPHS (Figure 5-37)

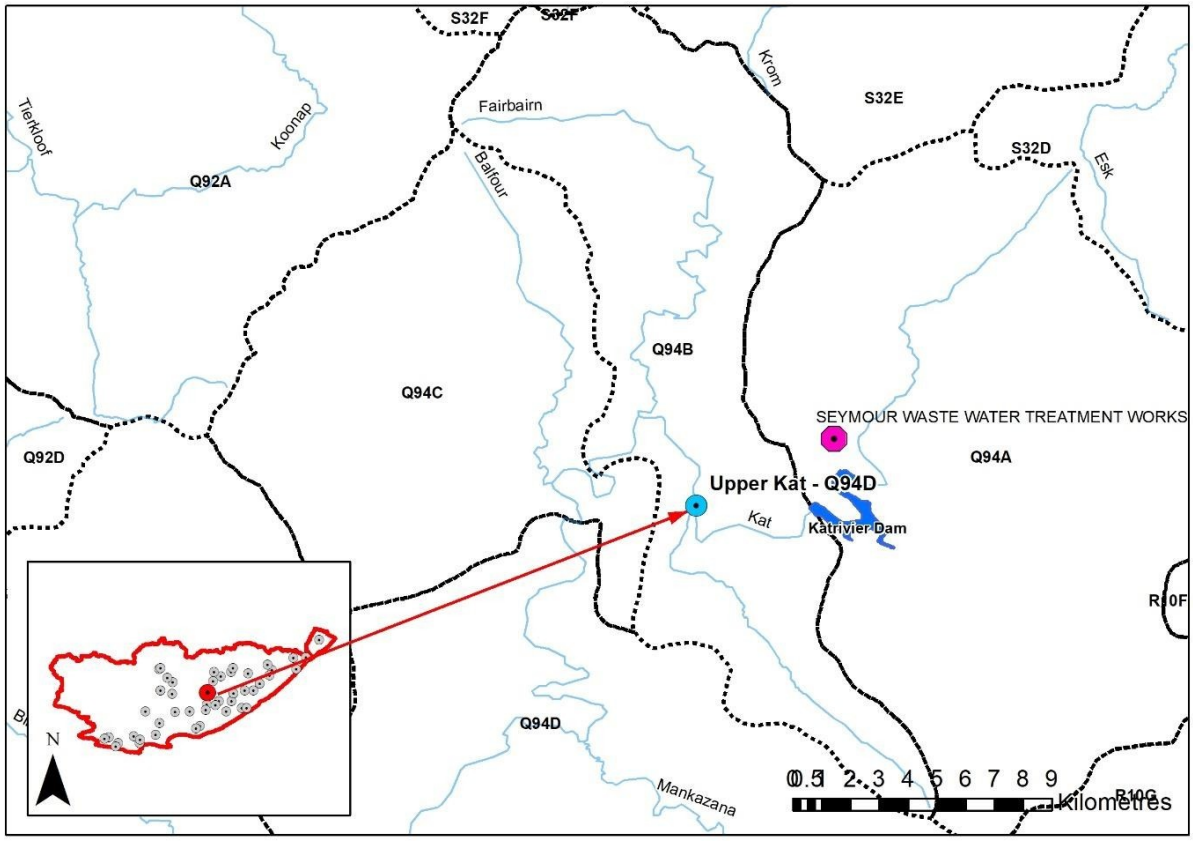


Figure 5-36: Location of site KAT01_I (Upper Kat) in relation to the study area.
(pink icon indicates a WWTW in relation to the EWR site)

Figure 5-37: Site photographs of the upper Kat EWR site.

The EWR for the Upper Kat River was determined for a REC of a B/C and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Upper Kat River were Heptageniidae (Flathead mayfly) and *Sandelia bainsii* (Eastern Cape Rocky, semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: A diversity of good availability of biotopes (SIC, SOOC, marginal vegetation and GSM) and hydraulic features were present for macroinvertebrates at this site on the Upper Kat, although the SIC biotope was dominated by large boulders. Heptageniidae were recorded in B abundances at this site during both surveys, including previously recorded during the REMP biomonitoring at this site. Therefore, Heptageniidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. Heptageniidae are widespread throughout the catchment and wider throughout South Africa. They have a high preference for moderate to fast flowing water (0.1 - 0.3 and 0.3 - 0.6 m/s respectively) over the cobbles biotope. Their preferred water depths are 10 - 30 cm depth range. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the SCS and FCS respectively. They are further are sensitive to any water quality change.

Fish: Of the five fish species expected to be present within the reach, only a single species, *Anguilla mossambica*, is classified as a semi-rheophilic species with a requirement for flowing water during part of its life-sycle. However, the site is close to the upper limit of the species migration ability, with multiple weirs within the various downstream reaches (for irrigiation purposes of the citrus industry) greatly limiting the ability of eels to migration into the upstream reaches. In addition, the presence of Kat River Dam upstream of the site will pose a final barrier for migration of eels into the extreme upper reaches of the catchment. The likelihood of *Anguilla mossambica* utilising the cross section for anything other than movement between deeper sections is unlikely. The remainder of the fish species present or expected to be present are regarded as limnophilic species with a very high

preference for the slow-deep class and a high preference for the slow-shallow class. Accordingly, no suitable indicator

species were identified. *Sandelia bainsii* (currently listed as Endangered) was nevertheless selected as an indicator in order for flows to facilitate movement between the inundated sections of the reach immediately downstream of the cross section to good qualiy habitat for the species upstream of the reach. Consideration is nevertheless given to the potential impact of flow on *Anguilla mossambica* in the assessment of stress. Fish are however unlikely to present a good indicator for flow management.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 40th percentile for March (0.330 m^3/s) and a minimum dry flow or 95th percentile for July (0.095 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats and velocities. The selected stress values and associated flows are provided in **Table 5-22** and the final integrated stress curve is shown in **Figure 5-38**.

Table 5-22: Selected stress values, flows and rationale for the Upper Kat EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	0.349	The 0.239 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance to the hydrology. Thus the stress of 0 was based on this. Critical habitats along the cross section for the Heptageniidae family at a discharge of 0.349 m^3/s was selected for 0 stress owing to both critical habitats available (36% and 13% for SCS and FCS respectively). The average flow velocity is 0.2 m/s and 0.6 m/s, suitable for this indicator taxon to occur on the cobbles biotope. The average depth is 19 cm and the wetted perimeter 10 m of the full cross-section.	0.308	Maximum baseflow during high flow periods. Value is likely slightly elevated due to revised baseline conditions.
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken

3	0.132	The SCS critical habitat for Heptageniidae has reduced to 31% and the FCS to 5% along the cross-section, although still plentiful for this taxon. The average and maximum velocity is 0.1 m/s and 0.4 m/s respecitvely, still within the velocity range for Heptegeniidae. The wetted perimeter is slightly reduced at 8 m of the cross section.	0.095	Loss of fast-intermediate class, with limited fast-shallow and fast-very shallow classes present. Slow-shallow velocity-depth class noted as the dominant class representing 68% of the cross section. Velocities and depth considered suitable to allow for movement of various species between deeper reaches.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
4		No assessment undertaken		No assessment undertaken
5	0.067	The FCS critical habitat availability has drastically reduced at only 1% remaining, although 23% of SCS is available. Thus the critial habitat is slowly reducing, along with the quality of these habitats. The average depth of 11 cm and a maximim velocity of 0.25 m/s is falling below this indicator taxons preferences, and thus the habitat is becoming limiting for the indicator taxon at these variables.	0.004	Slow-shallow veloity-depth class residual, with only 0.4m of the wetted perimeter represented with the remainder of the cross sectional area being slow-very shallow. Flow likely to present a limiting factor for movement of species between reaches.
6		No assessment undertaken		No assessment undertaken
7	0.004	The SCS and FCS critical habitat availabilit is 1% and 0% respectively at this discharge of 0.04 m^3/s. Thus very shallow habitat (average depth of 4cm) and an average velocity of 0.01 m/s. This will not support the Heptageniidae family and their abundances will diminish as biotopes are completely exposed. Habitat quality is expected to deteriorate at this measurement. A more resilient invertebrate community will colonise instead.	0.002	Wetted perimeter greatly reduced, with loss of slow-shallow velocity-depth class. Flow likely to present a limiting factor for movement of species between reaches.
8		No assessment undertaken		No assessment undertaken
9	0	Discharge 0 m^3/s, thus no critical habitat.		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	Only hyperheic refugia present, thus not supportive of fish within cross section.

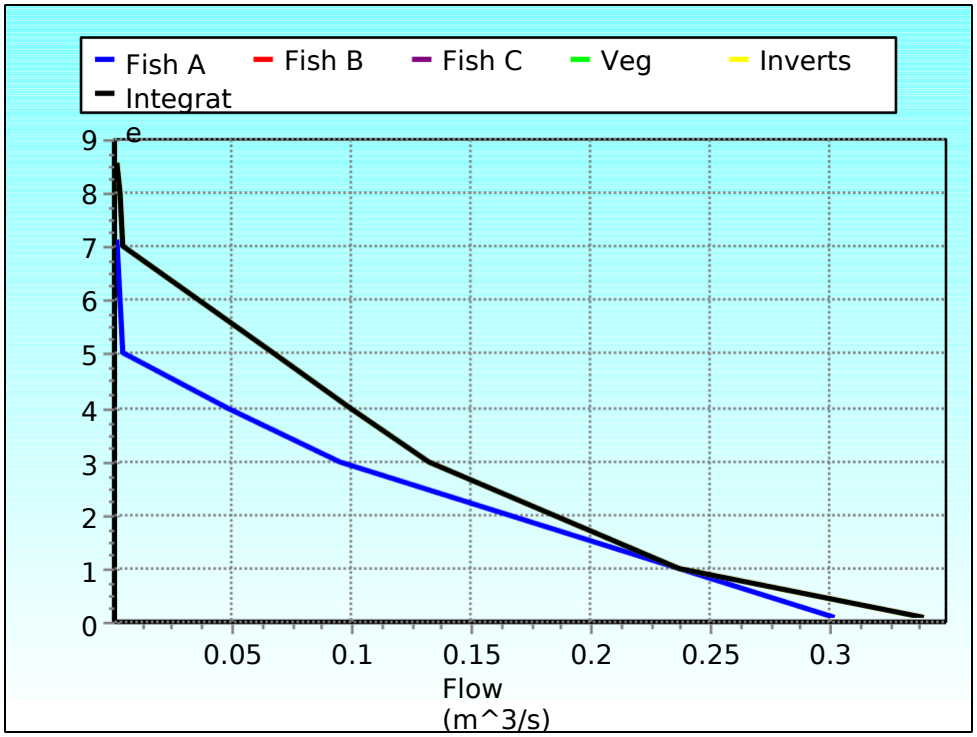


Figure 5-38: Final integrated stress curve for the Upper Kat EWR site (KAT01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-39** and **Figure 5-40** below. The adjustments made to the DRM results are as follows:

Increase March maintenance low flows from 0.145 m^3/s to 0.244 m^3/s.

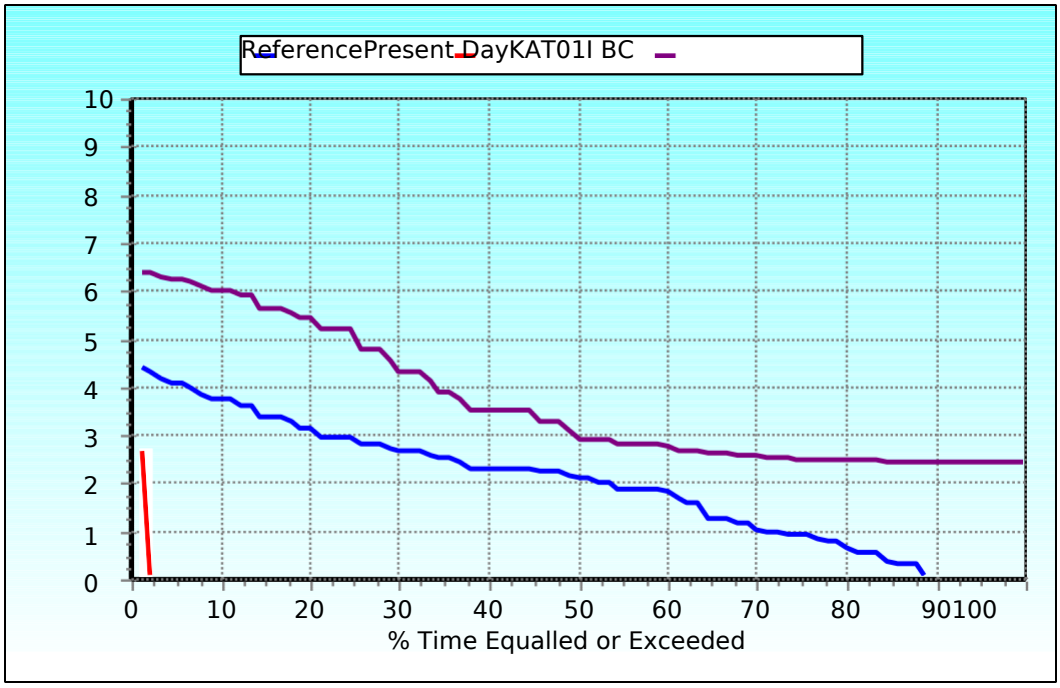


Figure 5-39: Final stress duration curves – dry season (July).

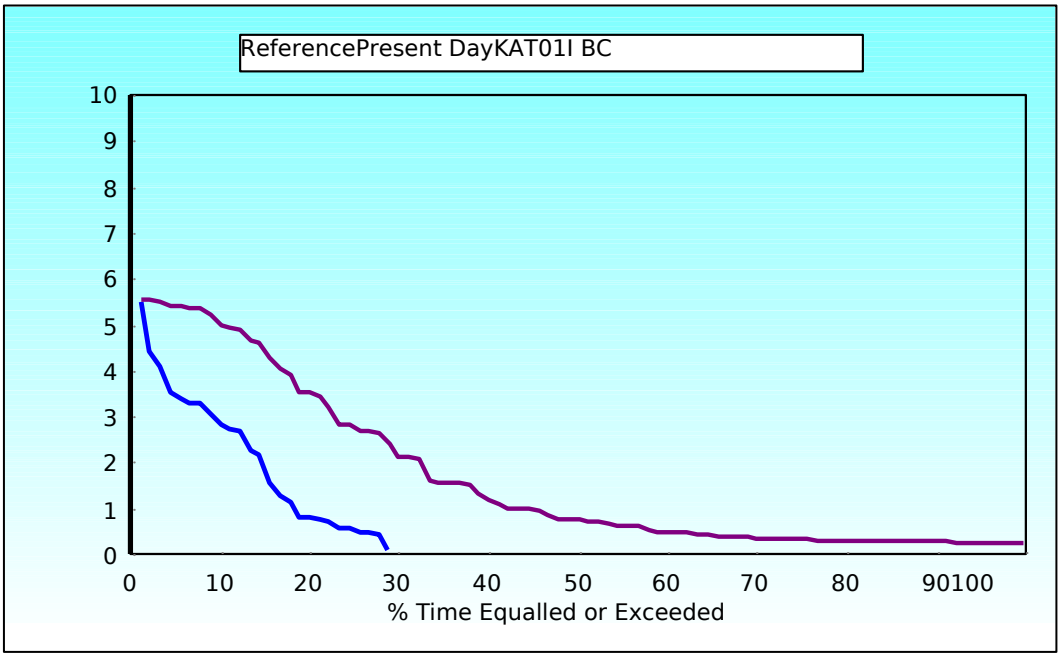


Figure 5-40: Final stress duration curves – wet season (March).

The flood requirements for the Upper Kat EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-23**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-23: Flood requirements for the Upper Kat at the EWR site (KAT01_I).

Floods	Flood size (range)	FINAL
Class 1 (0-4 m^3/s)	m^3/s	2 (2.5)
	# days	3
	Months	Oct, Apr (Dec, Jan)
	Type	Daily average
Class 2 (5-12 m^3/s)	m^3/s	6
	# days	3
	Months	Nov, Feb
	Type	Daily average
Class 3 (20-25 m^3/s)	m^3/s	10
	# days	3
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in Table 5-24.

Table 5-24: Upper Kat - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q94B
Site name	KAT01_I
River	Upper Kat
EWR Site Co-ordinates	-32.5696; 26.7218
Recommended Ecological Category	B/C
nMAR at EWR site	23.9
Total EWR	10.413 (43.53 %MAR)
Maintenance Low flows	5.592 (23.38 %MAR)
Drought Low flows	1.069 (4.47 %MAR)
Maintenance High flows	4.821 (20.15 %MAR)
Overall confidence	High

5.9 FISH03_I: Lower Great Fish River

Sample Date	20 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	FISH03_I	**IUA**	IUA_Q02
River	Great Fish	**IUA description**	Great Fish
Altitude (m.a.s.l.)	375m	**Prioritised RU**	R_RU06_I
Latitude	-33.08373323	**Longitude**	26.22527359
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**Q91B**
Level 2 EcoRegion	18.02	**SQ Reach**	Q91B-08144
Geomorphological zone	E (slope 0.001)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-41) AND SITE PHOTOGRAPHS (Figure 5-42)

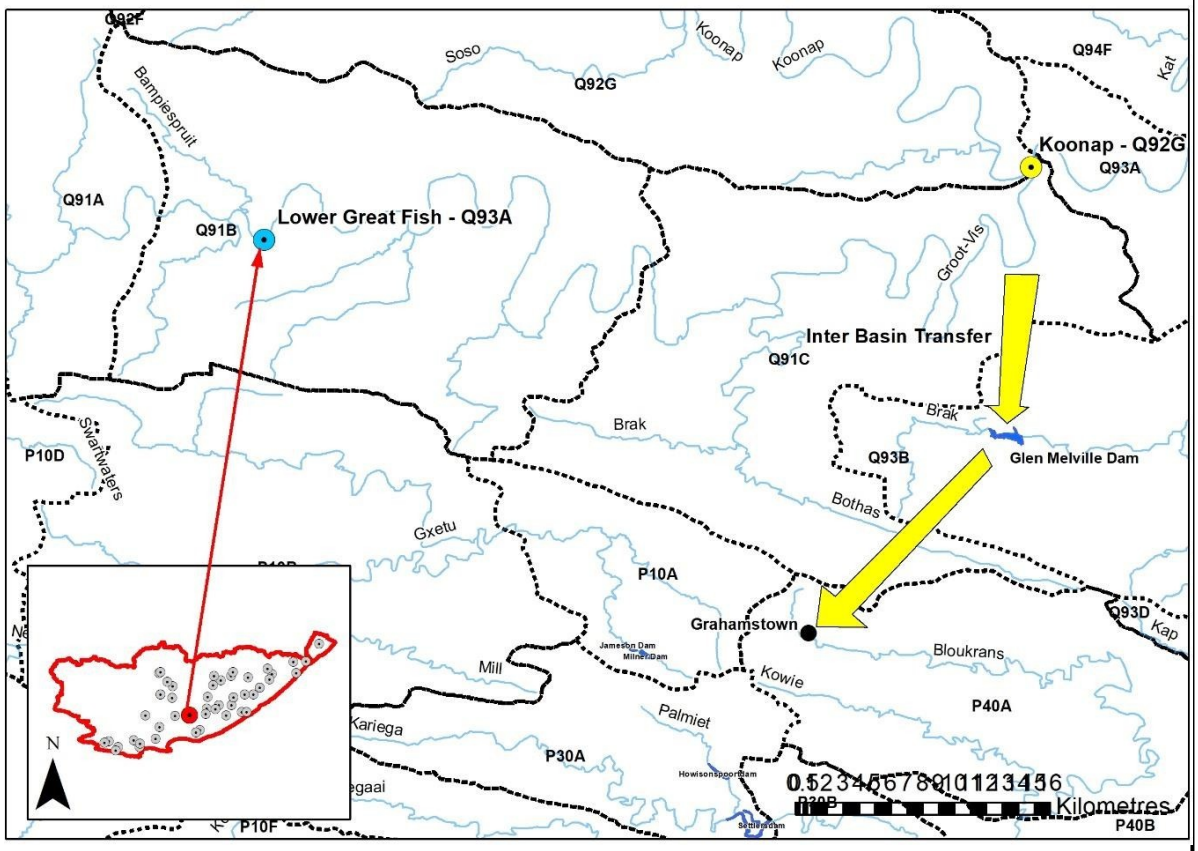


Figure 5-41: Location of site FISH03_I (Lower Great Fish) in relation to the study area.
(yellow dot represents a Rapid 3 EWR site. The yellow arrows represents the IBT)

Figure 5-42: Site photographs of the lower Great Fish EWR site.

The EWR for the Lower Great Fish River was determined for a REC of a C and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Lower Great Fish River were Perlidae (Stonefly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: Biotope availability within the Lower Great Fish for macroinvertebrates included SIC, boulders, SOOC, GSM and marginal vegetation (although wood species). Perlidae were recorded in abundances at this site during both surveys. Therefore, Perlidae have been identified to be the indicator taxon for this reach, as they are a flow dependent taxon. They have a preference for cobbles and high velocities of >0.6 m/s, although appear optimally at flows between 0.3 and 0.6 m/s. If flows fall below this target, Perlidaes will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS. They are further very sensitive to any water quality change.

Fish: Although various fish species present, no true rheophilics expected. Various eel species expected under natural conditions, with the only species with a preference for fast flowing water being *Anguilla mossambica*. *Anguilla mossambica* inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-shallow (medium preference), fast-intermediate (high preference), fast-deep (very high preference). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus critical life stage regarded as elvers (60-120 mm), with upstream migration taking place during high-flow period and during receding limb of freshets and floods. As such, the semi-rheophilic *Anguilla mossambica* was selected as an indicator species. Consideration was also given to *Labeo umbratus* (Moggel) juveniles which are known to exhibit a distinct preference for flowing water, with the migration of juveniles probably having evolved to optimise feeding, to avoid unfavourable conditions and

possibly to promote

colonisation (Cambray, 1990). The remainder of the fish species present or expected to be present were considered to be eurytopic or lymnophilic. A significant driver of the system was however the presence of large non-native fish species within the system, having been translocated from the Orange River system (i.e. *Labeobarbus aeneus*, *Labeo capensis* - Orange River Mudfish, *Clarias gariepinus* – African Sharptooth Catfish).

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 60th percentile for March (2.693 m^3/s) and a minimum dry flow or 95th percentile for July (0.655 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats and velocities. The selected stress values and associated flows are provided in **Table 5-25** and the final integrated stress curve is shown in **Figure 5-43**.

Table 5-25: Selected stress values, flows and rationale for the Lower Great Fish EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	2.693	The 2.694 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance to the hydrology. Thus the stress of 0 was based on this. Critical habitats along the cross section for the Perlidae family at a discharge of 3.01 m^3/s was selected for 0 stress owing to both critical habitats available (26% and 33% for FCS and VFCS respectively) being in excess and high quality. The average and maximum velocities are suitable for Perlidae measuring 0.5 m/s and 1.6 m/s respectively and the wetted perimeter being 16 m of the cross section.	2.693	The 2.694 m^3/s was the selected maxium natural Baseflow for this site (60% percentile) in accordance to the hydrology. Critical habitat from a fish perspective include fast-deep (42%, or 6.76 m of cross section width), fast-intermediate (19%, or 3.06 m of cross section width) and fast-shallow (6%, or 0.97 m of cross section width), thus representing good velocity-depth classes for indicator species.
1		No assessment undertaken		No assessment undertaken
2	1.389	The critical habitat remains sufficient with 31% and 20% of the FCS and VFCS available respectively. The velocities remain within the preferences of this indicator taxon (average and maximum velocity being 0.4 m/s and 1.3 m/s respectively). The wetted perimeter remains wide at 15 m of the cross-section.		No assessment undertaken

3	0.88	The VFCS critical habitat has slightly reduced to 16% along the	1.229	Critical habitat remains well represented across various flow-

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		cross-section, although the FCS critical habitat remains plentiful. The velocities remain within the preferences of this indicator taxon (average and maximum velocity being 0.4 m/s and 1.1 m/s respectively). Although, the wetted perimeter is starting to reduce at 13 m of the cross-section.		depth classes, with fast-shallow, fast-intermediate and fast-deep proportioned similarly throughout the cross section (44% cumulative extent).
4		No assessment undertaken		No assessment undertaken
5	0.174	The VFCS critical habitat is reduced with moderate to low quality (6%). The maximum depth is 20 cm and the wetted perimeter is 5.8 m of the cross section, thus the cobbles biotope will begin to become exposed and leaving few deep areas available. Thus a level of stress will set in at these flows for the indicator taxon.	0.384	Loss of fast-deep velocity-depth class, with reduction in extent of fast-shallow (1.27 m of the cross section extent - down from 2.16 m) as well as fast-intermediate (1.37 m of cross section extent - down from 2.12m). Discharge and depth expected to still facilitate movement of smaller *Labeo umbratus* cohorts.
6		No assessment undertaken		No assessment undertaken
7	0.028	The maximum depth is only 10 cm, with an average and maximum velocity of 0.15 m/s and 0.48 m/s, of which at this point the Perlidae taxon will not persist and tolerate these lowered velocities. The perimeter has reduced to 3m of the cross-section and thus overall, the habitat quality is expected to deteriorate at this measurement. A more resilient invertebrate community will colonise instead.	0.036	Only residual fast-shallow remaining at 0.07 m of the cross section extent.
8		No assessment undertaken		No assessment undertaken
9	0	Zero discharge thus no flow, standing water and habitats available are of very low quality, with no critical habitat available.		No assessment undertaken
10	0	Average depth is 0 cm, no flowing water and no critical habitat (0% for FCS and VFCS, including other habitats), pooled in-stream. Only specialists will persist.	0	Only hyperheic refugia present, thus not supportive of fish within cross section.

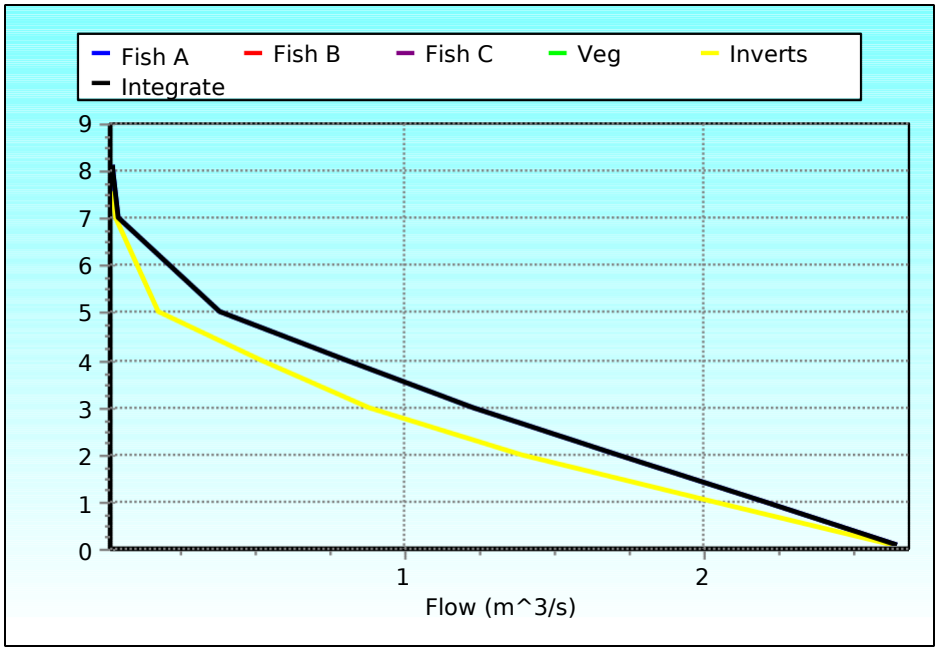


Figure 5-43: Final integrated stress curve for the Lower Great Fish EWR site (FISH03_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (July) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-44** and **Figure 5-45** below. The adjustments made to the DRM results are as follows:

Increase July drought flows from 0.218 m^3/s to 0.434 m^3/s.

Increase March maintenance low flows from 1.473 m^3/s to 2.607 m^3/s.

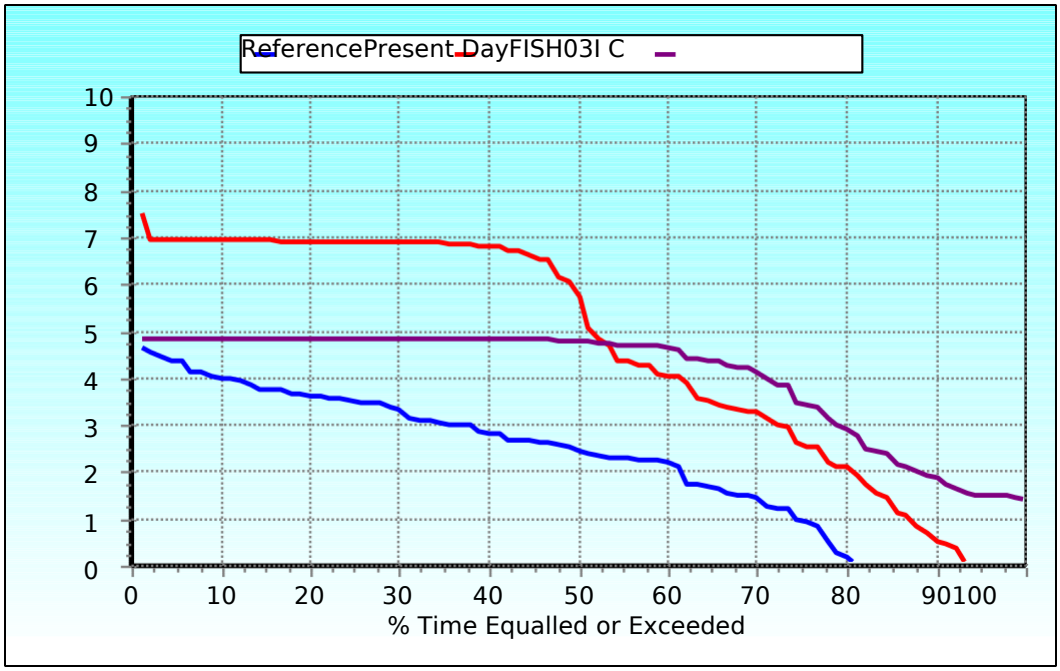


Figure 5-44: Final stress duration curves – dry season (July).

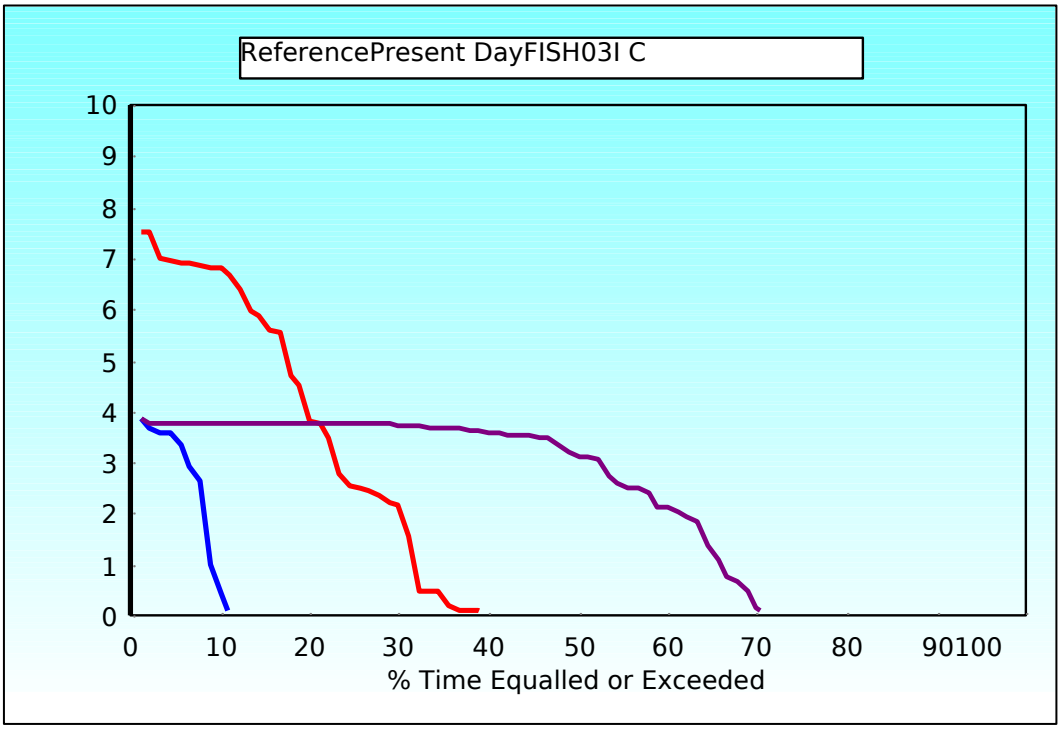


Figure 5-45: Final stress duration curves – wet season (March).

The flood requirements for the Lower Great Fish EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-26**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-26: Flood requirements for the Lower Great Fish at the EWR site (FISH03_I).

Floods	Flood size (range)	FINAL
Class 1 (10-20 m^3/s)	m^3/s	10 (15)
	# days	5
	Months	Oct, Nov, (Dec-Apr)
	Type	Daily average
Class 2 (20-50 m^3/s)	m^3/s	30
	# days	4
	Months	Nov, Dec, Jan, Feb
	Type	Daily average
Class 3 (85-100 m^3/s)	m^3/s	90
	# days	4
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-27**.

Table 5-27: Lower Great Fish - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q91B
Site name	FISH03_I
River	Lower Great Fish
EWR Site Co-ordinates	-33.0837; 26.2252
Recommended Ecological Category	C
nMAR at EWR site	331.8
Total EWR	98.643 (29.73 %MAR)
Maintenance Low flows	46.531 (14.02 %MAR)
Drought Low flows	16.057 (4.84 %MAR)
Maintenance High flows	52.112 (15.70 %MAR)
Overall confidence	Moderate to high

5.10 SWAR01_I: KwaZungu / Swartkops River

Sample Date	24 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	SWAR01_I	**IUA**	IUA_M01
River	KwaZungu / Swartkops	**IUA description**	M primary catchment
Altitude (m.a.s.l.)	77	**Prioritised RU**	R_RU03_I
Latitude	-33.722183	**Longitude**	25.300816
Level 1 EcoRegion	Southern Folded Mountains	**Quaternary catchment**	**M10C**
Level 2 EcoRegion	19.02	**SQ Reach**	M10C-08897
Geomorphological zone	E (slope 0.005)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-46) AND SITE PHOTOGRAPHS (Figure 5-47)

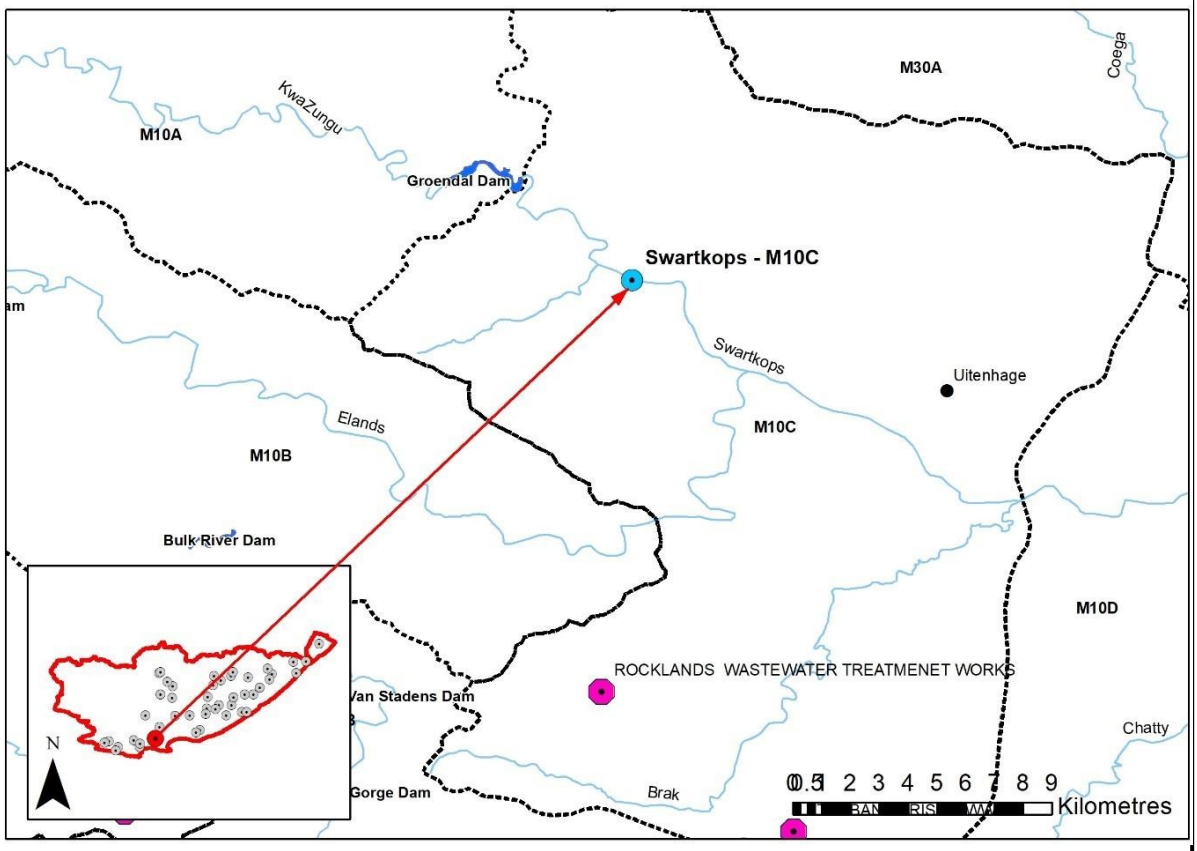


Figure 5-46: Location of site SWAR01_I (Swartkops) in relation to the study area.
(pink dot represents an existing WWTW)

Site Photographs: Survey 1 (September 2022)

Figure 5-47: Site photographs of the Swartkops EWR site.

The EWR for the Swartkops River was determined for a REC of a B/C and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Swartkops River were Philopotamidae (Finger-net caddisfly) and *Pseudobarbus afer* (Eastern Cape Redfin, semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: A diversity of good availability of biotopes (SIC, SOOC, instream and marginal vegetation) and hydraulic features were present for macroinvertebrates at this site on the Swartkops. Philopotamidae were recorded in B abundances during the September 2022 survey, although not recorded during the May 2023 survey. However, this flow sensitive and dependent taxon was and continues to be recorded in B abundances during the quarterly REMP biomonitoring (the same site). Therefore, Philopotamidae have been identified to be the indicator taxon for this reach. They have a preference for cobbles and high velocities of >0.6 m/s, although also appear at flows between 0.3 and
0.6 m/s. If flows fall below this target, this taxon will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the VFCS and FCS. They are further moderately sensitive to any water quality change.

Fish: *Pseudobarbus afer*, a riverine semi-rheophilic species, favouring clear rocky pools, the fry and juveniles occur in large shoals with adults in small groups. Omnivorous, feeds mainly from the bottom on algae and small invertebrates. P. afer which has life-history attributes which are adapted to the relatively stable, clear mountain streams. Density correlated to presence of boulders. The indicator species is *Pseudobarbus afer*, which is a semi-rheophilic species. This species requires flowing water for spawning in riffle areas where it needs depths of over 10 - 15 cm and velocities of >0.3 m/s, thus fast-shallow and fast-intermediate velocity depth class. This species is sensitive to water quality and requires flow especially during the wet season, but can tolerate short periods of no flows.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 50th percentile for September (0.184 m^3/s) and a minimum dry flow or 95th percentile for January (0.004 m^3/s) to represent the dry season

were selected. The stress-flow relationships were determined using the hydraulic cross-section, available

habitats and velocities. The selected stress values and associated flows are provided in **Table 5-28** and the final integrated stress curve is shown in **Figure 5-48**.

Table 5-28: Selected stress values, flows and rationale for the Swartkops EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	0.155	0.155 m^3/s was selected as the maxium natural Baseflow for this site (60% percentile) in accordance with the hydrology (September). However, this BF would compromise the VFCS critical habitat. Consequently, the discharge was increased for the 0 stress to 0.155 m^3/s, as it provides average and maximum velocities of 0.2 m/s and 0.5 m/s respectively, suitable for this indicator taxon. The critical habitats available was FCS (9%) and VFCS (1%). The wetted perimeter is 5 m of the cross section. Thus, all cobbles are covered and overall adequate velocities. Unfortunatley, owing to the nature of the system, at these discharges, the velocities are not exceedingly more than 0.6 m/s which is the optimal habitat for Philopotamidae, although they do still occur within the velocity ranges for this stress nonetheless.	0.132	Maximum baseflow as provided by hydrologist, with critical spawning habitat (fast-shallow and fast-intermediate) present at 7% (0.329 m) of the cross section. Cross section dominated by slow-shallow velocity-depth class over cobble habitat.
1		No assessment undertaken	0.102	Maximum critical spawning habitat present at 5% (0.264 m) of the cross section. Cross section still dominated by slow-shallow on margins but still presence of fast-intermediate class within central portion of channel.
2		No assessment undertaken		No assessment undertaken
3	0.093	The VFCS critical habitat has reduced to 6% along the cross-section, with no longer any more VFCS critical habitat. However, the maximum velocity is 0.4 m/s, still within the range for this indicator taxon of 0.3 m/s - 0.6 m/s. The	0.069	Fast-shallow habitat at maximum, with fast-intermediate starts to decrease and marginal vegetation contact unlikely. Slow-shallow velocity-depth class dominating across section.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		wetted perimeter has slightly decreased to 4.2 m.		
4				
5	0.062	The critical habitats are reduced with moderate to low quality (5% and 0% for VFCS and FCS respectively). Maximum depth is 22 cm, with average depth at 16 cm, thus lower water levels. The wetted perimeter remains sufficient at 3.6 m of the cross section, but the average and maximum velocities are 0.1 m/s and 0.4 m/s respectivley. Thus the maximum velocity on the lower spectrum of this indicator taxons preference. Thus a level of stress will set in at these flows for the indicator taxon.	0.049	Significant loss of spawning habitat, with extent of cross section dominated by slow-very shallow and slow-shallow habitats. Depth likely to be sufficient to facilitate spawning, although velocities may be limiting factor.
6		No assessment undertaken		No assessment undertaken
7	0.024	Almost zero critical habitat for the Philopotamidae (1% for FCS) remaining. The maximum velocity of 0.27 m/s being below the flow preferences for this taxon. This will not support this family and their abundances will diminish as biotopes are completely exposed. Habitat quality is expected to deteriorate at this measurement. A more resilient invertebrate community will colonise instead.	0.02	Loss of critical spawning habitat within cross section. Only slow-shallow and slow-very shallow present to any signficant extent, with the later being dominant.
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Natural stress owing to the system as it does dry out and the fact that the upstream Groendal Dam does not release.	0	Only hyporheic habitat present, this unlikely to support fish.

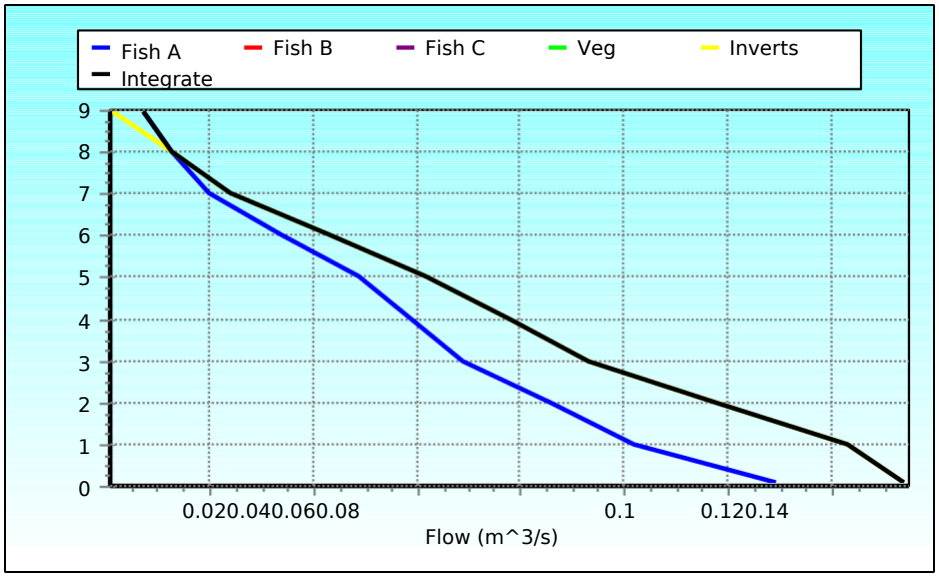


Figure 5-48: Final integrated stress curve for the Swartkops EWR site (SWAR01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (January) and wet season (September) and the final adjusted EWRs are shown in **Figure 5-49** and **Figure 5-50** below. The adjustments made to the DRM results are as follows:

Increase September maintenance low flows from 0.116 m^3/s to 0.185 m^3/s.

The 'High flow shape' for the months March to May and September to November was adjusted to 8.

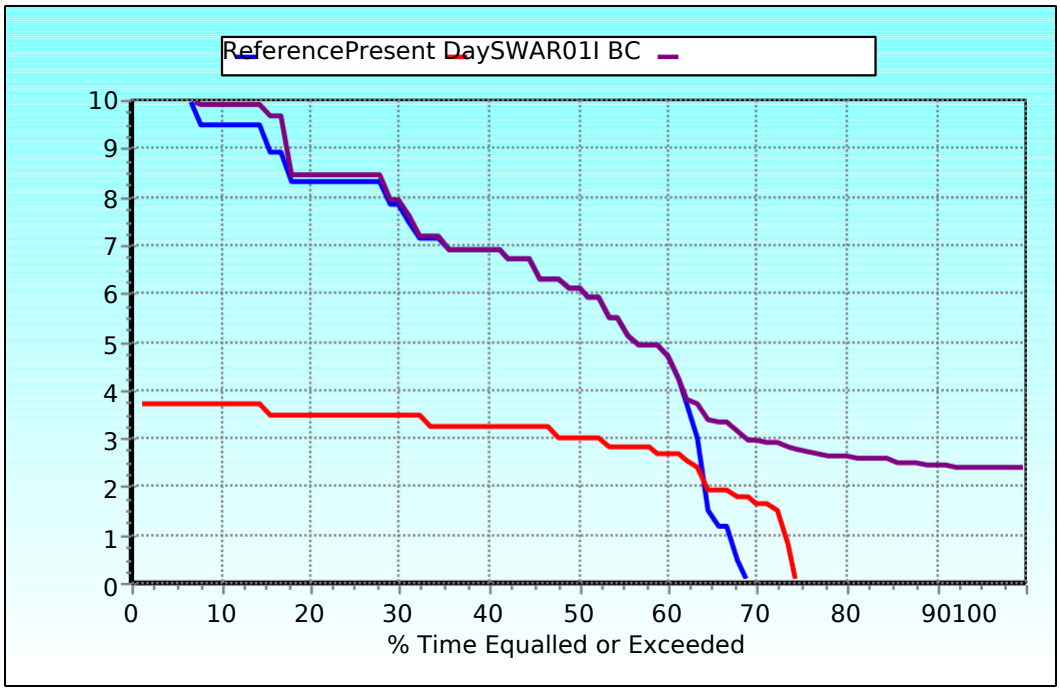


Figure 5-49: Final stress duration curves – dry season (January).

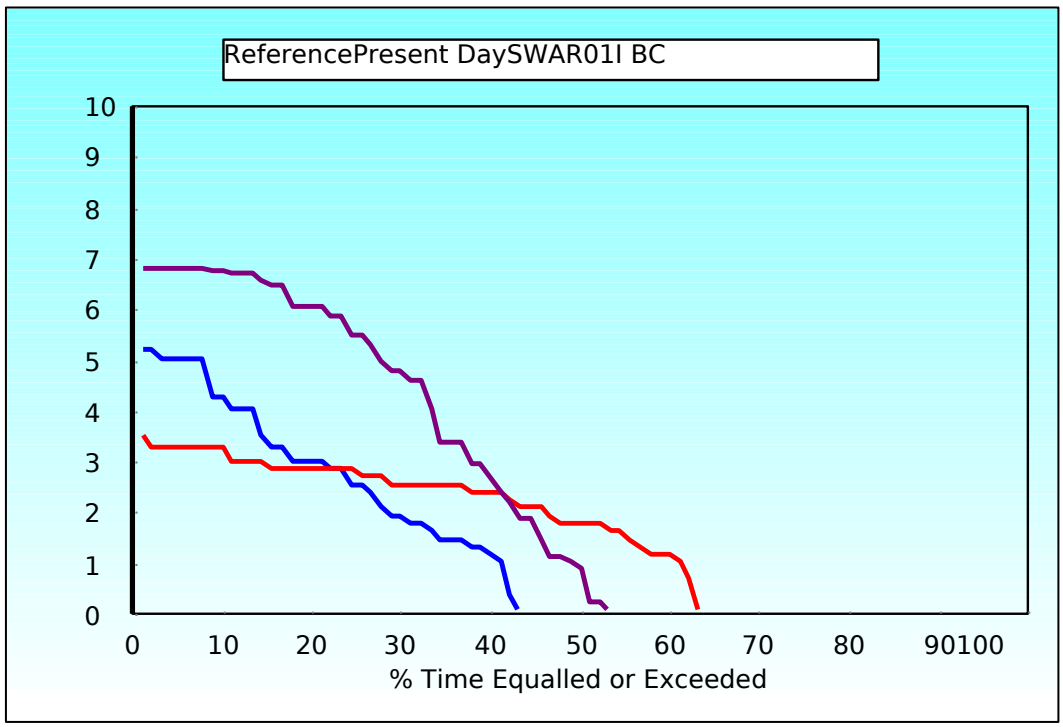


Figure 5-50: Final stress duration curves – wet season (September).

The flood requirements for the Swartkops EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-29**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-29: Flood requirements for the Swartkops at the EWR site (SWAR01_I).

Floods	Flood size (range)	FINAL
Class 1 (0.5-2.0 m^3/s)	m^3/s	1.5
	# days	2
	Months	Aug, Oct, Nov
	Type	Daily average
Class 2 (5-15 m^3/s)	m^3/s	6
	# days	2
	Months	Aug, Nov, Mar, Apr, May
	Type	Daily average
Class 3 (30-45 m^3/s)	m^3/s	20
	# days	2
	Months	Sep
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-30**.

Table 5-30: Swartkops - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	M10C
Site name	SWAR01_I
River	Swartkops
EWR Site Co-ordinates	-33.7221; 25.3008
Recommended Ecological Category	B/C
nMAR at EWR site	27.3
Total EWR	10.919 (39.97 %MAR)
Maintenance Low flows	4.327 (15.84 %MAR)
Drought Low flows	0.484 (1.77 %MAR)
Maintenance High flows	6.592 (24.13 %MAR)
Overall confidence	High

5.11 GAMT01_I: Gamtoos River

Sample Date	25 September 2022	**Reserve Level Assessment**	**Intermediate**
Site Name	GAMT01_I	**IUA**	IUA_KL01
River	Gamtoos	**IUA description**	Kromme from Kromme Dam to estuary and Gamtoos
Altitude (m.a.s.l.)	74	**Prioritised RU**	R_RU02_I
Latitude	-33.760983	**Longitude**	24.693677
Level 1 EcoRegion	Southern Folded Mountains	**Quaternary catchment**	**L90A**
Level 2 EcoRegion	19.02	**SQ Reach**	L90A-08877
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

MAP ILLUSTRATION (Figure 5-51) AND SITE PHOTOGRAPHS (Figure 5-52)

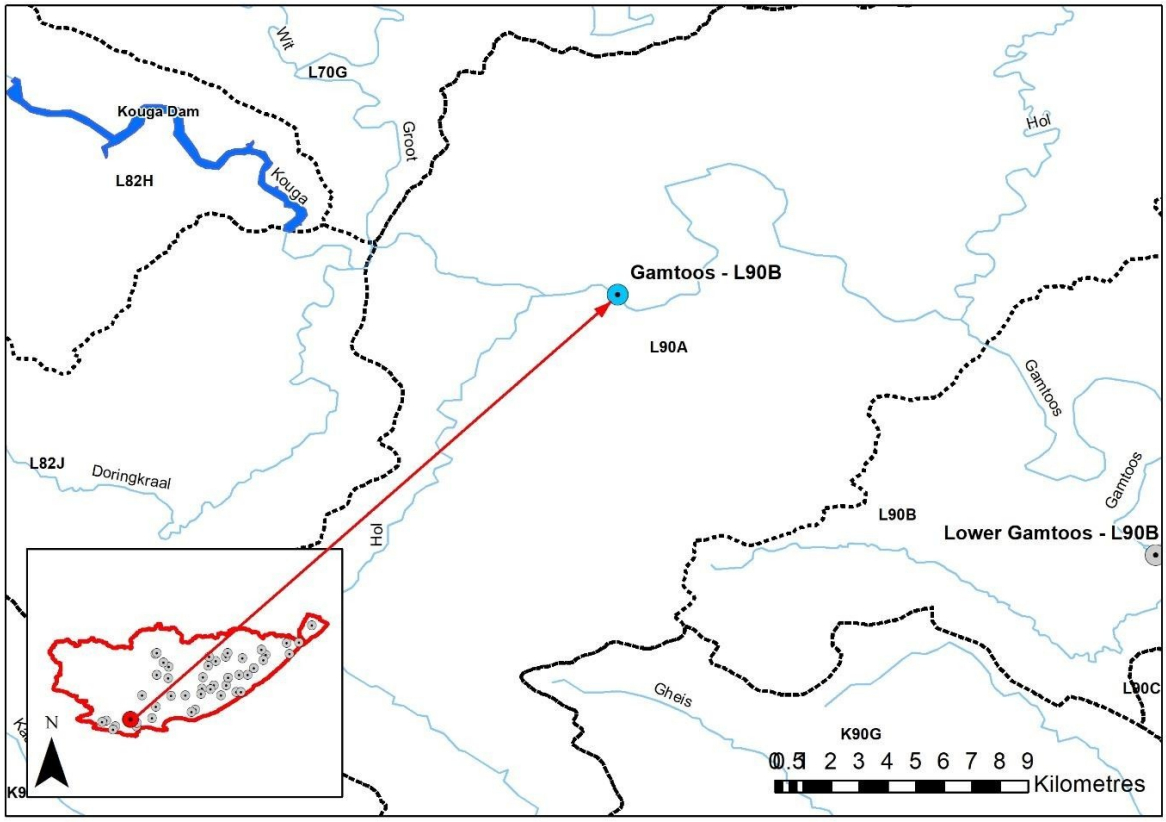


Figure 5-51: Location of site GAMT01_I (Gamtoos) in relation to the study area.

Figure 5-52: Site photographs of the Gamtoos EWR site

The EWR for the Gamtoos River was determined for a REC of a D and the HFSR approach was used to determine the EWRs. The indicator species for macroinvertebrate taxa and fish species selected for the Gamtoos River were Leptophlebiidae (Prong-gilled mayfly) and *Anguilla mossambica* (semi-rheophilic) due to the lack of true rheophilic species.

Macroinvertebrates: The Gamtoos River follows a pool-riffle reach type and is dominated by boulder, cobble, gravel, sand and muddy sediment types. However, should the upstream Kouga Dam not be overflowing, this part of the reach is renound to pool upstream of the low water bridge, leaving limited to no flow downstream (which is what was observed during the May 2023 survey). Although, Leptophlebiidae, being flow-dependent taxon, were not recorded during the September 2022 survey, they have nonetheless been previously recorded during the quarterly DWS REMP monitoring programme (L9GAMT-PATEN). Therefore, Leptophlebiidae have been identified to be the indicator taxon for this reach. They show the greatest response for moderately-fast flowing water between 0.3 – 0.6 m/s, over cobbles, but can tolerate >0.6 m/s and in the habitats of gravel, sand, mud. Should flows fall below this target, this taxon will be absent from the macroinvertebrate community. Thus, the macroinvertebrate habitat availability assessed as critical habitat will be the FCS. They further exhibit a preference for shallow (<30 cm) water and have moderate requirement for unmodified physico-chemical conditions.

Fish: Although various fish species present, no true rheophilics expected. Two eel species expected under natural conditions, with the only species with a preference for fast flowing water being *Anguilla mossambica*. *Anguilla mossambica* inhabits both quiet and fast flowing water, with velocity-depth preferences listed as being fast-shallow (medium preference), fast-intermediate (high preference), fast-deep (very high preference). The species breeds in the ocean and elvers ascend rivers at night under the cover of darkness, with adults being mostly sedentary. Thus critical life stage regarded as elvers (60-120 mm), with upstream migration taking place during high-flow period

and during receding

limb of freshets and floods. As such, the semi-rheophilic *Anguilla mossambica* was selected as an indicator species. Consideration was also given to *Labeo umbratus* juveniles which are known to exhibit a distinct preference for flowing water, with the migration of juveniles probably having evolved to optimise feeding, to avoid unfavourable conditions and possibly to promote colonisation (Cambray, 1990). The remainder of the fish species present or expected to be present were considered to be eurytopic or lymnophilic.

Next, the optimum baseflows were selected from the reference baseflows to assist in the definition of the stress-flow relationships. The wet season baseflow or 80th percentile for March (3.018 m^3/s) and a minimum dry flow or 95th percentile for January (2.057 m^3/s) to represent the dry season were selected. The stress-flow relationships were determined using the hydraulic cross-section, available habitats and velocities. The selected stress values and associated flows are provided in **Table 5-31** and the final integrated stress curve is shown in **Figure 5-53**.

Table 5-31: Selected stress values, flows and rationale for the Gamtoos EWR site.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
0	3.105	Due to limitations imposed by the upstream Kouga Dam, restricted overflow capacity, and the river's vulnerability due to significant water abstractions for citrus farming, the 80th percentile of natural baseflows (typically occurring in March) has been adopted as a practical guideline for this system. It is important to note that this system is currently under stress. During the quarterly monitoring of the REMP, there have been instances where the river ceases to flow and becomes completely dry downstream of the low water bridge. Therefore, if the system were to receive flows with no stress, the physical habitat would generally exceed expectations and exhibit high quality. With a discharge rate of 3.105 m^3/s, the maximum and average velocities are 0.85 m/s and 0.3 m/s, respectively, which fall within the preferred range for this indicator taxon (0.3 - 0.6 m/s) on average. This discharge rate provides access to 15% of the critical habitat for FCS, 3% for	3.105	Good representation of various flow-depth classes, with fast-shallow, fast-intermediate and fast-deep classes representing 34% of the available habitat. Wetted perimeter also significant (28 m), with average depth across floodplain at 0.4 m and discharge of 3 m^3/sec. Velocity-depth classes present thus support movement of various fish species within the reach.

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		VFCS, and 17% for FFS, respectively, reflecting the distribution of suitable habitat types. The wetted perimeter measures 28m across the cross section of the river.		
1		No assessment undertaken		No assessment undertaken
2		No assessment undertaken		No assessment undertaken
3	2.017	Both FCS and FFS critical habitats have reduced to 11% and 12% respectively, and the VFCS by a percentage at this stress of a 3. The average and maximum velocities have reduced, although the maximum still being within the range of this indicator taxon, but the average velocity falling below the Leptophlebidae preference starting from 0.3 m/s. The wetted perimeter has slightly decreased to 25 m of the cross section, thus at this flow and barring the water quality remains moderate, and these indicator taxon will persist.	0.888	Reduced critical habitat, with fast-shallow, fast-intermediate and fast-deep classes now representing only 10% of the available habitat within the cross-section and a loss of slow-deep class. Nevertheless, the persistence of fast-deep and fast-intermediate classes is expected to still support signficant upstream movement of fish within the reach with an average depth of 0.27 m and a maximum depth of 0.46 m.
4		No assessment undertaken		No assessment undertaken
5	0.888	The critical habitats for this taxon have been significantly diminished, with only 5% of FCS, 1% of VFCS, and 6% of FFS remaining, and they exhibit low quality. Despite having an average depth of 27 cm, which remains suitable for this taxon, the average velocity of 0.15 m/s falls well below the lower end of the preferred flow range for this indicator taxon. Consequently, these flow conditions represent a source of stress for the indicator taxon, exacerbated by the poor availability of VFCS.	0.319	Loss of fast-deep class and greatly reduced fast-flowing classes (now 3% of cross-section). Average depth of 0.17 m velocity of 0.36 m/s is expected to place abuncance of indicator species within the reach at risk.
6		No assessment undertaken		No assessment undertaken
7	0.192	Almost zero critical habitat for the Leptophlebidae (1% for FCS and FFS) remaining. The maximum velocity of 0.3 m^3/s being on the border line of the flow preferences for this taxon, although the	0.119	Loss of all faster-flowing habitat that would otherwise facilitate movement within reach. Only slow-shallow and slow-very shallow habitat remaining, with some upstream movement still

Stress	Inverts (m^3/s)	Rationale	Fish (m^3/s)	Rationale
		maximum depth is 0.28 m, below their depth preference. This will not support this family and their abundances will diminish as biotopes are completely exposed. Habitat quality is expected to deteriorate at this flow. A more resilient invertebrate community will colonise instead.		expected (albeit greatly reduced). Indicator species is however expected to persist in deeper pools and under stucture (e.g. low-water bridge overhang), but likely to be present in only limited abundances.
8		No assessment undertaken		No assessment undertaken
9		No assessment undertaken		No assessment undertaken
10	0	Natural stress owing to the system as it does dry out and the fact that the upstream Kouga Dam does not release into the river.	0	Loss of all surface water - only hyporheic refugia present. Fish species located in pools upstream of reach only, with no species present along cross section.

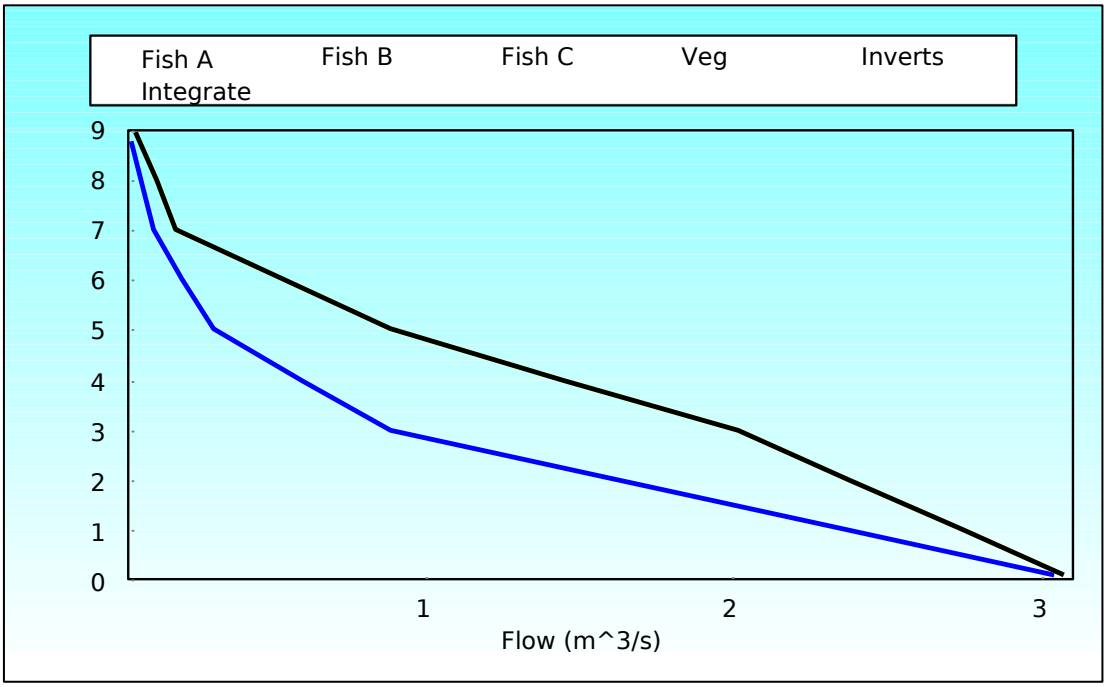


Figure 5-53: Final integrated stress curve for the Gamtoos EWR site (GAMT01_I).

The information of the above stress curve was used to convert the flows into stress duration curves for the EWR site for the dry season (January) and wet season (March) and the final adjusted EWRs are shown in **Figure 5-54** and **Figure 5-55** below. The adjustments made to the DRM results are as follows:

Increase March maintenance low flows from 0.676 m^3/s to 0.821 m^3/s.

The 'High flow shape' for the months March, November and August was adjusted to 8 and the 'Low

flow shape' for the months January, April to July and December was adjusted to 6.

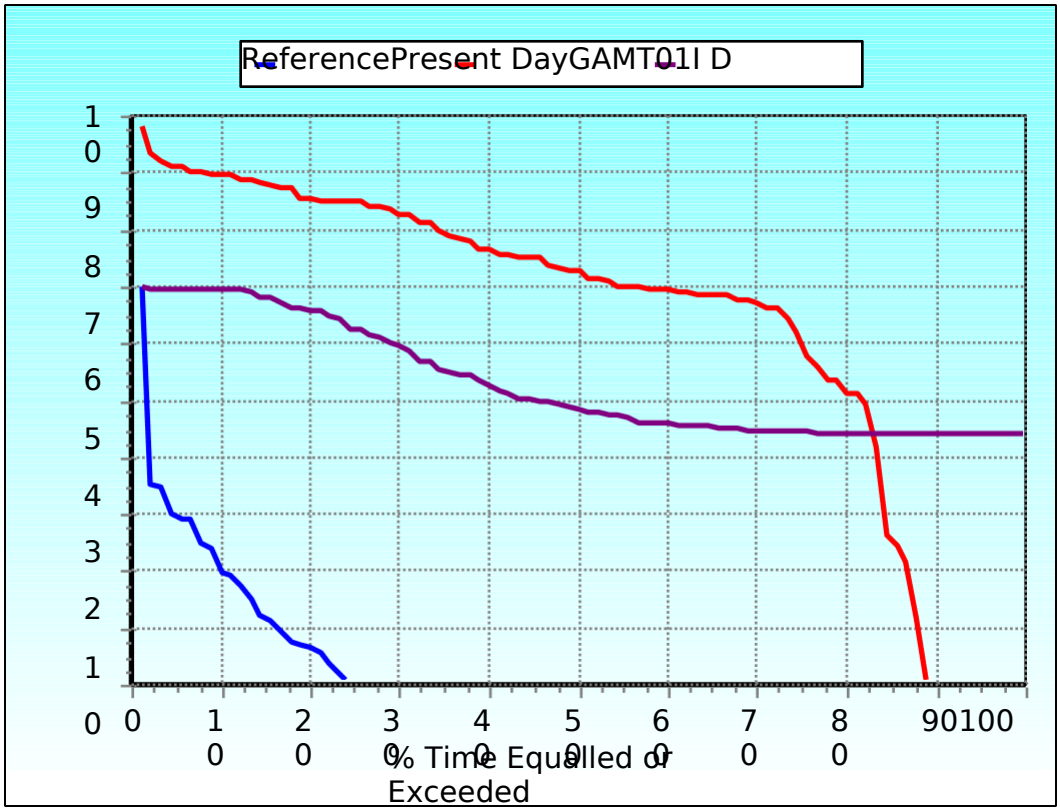


Figure 5-54: Final stress duration curves – dry season (January).

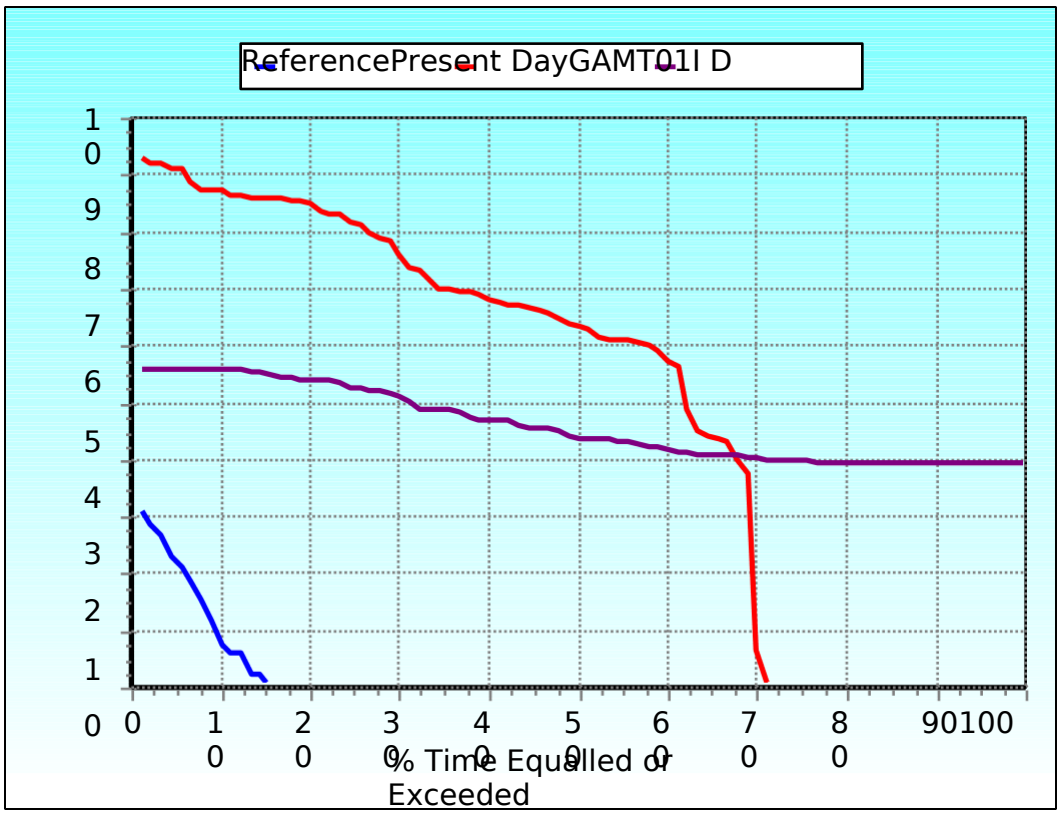


Figure 5-55: Final stress duration curves – wet season (March).

The flood requirements for the Gamtoos EWR site were specified by the specialists and include small freshets to provide cues for fish (upstream movement and spawning) and macroinvertebrate (breeding and hatching), as well as larger floods for clearing of the river channel. The individual requirements were integrated for inclusion in the final EWR results and are summarised in **Table 5-32**. The detailed requirements and motivations per component are presented in **Appendix A**.

Table 5-32: Flood requirements for the Gamtoos at the EWR site (GAMT01_I).

Floods	Flood size (range)	FINAL
Class 1 (0-5.0 m^3/s)	m^3/s	3.2
	# days	5
	Months	Aug, Sep, Nov, Mar
	Type	Daily average
Class 2 (7-15 m^3/s)	m^3/s	10
	# days	3
	Months	Aug, Sep, Nov, Dec, Jan, Feb, Mar
	Type	Daily average
Class 3 (40-45 m^3/s)	m^3/s	41
	# days	5
	Months	Mar
	Type	Peak

* The 1:2, 1:5 and 1:10 year floods not modelled but important to include in any water resource developments

The final ecological water requirements using the stress duration curves and the integrated flood requirements are summarised in **Table 5-33**.

Table 5-33: Gamtoos - Summary of the EWR results (flows in Mm^3 per annum).

Quaternary Catchment	L90A
Site name	GAMT01_I
River	Gamtoos
EWR Site Co-ordinates	-33.7609; 24.6936
Recommended Ecological Category	D
nMAR at EWR site	427.0
Total EWR	46.136 (10.80 %MAR)
Maintenance Low flows	24.200 (5.67 %MAR)
Drought Low flows	18.928 (4.43 %MAR)
Maintenance High flows	21.936 (5.14 %MAR)
Overall confidence	Moderate to High

6. EWR RESULTS: RAPID 3 SITES

6.1 MNGA01_R: Mngazi River

Sample Date	7 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Code	MNGA01_R	**IUA**	IUA_T04
River	Mngazi	**IUA description**	Pondoland coastal
Altitude (m.a.s.l.)	34m	**Prioritised RU**	R_RU31_R
Latitude	-31.608958	**Longitude**	29.405132
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**T70B**
Level 2 EcoRegion	31.02	**SQ Reach**	T70B-06498
Geomorphological zone	E (Slope 0.003)	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-1: Site photographs of the Mngazi EWR site.

The EWR for the Mngazi River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for August and March. August is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 7 September 2022 was 0.389 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-2**).

The consensus reached by the aquatic ecologists was that the recommended flows for both August and March did not provide adequate velocities and availability of instream habitats for the

macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent and present macroinvertebrates, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Furthermore, flows were increased with the aim to improve velocity depth classes and activate additional fast intermediate critical habitat, and to further provide additional cover features for the fish. Therefore, the recommended flows (drought and maintenance) were adjusted as follows:

Increase August drought flows from 0.098 m^3/s to 0.186 m^3/s.

Increase March maintenance low flows from 0.464 m^3/s to 0.605 m^3/s.

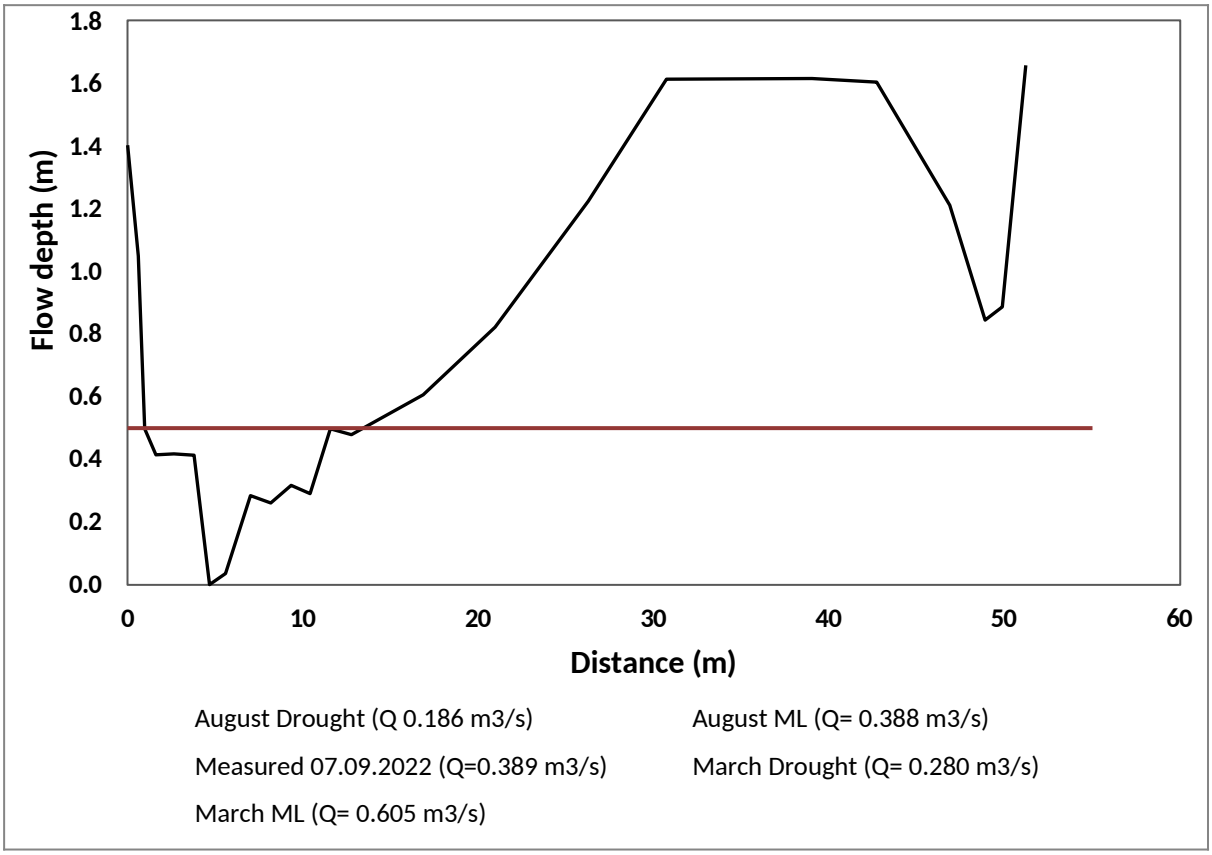


Figure 6-2: Water levels on cross-section of the EWR site for Mngazi River in T70B.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-1** and the final EWR for the Mngazi River at the EWR site is summarised in **Table 6-2**.

Table 6-1: Mngazi - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	Days		m^3/s	days
September	2	3	January	2	3
October	2	3	February	4	3
November	6	5	March	8	5
December	5	3			

Table 6-2: Mngazi - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T70B
River	Mngazi
Site code	MNGA01_R
Coordinates	-31.608958; 29.405132
Recommended Ecological Category	B/C
nMAR at EWR site	78.2
Total EWR	20.290 (25.94 %MAR)
Maintenance Low flows	15.091 (19.29 %MAR)
Drought Low flows	7.084 (9.06 %MAR)
Maintenance High flows	5.200 (6.65 %MAR)
Overall confidence	Low to moderate

6.2 NQAB01_R: Nqabarha River

Sample Date	9 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	NQAB01_R	**IUA**	IUA_T04
River	Nqabarha	**IUA description**	Pondoland coastal
Altitude (m.a.s.l.)	711m	**Prioritised RU**	R_RU33_R
Latitude	-32.091927	**Longitude**	28.400234
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**T90A**
Level 2 EcoRegion	16.06	**SQ Reach**	T90A-07092
Geomorphological zone	E (0.003)	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-3: Site photographs of the Nqabara EWR site.

The EWR for the Nqabara River were determined for a REC of a C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for August and November. August is the month with the lowest average flow (i.e., baseflow) and November is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 9 September 2022 was 0.024 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-4**).

The consensus reached by the aquatic ecologists was that the recommended flows for November did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent and present macroinvertebrates, as well as provided additional critical habitats namely fast course

substrate and/or very fast course substrate (being the stones biotope). Furthermore, flows were increased with the aim to improve velocity depth classes and activate additional fast intermediate critical habitat, and to further provide additional cover features for the fish. Therefore, the recommended flows (drought and maintenance) were adjusted as follows:

Increase November maintenance low flows from 0.041 m^3/s to 0.048 m^3/s.

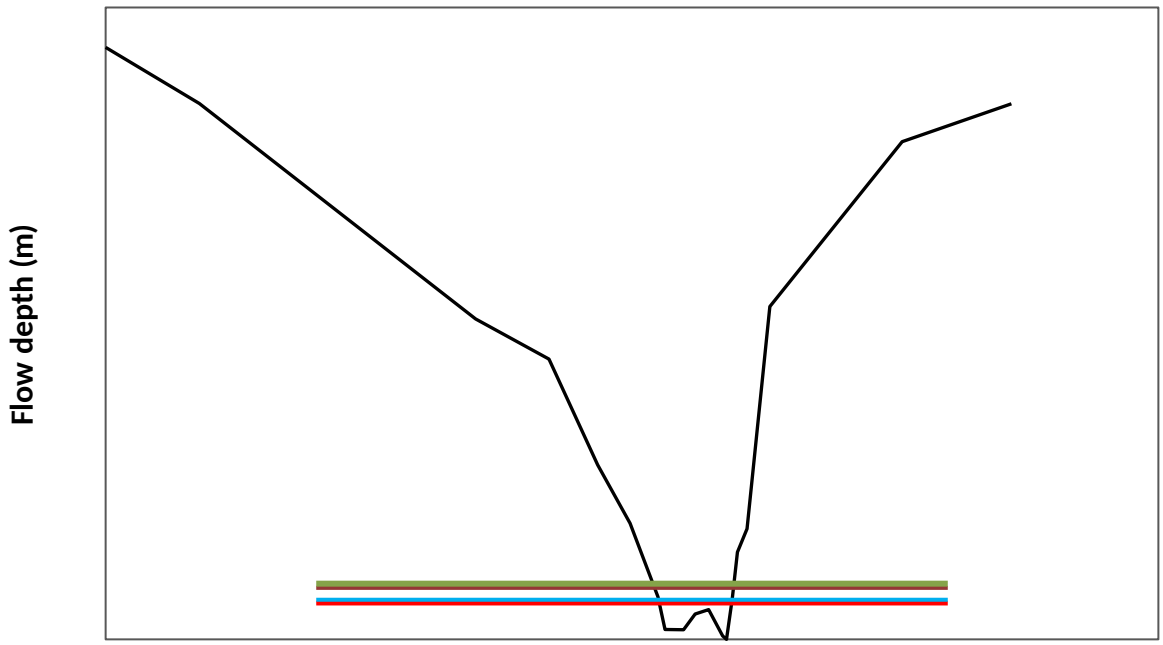


Figure 6-4: Water levels on cross-section of the EWR site for Nqabara River in T90A.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-3** and the final EWR for the Nqabara River at the EWR site is summarised in **Table 6-4**.

Table 6-3: Nqabara - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	Days		m^3/s	days
September	2	2	January	2	2
October	2	2	February	2	2
November	3	3	March	3	3
December	2	2			

Table 6-4: Nqabara - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T90A
River	Nqabara
Site code	NQAB01_R
Coordinates	-32.091927; 28.400234
Recommended Ecological Category	C
nMAR at EWR site	9.8
Total EWR	3.389 (34.51 %MAR)
Maintenance Low flows	1.246 (12.69 %MAR)
Drought Low flows	0.505 (5.14 %MAR)
Maintenance High flows	2.143 (21.82 %MAR)
Overall confidence	Low

6.3 MTEN01_R: Mtentu River

Sample Date	6 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Code	MTEN01_R	**IUA**	IUA_T04
River	Mtentu	**IUA description**	Pondoland coastal
Altitude (m.a.s.l.)	274m	**Prioritised RU**	R_RU29_R
Latitude	-31.130483	**Longitude**	29.757179
Level 1 EcoRegion	North Eastern Coastal Belt	**Quaternary catchment**	**T60C**
Level 2 EcoRegion	17.01	**SQ Reach**	T60C-05942
Geomorphological zone	D (slope 0.005)	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-5: Site photographs of the Mtentu EWR site.

The EWR for the Mtentu River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for August and November. August is the month with the lowest average flow (i.e., baseflow) and November is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 6 September 2022 was 0.954 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-6**). The baseflows were higher than expected during the survey, possibly because of the good rainfall in the catchment during the summer/ autumn months.

The consensus reached by the aquatic ecologists was that the recommended flows for November did not provide adequate velocities and availability of instream habitats for the macroinvertebrates.

The maintenance low flows were adjusted to ensure increased velocity for those flow dependent and present macroinvertebrates, as well as to provide additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Furthermore, flows were increased with the aim to improve velocity depth classes and activate additional fast intermediate critical habitat, and to further provide additional cover features for the fish. Therefore, the recommended flows (maintenance) were adjusted as follows:

Increase November maintenance low flows from 0.572 m^3/s to 1.150 m^3/s.

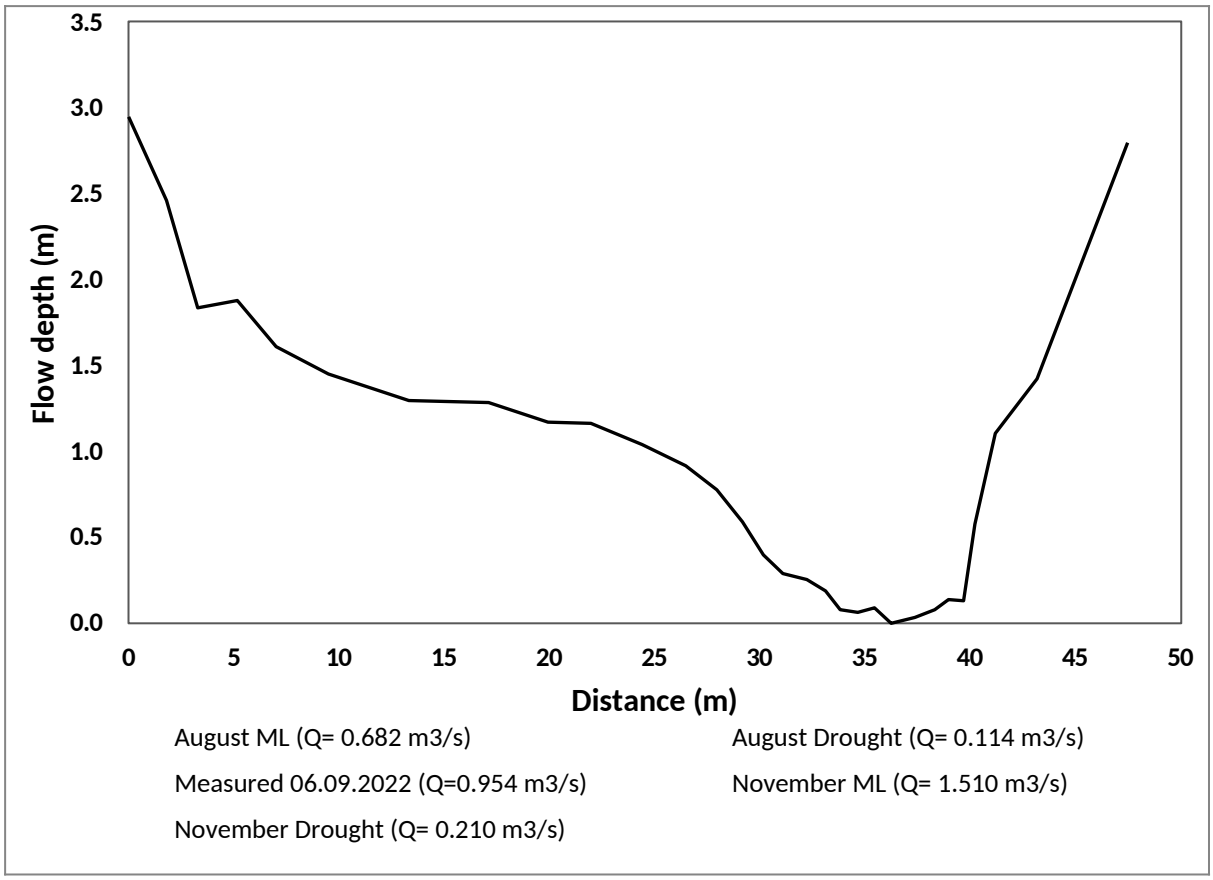


Figure 6-6: Water levels on cross-section of the EWR site for Mtentu River in T60C.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-5** and the final EWR for the Mtentu River at the EWR site is summarised in **Table 6-6**.

Table 6-5: Mtentu - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
August	2	3	December	7	2
September	2	3	January	7	2
October	4	3	February	7	2
November	15	5	March	10	5

Table 6-6: Mtentu - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T60C
River	Mtentu
Site code	MTEN01_R
Coordinates	-31.130483; 29.757179
Recommended Ecological Category	B/C
nMAR at EWR site	89.6
Total EWR	39.705 (44.33 %MAR)
Maintenance Low flows	30.802 (34.39 %MAR)
Drought Low flows	5.509 (6.15 %MAR)
Maintenance High flows	8.904 (9.94 %MAR)
Overall confidence	Low to moderate

6.4 MBHA02_R: Upper Mbhashe River

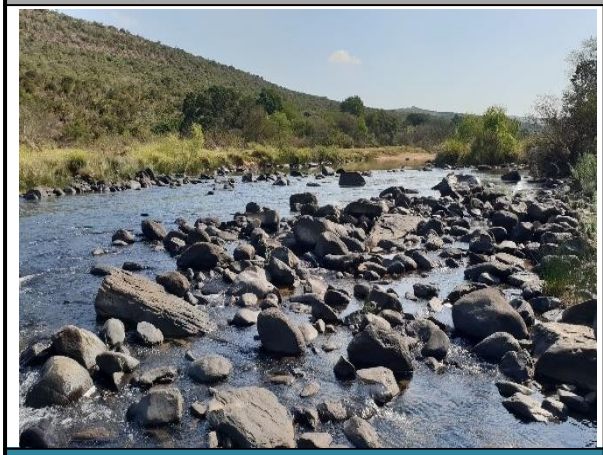
Sample Date	9 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	MBHA02_R	**IUA**	IUA_T01
River	Mbhashe	**IUA description**	Upper Mbhashe, Upper Mthatha
Altitude (m.a.s.l.)	555	**Prioritised RU**	R_RU27_R
Latitude	-31.807857	**Longitude**	28.346994
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	**T11H**
Level 2 EcoRegion	16.06	**SQ Reach**	T11H-06654
Geomorphological zone	E (slope 0.004)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-7: Site photographs of the Upper Mbashe EWR site.

The EWR for the Upper Mbashe River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for March and July. July is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 9 September 2022 was 1.822 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-8**).

The consensus reached by the aquatic ecologists was that the recommended drought flows for July and March did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The drought flows were adjusted to ensure increased velocity for those flow dependent and present macroinvertebrates. Furthermore, due to the presence of Simulidae, (black fly larvae), it is recommended that the maintenance flows for June, July and August are less than 2 m^3/s for any future developments, to prevent annual outbreaks. This should be followed with a freshet in September to flush out the Simulidae (refer to Chapter 8 for further information). Therefore, the recommended flows (drought) were adjusted as follows:

Increase July drought flows from 0.390 m^3/s to 0.778 m^3/s.

Increase March drought flows from 0.776 m^3/s to 1.381 m^3/s.

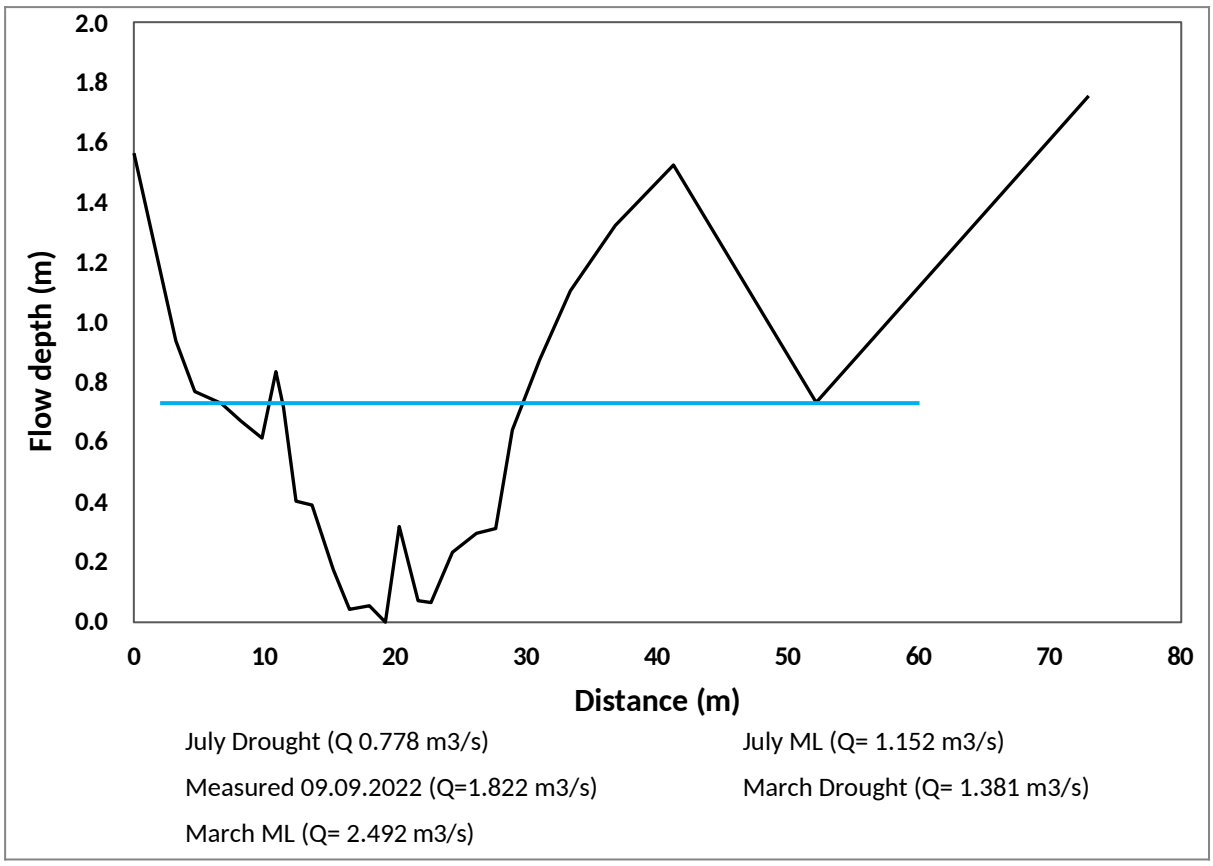


Figure 6-8: Water levels on cross-section of the EWR site for Upper Mbashe River in T11H.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-7** and the final EWR for the Upper Mbashe River at the EWR site is summarised in **Table 6-8**.

Table 6-7: Upper Mbashe - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	10	5	January	20	3
October	15	3	February	30	3
November	25	3	March	50	5
December	25	3			

Table 6-8: Upper Mbashe - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T11H
River	Upper Mbashe
Site code	MBHA02_R
Coordinates	-31.807857; 28.346994
Recommended Ecological Category	B/C
nMAR at EWR site	373.4
Total EWR	82.314 (22.05 %MAR)
Maintenance Low flows	52.143 (13.97 %MAR)
Drought Low flows	29.086 (7.79 %MAR)
Maintenance High flows	30.171 (8.08 %MAR)
Overall confidence	Low to moderate

6.5 GCUW01_R: Gcuwa River

Sample Date	11 May 2023	**Reserve Level Assessment**	**Rapid 3** *(higher confidence, including VEGRAI)*
Site Name	GCUW01_R	**IUA**	IUA_S03
River	Gcuwa	**IUA description**	Lower Great Kei
Altitude (m.a.s.l.)	536	**Prioritised RU**	R_RU26_R
Latitude	-32.319770°	**Longitude**	28.136094°
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	**S70D**
Level 2 EcoRegion	16.06	**SQ Reach**	S70D-07307
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs (May 2023)			

Upstream

Downstream

Figure 6-9: Site photographs of the Gcuwa EWR site.

The EWR for the Gcuwa River were determined for a REC of a D. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for March and June. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 11 May 2023 was 0.043 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-10**). The consensus reached by the aquatic ecologists was that the recommended maintenance low flows for May (0.058 m^3/s) that was just more than the discharge during the field survey, did not provide adequate velocities and availability of

instream habitats for the macroinvertebrates. These were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present. Therefore, the recommended flows were adjusted as follows:

Increase May maintenance low flows from 0.058 m^3/s to 0.307 m^3/s.

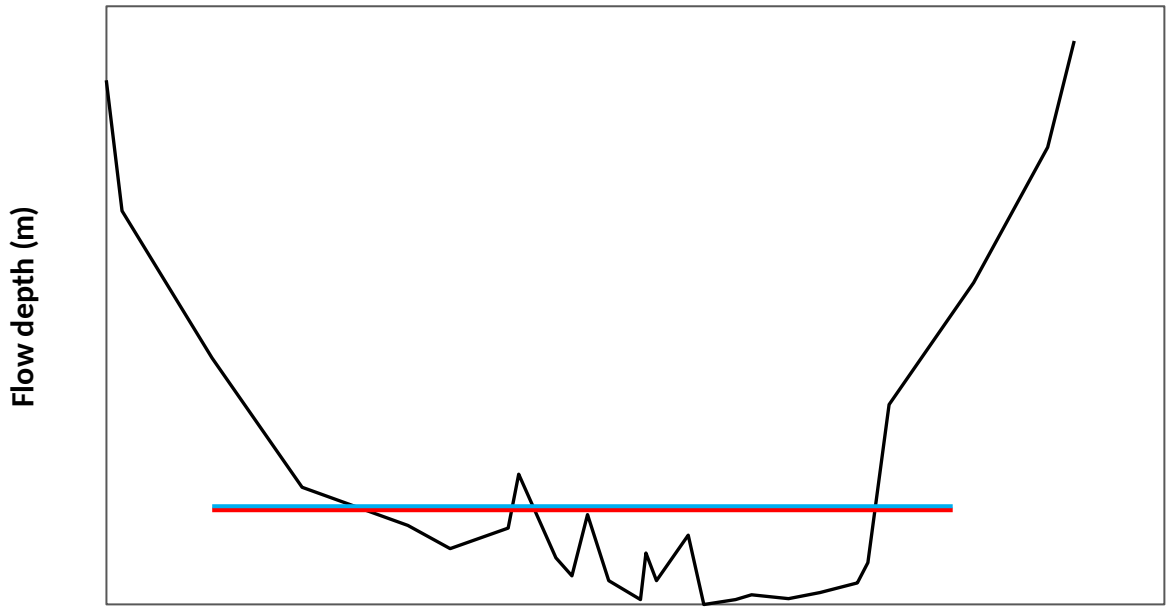


Figure 6-10: Water levels on cross-section of the EWR site for Gcuwa River in S70D.

No freshets or annual flood were specified for this site due to the short reach between the Gcuwa Dam upstream and the abstraction site for the water works downstream of the EWR site. The spills from the raised dam will be assessed during the ecological consequences and if inadequate, freshets will then be specified to determine the final EC and EWR. The final EWR for the Gcuwa River at the EWR site is summarised in **Table 6-9**.

Table 6-9: Gcuwa - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S70D
River	Gcuwa
Site code	GCUW01_R
Coordinates	-32.319369; 28.135801
Recommended Ecological Category	D
nMAR at EWR site	67.6
Total EWR	10.046 (14.86 %MAR)
Maintenance Low flows	10.046 (14.86 %MAR)
Drought Low flows	1.911 (2.83 %MAR)
Maintenance High flows	0.000 (0.00 %MAR)*
Overall confidence	Low to moderate

* To be confirmed during ecological consequences of scenarios of the raised dam

6.6 INDW01_R: Indwe River

Sample Date	10 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	INDW01_R	**IUA**	IUA_S01
River	Indwe	**IUA description**	Upper Great Kei
Altitude (m.a.s.l.)	838m	**Prioritised RU**	R_RU21_R
Latitude	-31.897077	**Longitude**	27.409825
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**S20D**
Level 2 EcoRegion	18.02	**SQ Reach**	S20D-06813
Geomorphological zone	D (slope 0.006)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-11: Site photographs of the Indwe EWR site.

The EWR for the Indwe River were determined for a REC of a C/D. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for June, September and March. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 10 September 2022 was 0.134 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-12**). The flows were very low during the survey, possibly due to the dam upstream not releasing into the river.

The consensus reached by the aquatic ecologists was that the recommended flows for September did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent

macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance) were adjusted as follows:

Increase September maintenance low flows from 0.134 m^3/s to 0.313 m^3/s.

Additionally, the maintenance low flows for June, July and August should be reduced to approximately 0.134 m^3/s to prevent the Simuliidae outbreak (refer to chapter 8 for further information regarding the manipulation of flow to try and alleviate these outbreatks).

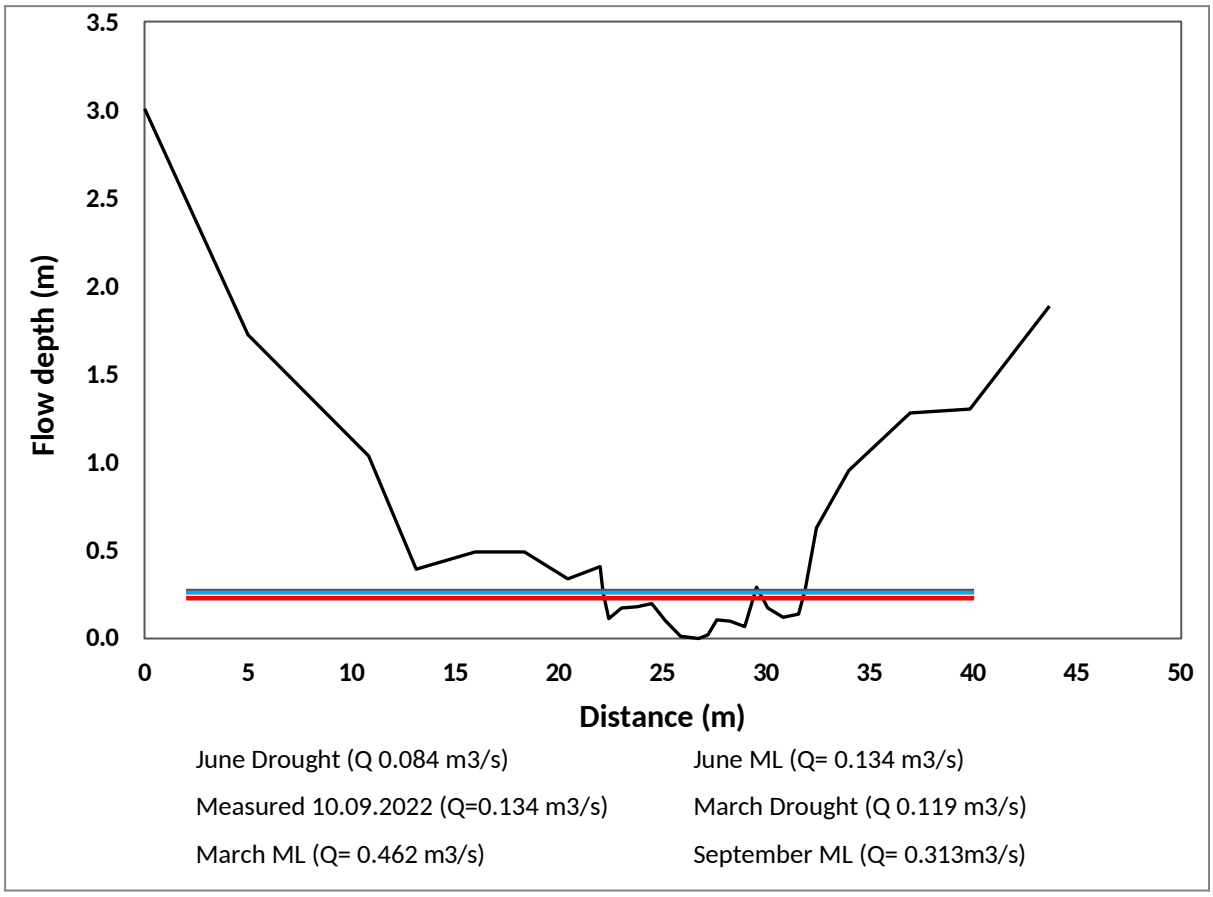


Figure 6-12: Water levels on cross-section of the EWR site for Indwe River in S20D.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-10** and the final EWR for the Indwe River at the EWR site is summarised in **Table 6-11**.

Table 6-10: Indwe - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	1.5	3	January	6	3
October	1.5	3	February	6	3
November	5	3	March	10	3
December	6	3			

Table 6-11: Indwe - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S20D
River	Indwe
Site code	INDW01_R
Coordinates	-31.897077; 27.409825
Recommended Ecological Category	C/D
nMAR at EWR site	61.9
Total EWR	15.303 (24.69 %MAR)
Maintenance Low flows	9.705 (15.65 %MAR)
Drought Low flows	2.817 (4.54 %MAR)
Maintenance High flows	5.599 (9.03 %MAR)
Overall confidence	Low

6.7 WKEI01_R: White Kei River

Sample Date	10 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	WKEI01_R	**IUA**	IUA_S01
River	White Kei	**IUA description**	Upper Great Kei
Altitude (m.a.s.l.)	787m	**Prioritised RU**	R_RU20_R
Latitude	-32.003057	**Longitude**	27.351052
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**S10J**
Level 2 EcoRegion	18.02	**SQ Reach**	S10J-06985
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-13: Site photographs of the White Kei EWR site.

The EWR for the White Kei River were determined for a REC of a C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for June, September and March. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 10 September 2022 was 0.931 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-14**).

The consensus reached by the aquatic ecologists was that the recommended flows for September did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent

macroinvertebrates present, as well as provided additional critical habitats namely fast course

substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance) were adjusted as follows:

Increase September maintenance low flows from 0.410 m^3/s to 0.802 m^3/s.

Additionally, the maintenance low flows for June, July and August should be reduced to approximately 0.4 m^3/s to prevent the Simuliidae outbreak (refer to chapter 8 for more information).

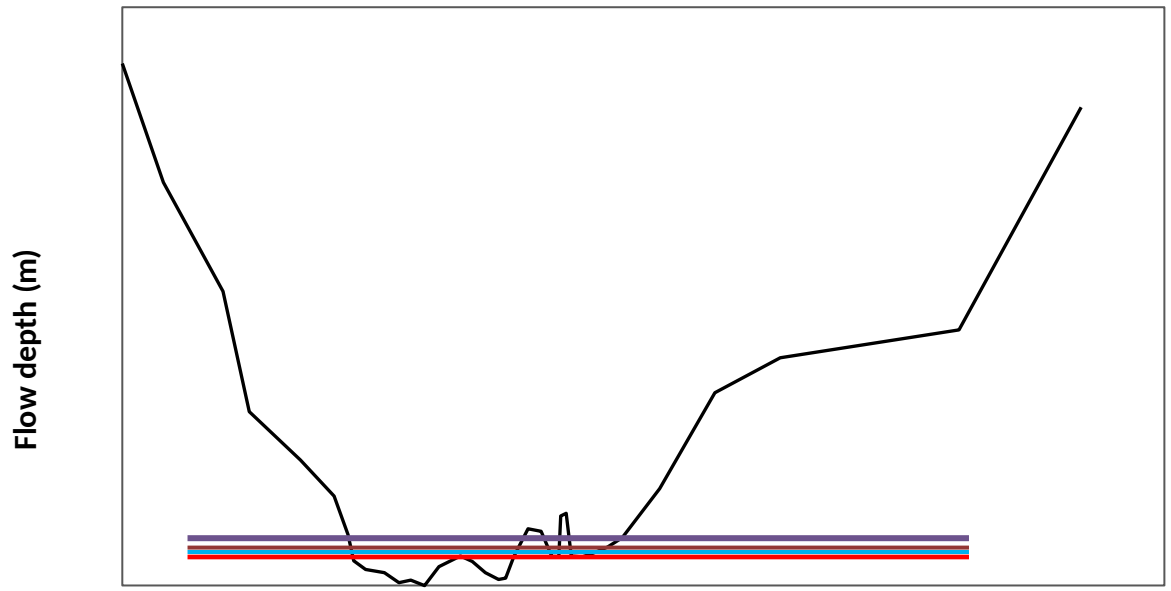


Figure 6-14: Water levels on cross-section of the EWR site for White Kei River in S10J.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-12** and the final EWR for the White Kei River at the EWR site is summarised in **Table 6-13**.

Table 6-12: White Kei - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	3.5	3	January	5	3
October	3.5	3	February	8	3
November	8	3	March	20	3
December	5	3			

Table 6-13: White Kei - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S10J
River	White Kei
Site code	WKEI01_R
Coordinates	-32.003057; 27.351052
Recommended Ecological Category	C
nMAR at EWR site	155.7
Total EWR	40.720 (26.16 %MAR)
Maintenance Low flows	32.477 (20.87 %MAR)
Drought Low flows	6.965 (4.47 %MAR)
Maintenance High flows	8.243 (5.30 %MAR)
Overall confidence	Low to moderate

6.8 KUBU03_R: Lower Kubusi River

Sample Date	10 May 2023	**Reserve Level Assessment**	**Rapid 3** *(higher confidence, including VEGRAI)*
Site Name	KUBU01_I	**IUA**	IUA_S03
River	Kubusi	**IUA description**	Lower Great Kei
Altitude (m.a.s.l.)	641m	**Prioritised RU**	R_RU0_12
Latitude	-32.50722	**Longitude**	27.731348
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	**S60B**
Level 2 EcoRegion	16.06	**SQ Reach**	S60E-07531
Geomorphological zone	D (slope 0.012)	**PES (DWS, 2014)**	C
Ecological Importance	High	**Ecological Sensitivity**	High
Site Photographs: Survey 2 (May 2023)			

Upstream	Downstream

Figure 6-15: Site photographs of the Lower Kubusi EWR site.

The EWR for the Lower Kubusi River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for May, June and March. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in May, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 10 May 2023 was 0.291 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-16**). The flows were very low during the survey, possibly due to the dam upstream not releasing into the river.

The consensus reached by the aquatic ecologists was that the recommended flows for May did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The recommended drought flows for June were very low, and didn't provide adequate velocities and habitats and were adjusted. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance and drought) were adjusted as follows:

Increase May maintenance low flows from 0.376 m^3/s to 0.421 m^3/s.

Increase June drought flows from 0.076 m^3/s to 0.139 m^3/s.

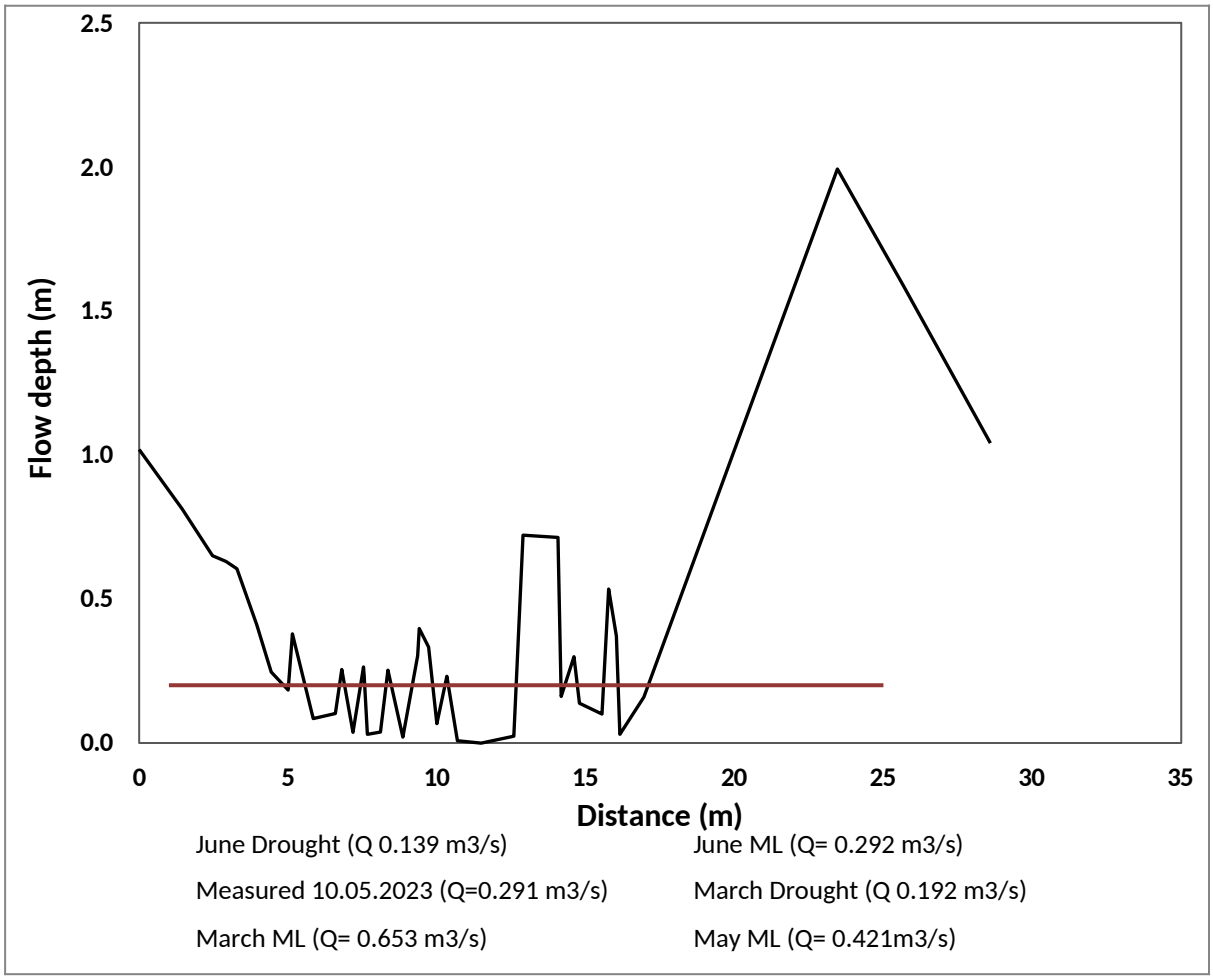


Figure 6-16: Water levels on cross-section of the EWR site for Lower Kubusi River in S60E.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-14** and the final EWR for the Lower Kubusi River at the EWR site is summarised in **Table 6-15**.

Table 6-14: Lower Kubusi - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	Days		m^3/s	days
September	2.5	3	January	4	3
October	4	3	February	4	3
November	8	5	March	8	5
December	4	3			

Table 6-15: Lower Kubusi - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	S60E
River	Lower Kubusi
Site code	KUBU03_R
Coordinates	-32.50722; 27.731348
Recommended Ecological Category	B/C
nMAR at EWR site	98.1
Total EWR	19.989 (20.38 %MAR)
Maintenance Low flows	13.836 (14.11 %MAR)
Drought Low flows	4.972 (5.07 %MAR)
Maintenance High flows	6.153 (6.27 %MAR)
Overall confidence	Low to moderate

6.9 KEIS02_R: Lower Keiskamma River

Sample Date	19 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	KEIS02_R	**IUA**	IUA_R01
River	Keiskamma	**IUA description**	Keiskamma
Altitude (m.a.s.l.)	118m	**Prioritised RU**	R_RU18_R
Latitude	-33.075316	**Longitude**	27.218534
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	**R10L**
Level 2 EcoRegion	31.01	**SQ Reach**	R10L-08173
Geomorphological zone	E (slope 0.003)	**PES (DWS, 2014)**	C
Ecological Importance	High	**Ecological Sensitivity**	High
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-17: Site photographs of the Lower Keiskamma EWR site.

The EWR for the Lower Keiskamma River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for June, September and March. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 19 September 2022 was 0.568 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-18**). Although good rainfall occurred the week before, the flows were very low during the survey. This is possibly due to the dams upstream not releasing into the river.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for September did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The recommended drought flows for June were also low, and didn't provide adequate velocities and habitats and were adjusted. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance and drought) were adjusted as follows:

Increase September maintenance low flows from 0.468 m^3/s to 0.754 m^3/s.

Increase June drought flows from 0.147 m^3/s to 0.220 m^3/s.

Additionally, the maintenance low flows for June, July and August should be reduced to approximately 0.220 m^3/s to prevent the Simuliidae outbreak (refer to chapter 8 for further information).

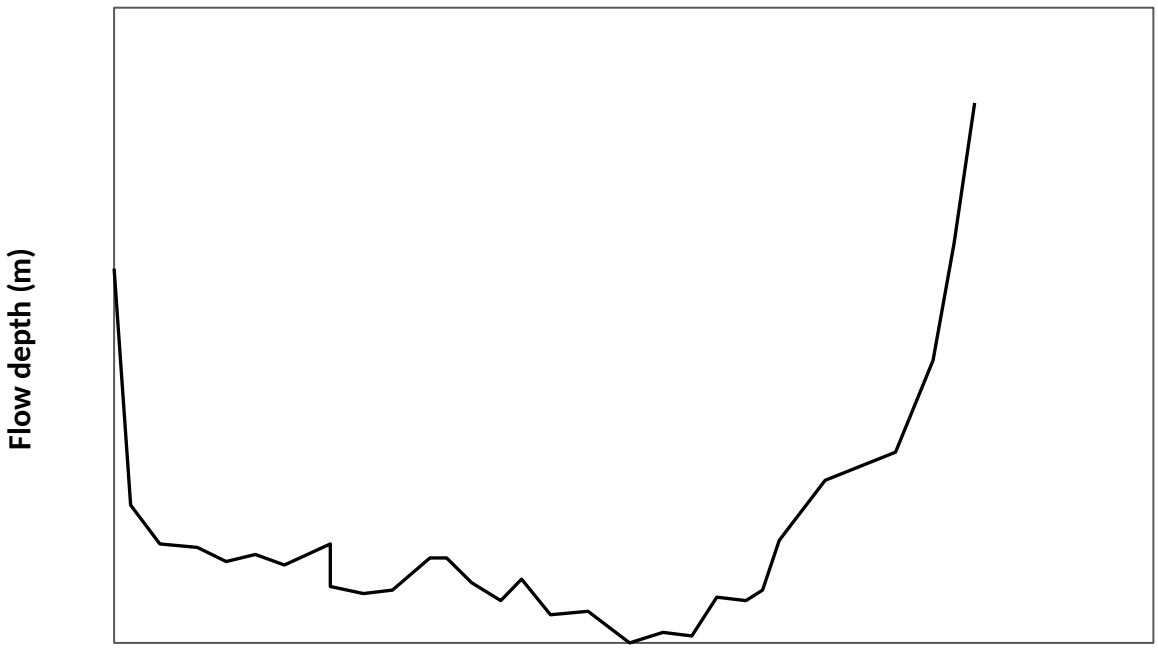


Figure 6-18: Water levels on cross-section of the EWR site for Keiskamma River in R10L.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-16** and the final EWR for the Lower Keiskamma River at the EWR site is summarised in **Table 6-17**.

Table 6-16: Lower Keiskamma - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	3	3	January	7	3
October	4	3	February	7	3
November	10	3	March	10	3
December	7	3			

Table 6-17: Lower Keiskamma - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	R10L
River	Lower Keiskamma
Site code	KEIS02_R
Coordinates	-33.075316; 27.218534
Recommended Ecological Category	B/C
nMAR at EWR site	107.8
Total EWR	30.019 (27.85 %MAR)
Maintenance Low flows	22.554 (20.92 %MAR)
Drought Low flows	9.073 (8.42 %MAR)
Maintenance High flows	7.465 (6.93 %MAR)
Overall confidence	Low

6.10 TYUM01_R: Tyume River

Sample Date	14 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	TYUM01_R	**IUA**	IUA_R01
River	Tyume	**IUA description**	Keiskamma
Altitude (m.a.s.l.)	347m	**Prioritised RU**	R_RU17_R
Latitude	-32.910291	**Longitude**	26.932242
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**R10H**
Level 2 EcoRegion	18.02	**SQ Reach**	R10H-07938
Geomorphological zone	D (slope 0.008)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	High
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-19: Site photographs of the Tyume EWR site.

The EWR for the Tyume River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for June, September and March. June is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 14 September 2022 was 0.198 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-20**). Although good rainfall occurred the week before, the flows were very low during the survey. This is possibly due to the dam upstream not releasing into the river.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for September did not provide adequate velocities and availability of instream habitats for the

macroinvertebrates. The recommended drought flows for June were also low, and didn't provide adequate velocities and habitats and were adjusted. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance and drought) were adjusted as follows:

Increase September maintenance low flows from 0.145 m^3/s to 0.237 m^3/s.

Increase June drought flows from 0.046 m^3/s to 0.0.076 m^3/s.

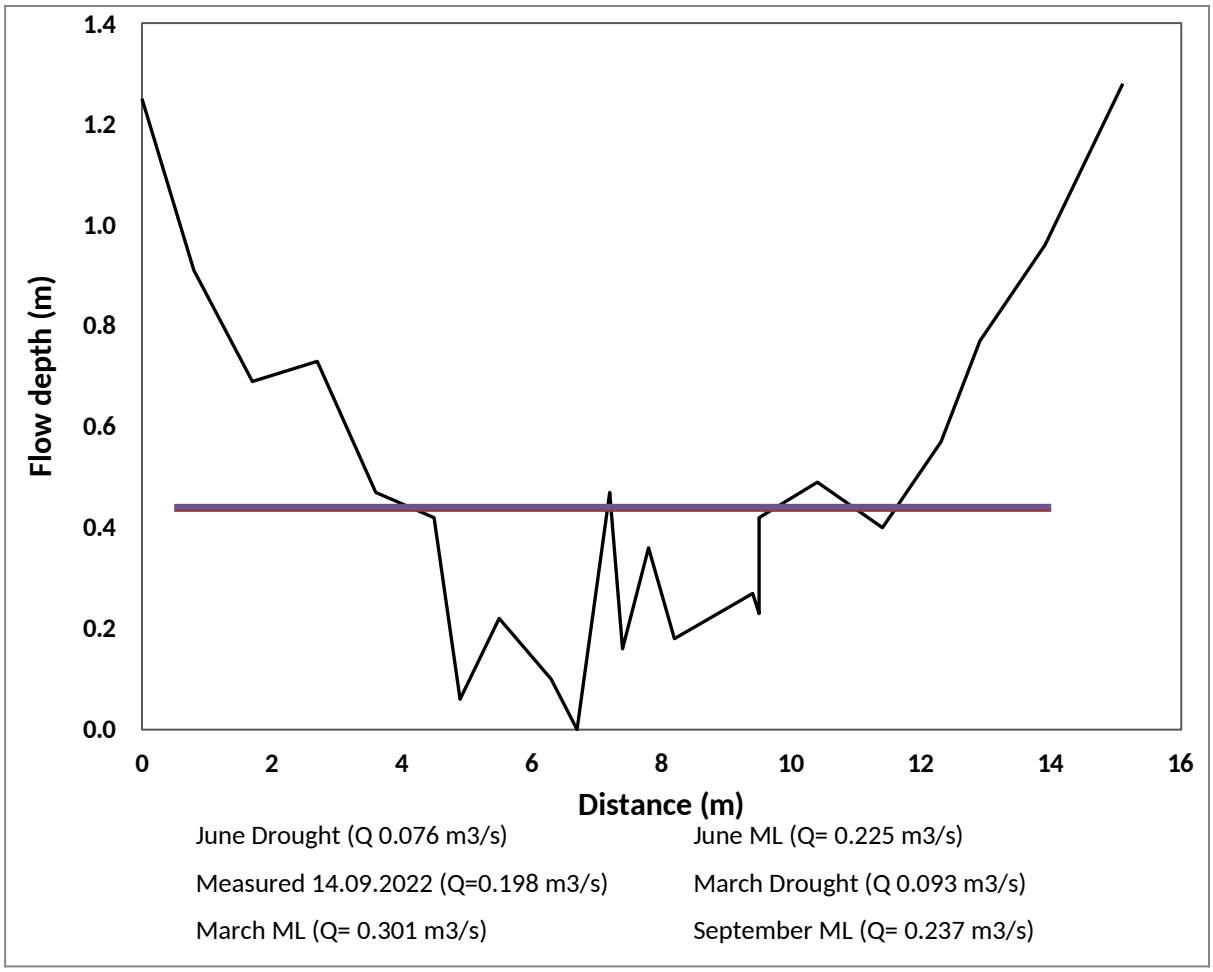


Figure 6-20: Water levels on cross-section of the EWR site for Tyume River in R10H.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-18** and the final EWR for the Tyume River at the EWR site is summarised in **Table 6-19**.

Table 6-18: Tyume - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	1.5	3	January	2	3
October	1.5	3	February	2	3
November	5	3	March	5	3
December	2	3			

Table 6-19: Tyume - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	R10H
River	Tyume
Site code	TYUM01_R
Coordinates	-32.910291; 26.932242
Recommended Ecological Category	B/C
nMAR at EWR site	32.6
Total EWR	11.141 (34.15 %MAR)
Maintenance Low flows	8.186 (25.09 %MAR)
Drought Low flows	2.744 (8.41 %MAR)
Maintenance High flows	2.955 (9.06 %MAR)
Overall confidence	Low to moderate

6.11 KOON01_R: Koonap River

Sample Date	12 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	KOON01_R	**IUA**	IUA_Q03
River	Koonap	**IUA description**	Koonap and Kat
Altitude (m.a.s.l.)	229m	**Prioritised RU**	R_RU16_R
Latitude	-33.042856	**Longitude**	26.658506
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**Q92G**
Level 2 EcoRegion	18.02	**SQ Reach**	Q92G-08203
Geomorphological zone	E (slope 0.003)	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-21: Site photographs of the Koonap EWR site.

The EWR for the Koonap River were determined for a REC of a D. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for July, September and March. July is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 12 September 2022 was 0.230 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-22**). The flows were low during the survey.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for September did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for

those

flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows (maintenance and drought) were adjusted as follows:

Increase September maintenance low flows from 0.072 m^3/s to 0.193 m^3/s.

Additionally, the maintenance low flows for July were also adjusted to 0.176m^3/s prevent the Simuliidae outbreak (refer to chapter 8 for more information).

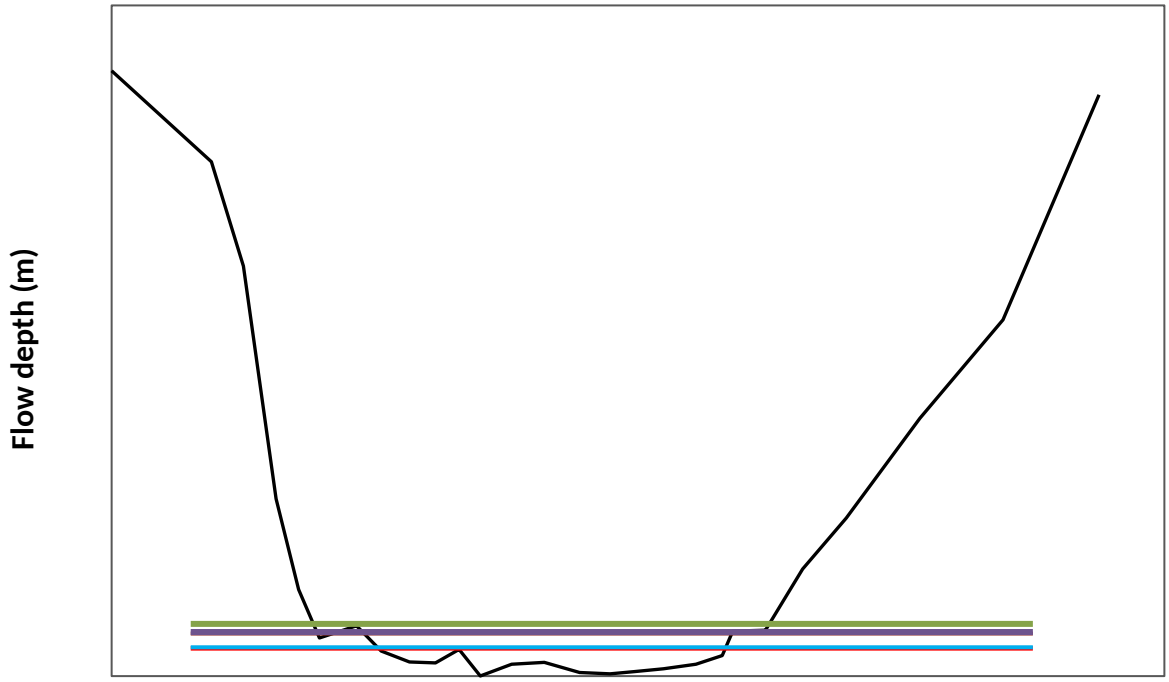


Figure 6-22: Water levels on cross-section of the EWR site for Koonap River in Q92G.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-20** and the final EWR for the Koonap River at the EWR site is summarised in **Table 6-21**.

Table 6-20: Koonap - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	3	3	January	5	3
October	3	3	February	5	3
November	7	3	March	12	3
December	7	3			

Table 6-21: Koonap - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	R10H
River	Koonap
Site code	KOON01_R
Coordinates	-33.042856; 26.658506
Recommended Ecological Category	D
nMAR at EWR site	76.9
Total EWR	13.403 (17.41 %MAR)
Maintenance Low flows	6.871 (8.93 %MAR)
Drought Low flows	2.377 (3.09 %MAR)
Maintenance High flows	6.532 (8.49 %MAR)
Overall confidence	Low to moderate

6.12 KAT02_R: Lower Kat River

Sample Date	12 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	KAT02_R	**IUA**	IUA_Q03
River	Kat	**IUA description**	Koonap and Kat
Altitude (m.a.s.l.)	325	**Prioritised RU**	R_RU15_R
Latitude	-32.890965	**Longitude**	26.68407
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	**Q94F**
Level 2 EcoRegion	18.02	**SQ Reach**	Q94F-07911
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-23: Site photographs of the Lower Kat EWR site.

The EWR for the Lower Kat River were determined for a REC of a C/D. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for July, September and March. July is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 12 September 2022 was 0.025 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-24**). The flows were extremely low during the survey, due to numerous weirs for irrigation upstream of the site. However, these flows still provided adequate velocities and habitats.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for

September did not provide adequate velocities and availability of instream habitats for the

macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). The drought flows were adjusted for all the months as the habitats available under these very low flow conditions were adequate. Therefore, the recommended flows were adjusted as follows:

Increase September maintenance low flows from 0.094 m^3/s to 0.136 m^3/s.

Reduce September drought flows from 0.055 m^3/s to 0.026 m^3/s.

Additionally, the maintenance low flows for June, July and August should be reduced to approximately 0.103 m^3/s, 0.088 m^3/s and 0.090 m^3/s to prevent the outbreak of Simuliidae in this reach (refer to Chapter 8 for further information).

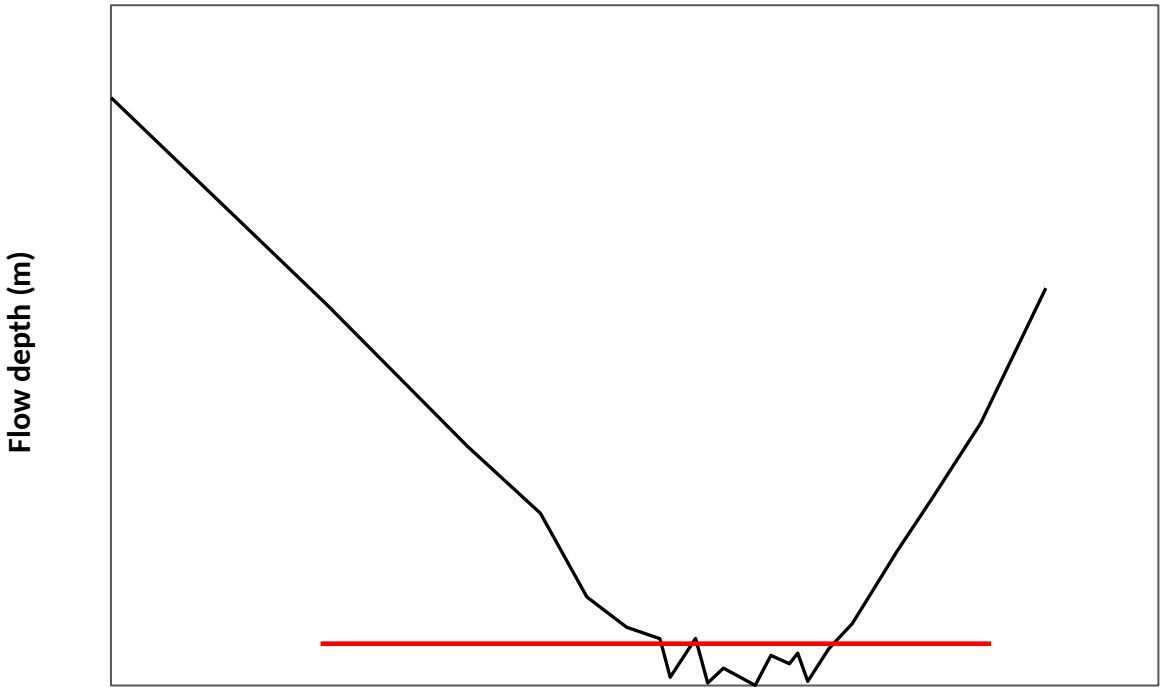


Figure 6-24: Water levels on cross-section of the EWR site for Lower Kat River in Q94F.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-22** and the final EWR for the Lower Kat River at the EWR site is summarised in **Table 6-23**.

Table 6-22: Lower Kat - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	1.5	3	January	3.5	3
October	1.5	3	February	3.5	3
November	5	3	March	5	3
December	3.5	3			

Table 6-23: Lower Kat - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q94F
River	Lower Kat
Site code	KAT02_R
Coordinates	-32.890927; 26.684335
Recommended Ecological Category	C/D
nMAR at EWR site	61.8
Total EWR	9.372 (15.16 %MAR)
Maintenance Low flows	5.717 (9.25 %MAR)
Drought Low flows	1.188 (1.92 %MAR)
Maintenance High flows	3.655 (5.91 %MAR)
Overall confidence	Low to moderate

6.13 SUND02_R: Lower Sundays River

Sample Date	23 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	SUND02_R	**IUA**	IUA_N01
River	Sundays	**IUA description**	Sundays downstream Darlington Dam
Altitude (m.a.s.l.)	97	**Prioritised RU**	R_RU04_R
Latitude	-33.404384	**Longitude**	25.407919
Level 1 EcoRegion	South Eastern Coastal Belt	**Quaternary catchment**	**N40C**
Level 2 EcoRegion	20.01	**SQ Reach**	N40C-08566
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-25: Site photographs of the Lower Sundays EWR site.

The EWR for the Lower Sundays River were determined for a REC of a D. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for July, September and March. July is the month with the lowest average flow (i.e., baseflow) and March is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in September, it was used as a datum to guide the ecologists in setting the EWRs.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 23 September 2022 was 0.141 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-26**). The flows were extremely low during the survey, due to no releases from upstream weir and all the flows in the river were return flows from the irrigation in the catchment.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for September did not provide adequate velocities and availability of instream habitats for the macroinvertebrates. The maintenance low flows were adjusted to ensure increased velocity for those flow dependent macroinvertebrates present, as well as provided additional critical habitats namely fast course substrate and/or very fast course substrate (being the stones biotope). Therefore, the recommended flows were adjusted as follows:

Increase September maintenance low flows from 0.093 m^3/s to 0.141 m^3/s.

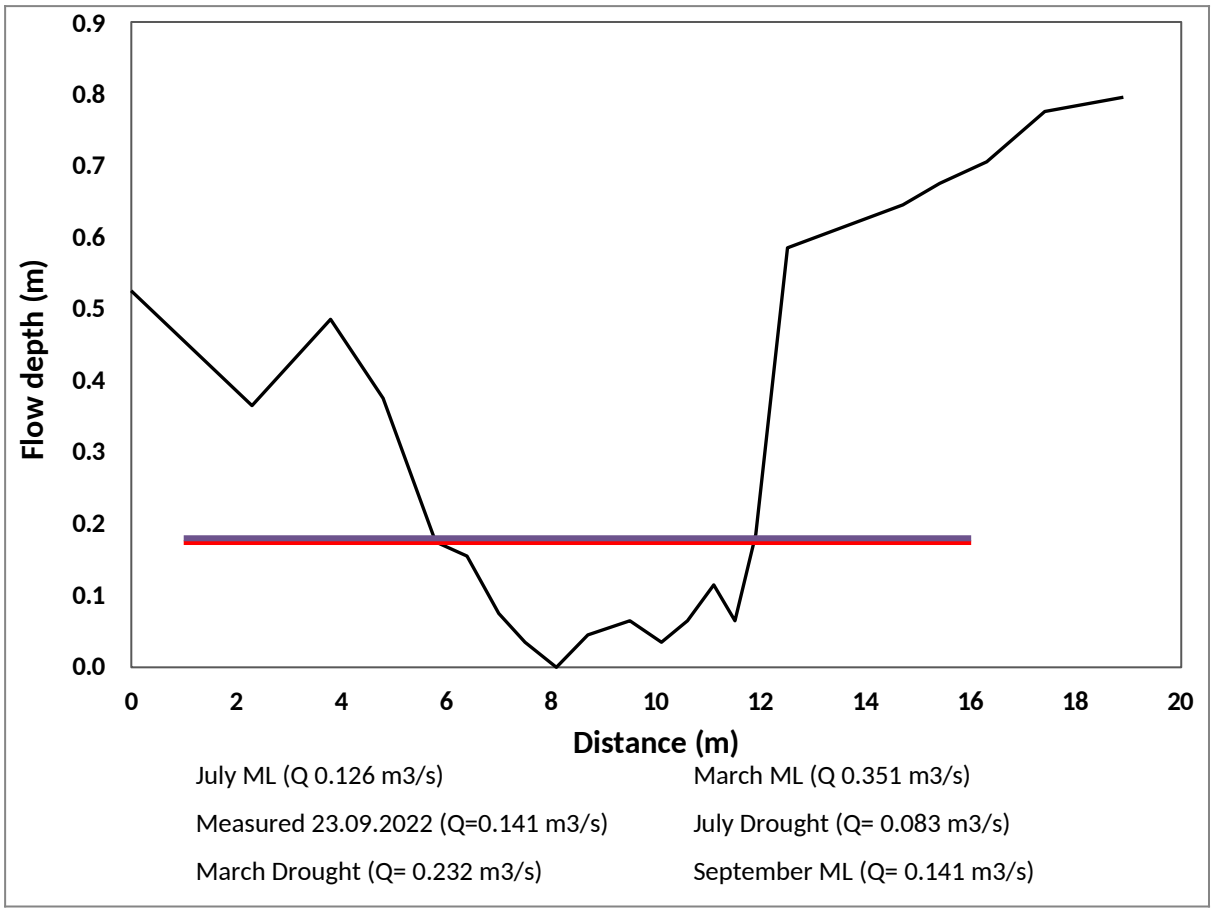


Figure 6-26: Water levels on cross-section of the EWR site for Lower Sundays River in N40C.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-24** and the final EWR for the Lower Sundays River at the EWR site is summarised in **Table 6-25**.

Table 6-24: Lower Sundays - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
September	2	3	January	4	3
October	2	3	February	6	3
November	6	3	March	8	3
December	6	3			

Table 6-25: Lower Sundays - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	N40C
River	Lower Sundays
Site code	SUND02_R
Coordinates	-33.404384; 25.407919
Recommended Ecological Category	D
nMAR at EWR site	214.0
Total EWR	11.592 (5.42 %MAR)
Maintenance Low flows	6.304 (2.95 %MAR)
Drought Low flows	4.166 (1.95 %MAR)
Maintenance High flows	5.288 (2.47 %MAR)
Overall confidence	Low to moderate

6.14 KOUG01_R: Kouga River

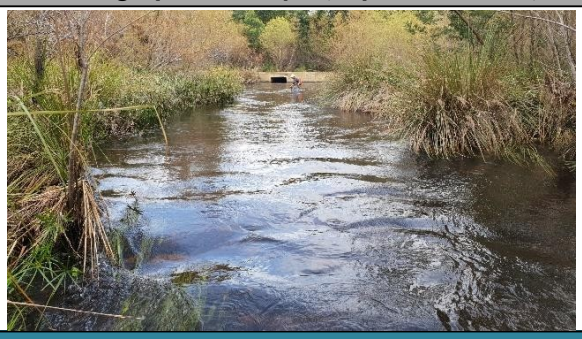
Sample Date	26 September 2022	**Reserve Level Assessment**	**Rapid 3**
Site Name	KOUG01_R	**IUA**	IUA_L01
River	Kouga	**IUA description**	Kouga to Kouga Dam, Baviaanskloof
Altitude (m.a.s.l.)	321	**Prioritised RU**	R_RU05_R
Latitude	-33.788449	**Longitude**	24.025821
Level 1 EcoRegion	Southern Folded Mountains	**Quaternary catchment**	**L82D**
Level 2 EcoRegion	19.02	**SQ Reach**	L82D-08977
Geomorphological zone	E (slope 0.003)	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 6-27: Site photographs of the Kouga EWR site.

The EWR for the Kouga River were determined for a REC of a B/C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for August and February. February is the month with the lowest average flow (i.e., baseflow) and August is the month with the highest average flow conditions (according to the natural flows).

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for drought and maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 26 September 2022 was 2.138 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-28**). The flows were high during the survey, due to rainfall in the catchment a few days before the survey and sampling was undertaken during the receding limb of the freshet.

The consensus reached by the aquatic ecologists was that the recommended maintenance flows for August provided more than adequate velocities and availability of instream habitats for the macroinvertebrates. Thus, the maintenance low flows were adjusted downward as it would still provide adequate velocities for those flow dependent macroinvertebrates present. Therefore, the recommended flows were adjusted as follows:

Decrease August maintenance low flows from 0.765 m^3/s to 0.607 m^3/s.

Additionally, the maintenance low flows for August were also adjusted to 0.607m^3/s to prevent the Simuliidae outbreak (refer to chapter 8 for more information).

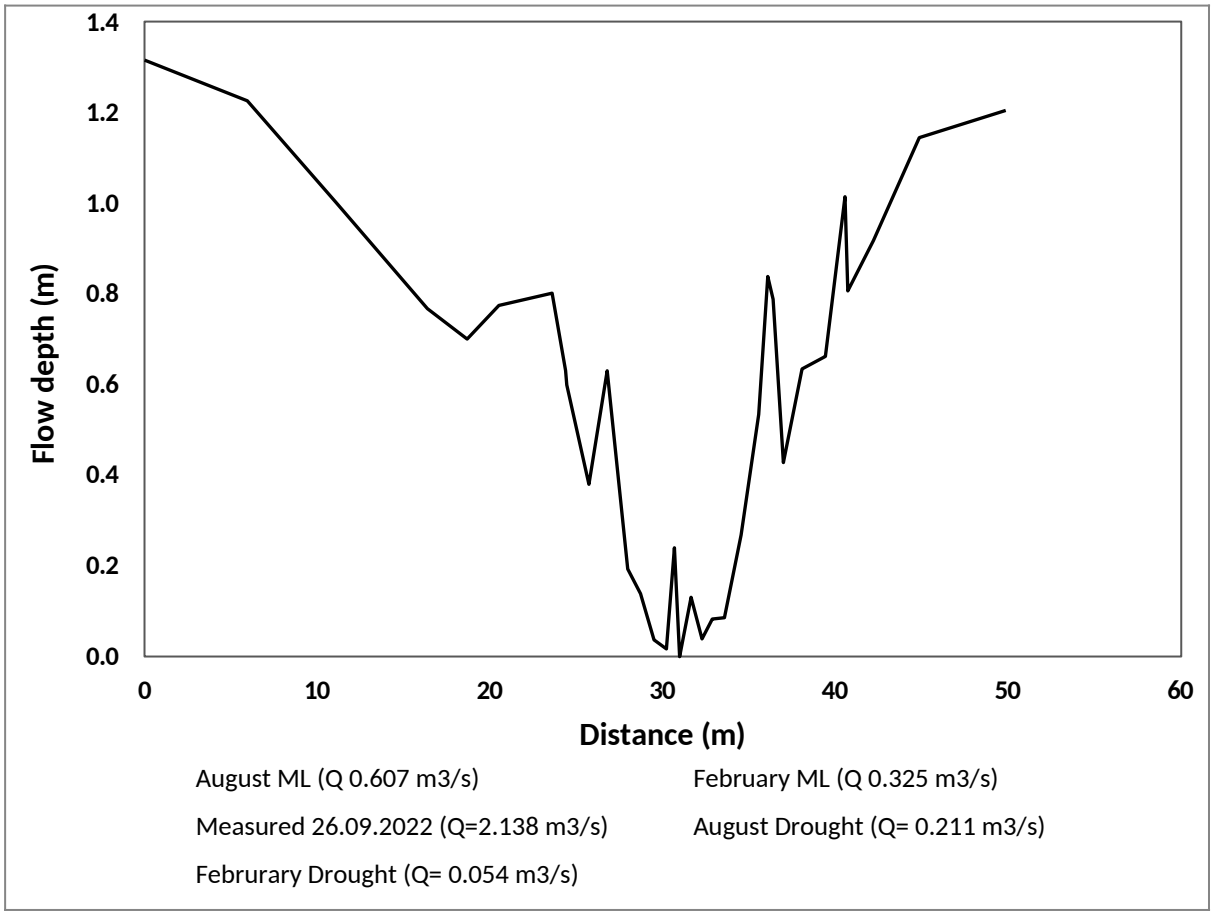


Figure 6-28: Water levels on cross-section of the EWR site for Kouga River in L82D.

The freshets and annual floods as required by the aquatic ecosystem for fish and macroinvertebrates are presented in **Table 6-26** and the final EWR for the Kouga River at the EWR site is summarised in **Table 6-27**.

Table 6-26: Kouga - Freshet requirements for implementation.

Months		Freshets/ Floods			
	m^3/s	days		m^3/s	days
April	3	2	August	20	3
May	10	3	September	10	3
June	10	3	October	5	2
July	5	3	November	5	2

Table 6-27: Kouga - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	L82D
River	Kouga
Site code	KOUG01_R
Coordinates	-33.788449; 24.025821
Recommended Ecological Category	B/C
nMAR at EWR site	155.1
Total EWR	24.471 (15.78 %MAR)
Maintenance Low flows	14.345 (9.25 %MAR)
Drought Low flows	4.896 (3.16 %MAR)
Maintenance High flows	10.126 (6.53 %MAR)
Overall confidence	Low

6.15 KROM01_R: Upper Kromme River

Sample Date	5 May 2023	**Reserve Level Assessment**	**Rapid 3** *(higher confidence, including VEGRAI)*
Site Code	KROMM01_R	**IUA**	IUA_K01
River	Upper Kromme	**IUA description**	Tsitsikamma and headwaters of Kromme to Kromme Dam
Altitude (m.a.s.l.)	239	**Prioritised RU**	R_RU01_I
Latitude	-33.9370951	**Longitude**	24.2690587
Level 1 EcoRegion	South-Eastern Coastal Belt	**Quaternary catchment**	**K90A**
Level 2 EcoRegion	20.02	**SQ Reach**	K90A-09040
Geomorphological zone	D (slope: 0.005)	**PES (DWS, 2014)**	D
Ecological Importance	High	**Ecological Sensitivity**	High
Site Photographs: Survey 2 (May 2023)			
			
Upstream		**Downstream**	

Figure 6-29: Site photographs of the Upper Kromme EWR site.

The EWR for the Upper Kromme River were determined for a REC of a C. The EWR flow data from the DRM was converted to hydraulic conditions at the EWR site (i.e., depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance flows were examined for September, February and May. February is the month with the lowest average flow (i.e., baseflow) and September is the month with the highest average flow conditions (according to the natural flows). As the survey was undertaken in May, it was used as a datum to guide the ecologists in setting the EWRs.

The EWRs have also been determined as part of the 2006 comprehensive Reserve determination study for the Kromme River. Comparisons between the 2006 (Krom-EWR1) and current study were made (REC of a C for both studies) and the drought and freshet/ flood requirements of the 2006

were

accepted. However, the maintenance low flows were adjusted as the PES for the current study is a D category compared to the C category for the 2006 study.

Together with the site photographs and rating relationships (flow depth versus discharge) from the hydraulic model, water levels proposed by the DRM for maintenance low flows were assessed in terms of the habitat and biotic requirements. The site-specific flow requirements were based mainly on the velocity and habitat requirements of flow-sensitive aquatic macroinvertebrates.

The discharge at the EWR site during the survey on 5 May 2023 was 1.156 m^3/s and was used as reference to adjust the recommended EWRs (see **Figure 6-30**). The flows were very high during the survey, due to good rainfall in the catchment during the autumn season.

Thus, the consensus reached by the aquatic ecologists was that the recommended maintenance low flows for February, May and September should be adjusted to provide adequate velocities and availability of instream habitats for the macroinvertebrates. Therefore, the recommended flows were adjusted as follows:

Increase February (2006) maintenance low flows from 0.100 m^3/s to 0.122 m^3/s.

Increase May (2006) maintenance low flows from 0.120 m^3/s to 0.162 m^3/s.

Increase September (2006) maintenance low flows from 0.200 m^3/s to 0.257 m^3/s.

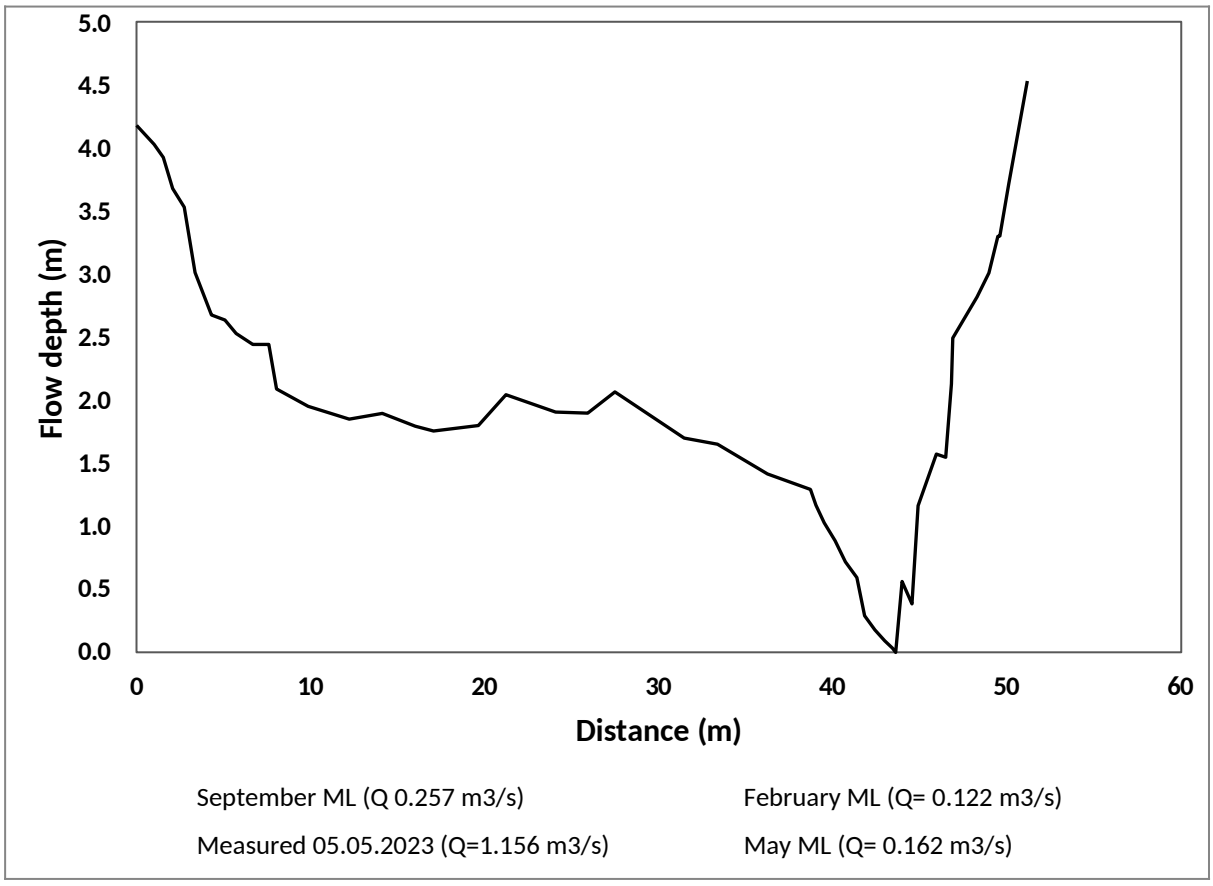


Figure 6-30: Water levels on cross-section of the EWR site for Kromme River in K90A.

The final EWR for the Upper Kromme River and a comparison with the final 2006 EWR at the EWR site is summarised in **Table 6-28**.

Table 6-28: Kouga - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	K90A	
River	Upper Kromme	
Site code	KROM01_R	
Coordinates	-33.937095; 24.269058	
Recommended Ecological Category	C	
nMAR at EWR site	27.6	34.3
	Current, 2023	2006
Total EWR	10.106 (36.66 %MAR)	27.5 %MAR
Maintenance Low flows	5.683 (20.61 %MAR)	13.8 %MAR
Drought Low flows	0.663 (2.40 %MAR)	1.93 %MAR
Maintenance High flows	4.424 (16.05 %MAR)	15.9 %MAR
Overall confidence	High	

The higher percentage requirement for the current study is mainly due to the increased requirements in the maintenance flows as well as the lower natural MAR with the revised hydrology.

7. EWR RESULTS: FIELD VERIFICATION/ DESKTOP SITES

Additional to the Intermediate and Rapid 3 EWR sites, several field verification and desktops sites have been identified as hydronodes to provide requirements in IUAs with multiple outlets or where the selected EWR sites was not close to the outlet of the IUA. Where a EWR site was selected in the upper catchment, but in the same ecoregion level 2, the characteristics of the EWR site was used for **extrapolatation to the hydronodes**. In the lower reaches of rivers where no EWR sites were selected, the estuarine requirements will be used. The results of previous Reserve determination studies will also be utilised in those catchments or IUAs where no new sites were selected and surveyed.

It should be noted that the PES for these field verification sites were based on the diatoms and IHI results, taking into consideration the results of the 2014 desktop PES/EI/ES, including professional opinion. As no hydraulic cross-sections were surveyed at these sites, the EWRs as proposed by the DRM were accepted, except where extrapolation has been undertaken, using the characteristic of the EWRs from Rapid 3 or Intermediate sites.

7.1 XORA01_D: Xora River

Site Name	XORA01_D	**Reserve Level Assessment**	**Desktop**
River	Xora	**IUA**	IUA_T04
Quaternary catchment	**T80D**	**IUA description**	Pondaland Coastal
Latitude	-32.135524	**Longitude**	28.973139
Level 1 EcoRegion	Eastern Coastal Belt	**Level 2 EcoRegion**	31.02
SQ Reach	T80D-06960	**PES (DWS, 2014)**	B
Ecological Importance	Moderate	**Ecological Sensitivity**	High

The Xora River represent drainage region T80 in this IUA. As no surveys were undertaken for any of the rivers in the T80 drainage region, only desktop information is available for the classification of the water resources. The estuarine requirements will possibly drive the final ecological requirements as it is situated just downstream of the EWR site in quaternary catchment T80D. The final EWR for REC of a B for this site is specified below in **Table 7.1**.

Table 7-1: Xora - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T80D
nMAR at EWR site	83.0
Recommended Ecological Category (REC)	B
Total EWR	25.334 (30.53 %MAR)
Maintenance Low flows	14.381 (17.33 %MAR)
Drought Low flows	3.738 (4.50 %MAR)
Maintenance High flows	10.953 (13.20 %MAR)
Overall confidence	Very low
Estuary downstream	T80D, just below EWR site

7.2 MTHA02_D: Upper Mthatha River

Site Name	MTHA02_D	**Reserve Level Assessment**	**Desktop**
River	Upper Mthatha	**IUA**	IUA_T01
Quaternary catchment	**T20A**	**IUA description**	Upper Mbhashe , Upper Mthatha
Latitude	-31.475254	**Longitude**	28.605656
Level 1 EcoRegion	South Eastern Uplands	**Level 2 EcoRegion**	16.06
SQ Reach	T20A-06425	**PES (DWS, 2014)**	C
Ecological Importance	Low	**Ecological Sensitivity**	Moderate

This site on the Upper Mthatha River represents one of the outlets of IUA_T01. As no surveys were undertaken at this site, only desktop information is available for the classification. However, a rapid 3 was undertaken on the Upper Mbashe River (MBHA02_R) that is the main outlet of this IUA. The final EWR for REC of a C for this site is specified in Table 7-2 below.

Table 7-2: Upper Mthatha - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	T20A
nMAR at EWR site	122.5
Recommended Ecological Category (REC)	C
Total EWR	26.320 (21.49 %MAR)
Maintenance Low flows	14.410 (11.76 %MAR)
Drought Low flows	6.904 (5.64 %MAR)
Maintenance High flows	11.910 (9.72 %MAR)
Overall confidence	Very low

7.3 BUFF02_FV: Lower Buffalo River

Site Name	BUFF02_FV	**Reserve Level Assessment**	**Field verification**
River	Lower Buffalo	**IUA**	IUA_R02
Quaternary catchment	**R20G**	**IUA description**	Buffalo/ Nahoon
Latitude	-32.991768	**Longitude**	27.775910
Level 1 EcoRegion	Eastern Coastal Belt	**Level 2 EcoRegion**	31.02
SQ Reach	R20F-08045	**PES (DWS, 2014)**	D
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 7-1: Site photographs of the Lower Buffalo EWR site.

This site on the Lower Buffalo River represents the outlet of IUA_R02. Due to the extensive water quality impacts and no good hydraulic site for the surveying of a cross-section, only a field verification was undertaken to determine the PES.

This EWR site falls in the same ecoregion level 2 as the Intermediate EWR site on the Middle Buffalo (BUFF01_I) and thus the characteristics of this site was used to extrapolate the requirements for the maintenance low and drought flows. The REC is a D category at both the EWR sites.

As the increase in nMAR is less than 10% and the Bridle Drift Dam is beteen the EWR sites, the freshets and floods as specified for the Intermediate site was used at this site. The final EWR for REC of a D for this site is specified in Table 7-3 below.

Table 7-3: Lower Buffalo - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	R20G
nMAR at EWR site	91.9
Recommended Ecological Category (REC)	D
Total EWR	30.187 (32.83 %MAR)
Maintenance Low flows	14.842 (16.14 %MAR)
Drought Low flows	5.070 (5.51 %MAR)
Maintenance High flows	15.345 (16.69 %MAR)
Overall confidence	Low to moderate
Estuary downstream	R20G, just below EWR site but converted into a harbour

7.4 TARK01_FV: Tarka River

Site Name	TARK01_R	Reserve Level Assessment	Field Verification
River	Tarka	IUA	IUA_Q02
Quaternary catchment	Q44C	IUA description	Great Fish
Latitude	-32.283315	Longitude	25.759280
Level 1 EcoRegion	Drought Corridor	Level 2 EcoRegion	18.01
SQ Reach	Q44C-7276	PES (DWS, 2014)	D
Ecological Importance	Moderate	Ecological Sensitivity	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		Downstream	

Figure 7-2: Site photographs of the Tarka EWR site.

The Tarka River is one of the larger tributaries in this IUA_Q02 with the Great Fish as the main stem. The other tributaries in the IUA are all small and almost seasonal and contributes very little to the flows in the middle reaches of the Great Fish River. Lake Arthur Dam is upsteam of this EWR site and releases from the dam are made into a canal system with almost no flows in the river for long periods except return flows from the extensive irrigation. The final EWR for REC of a D for this site is specified in **Table 7-4** below.

Table 7-4: Tarka - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q44C
nMAR at EWR site	63.3
Recommended Ecological Category (REC)	D
Total EWR	7.731 (12.21 %MAR)
Maintenance Low flows	1.667 (2.63 %MAR)
Drought Low flows	1.603 (2.53 %MAR)
Maintenance High flows	6.064 (9.57 %MAR)
Overall confidence	Low

7.5 FISH02_FV: Middle Great Fish River

Site Name	FISH02_FV	**Reserve Level Assessment**	**Field Verification**
River	Great Fish	**IUA**	IUA_Q02
Quaternary catchment	**Q50B**	**IUA description**	Great Fish
Latitude	-32.604885	**Longitude**	25.751772
Level 1 EcoRegion	Drought Corridor	**Level 2 EcoRegion**	18.02
SQ Reach	Q50C-07657	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			

Figure 7-3: Site photographs of the Middle Great Fish EWR site.

The flows at this EWR site on the Middle Great Fish River are impacted by the Orange River (Gariep Dam) transfer to the Fish River. The Elandsdrift weir (Q5H007), approximately 20 km upstream of the EWR site, is used to release the flows into either a canal system or into the river for irrigation downstream. Most of the time the system operates to release high volumes of water for part of a week and then to reduce releases for the rest of the week. During early winter (mostly June) the releases are discontinued for approximately a month for maintenance on the weir and canal system. This operation of the system impacts on the available habitats and biota (see **Figure 7-4** below). The final EWR for REC of a D for this site is specified below.

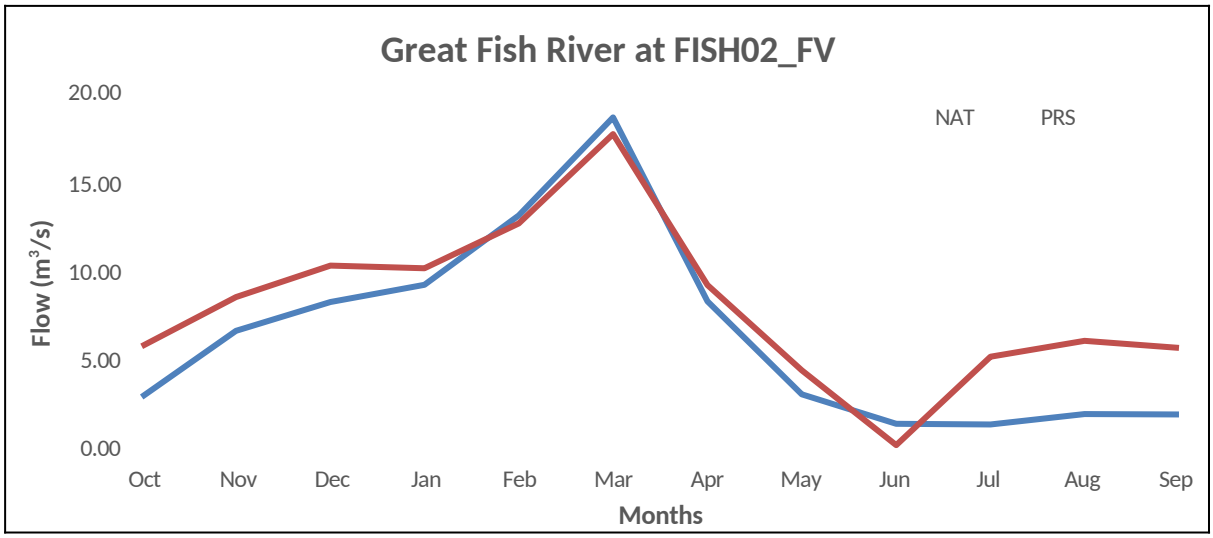


Figure 7-4: Monthly hydrograph for Great Fish River at FISH02_FV.

Unfortunately, during both surveys, the flows were too high to undertake any surveys (both biota and hydraulics). Thus, the minimum flows that are specified in the table below are on a desktop level with some information from the field verification that was undertaken and based on the natural flows. The possible changes to operation will be further addressed as part of the ecological consequences and trade-offs tasks of this study. The final EWR for this site for a REC of D is specified in **Table 7-5** below.

Table 7-5: Middle Great Fish - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q50B
nMAR at EWR site	201.9
Recommended Ecological Category (REC)	D
Total EWR	25.233 (12.50 %MAR)
Maintenance Low flows	6.270 (3.11 %MAR)
Drought Low flows	6.270 (3.11 %MAR)
Maintenance High flows	18.963 (9.39 %MAR)
Overall confidence	Low

7.6 LFIS02_FV: Lower Little Fish River

Site Name	LFIS02_FV	**Reserve Level Assessment**	**Field Verification**
River	Little Fish	**IUA**	IUA_Q01
Quaternary catchment	**Q80G**	**IUA description**	Upper Fish
Latitude	-33.09345	**Longitude**	25.82152
Level 1 EcoRegion	Drought Corridor	**Level 2 EcoRegion**	18.03
SQ Reach	Q80G-08143	**PES (DWS, 2014)**	C
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 7-5: Site photographs of the Lower Little Fish EWR site.

Like the Middle Great Fish, the flows at this EWR site on the Lower Little Fish River are impacted by the Orange River (Gariep Dam) transfer to the Fish River. The De Mistkraal Dam (Q8R001), approximately 25 km upstream of the EWR site, regulates releases of flows into either a canal system or into the river for irrigation downstream. Most of the time the system operates to release high volumes of water with a shut down period early winter (mostly June) when the releases are discontinued for approximately a month for maintenance of the canal system. This operation of the system impacts on the available habitats and biota (see **Figure 7-6** below).

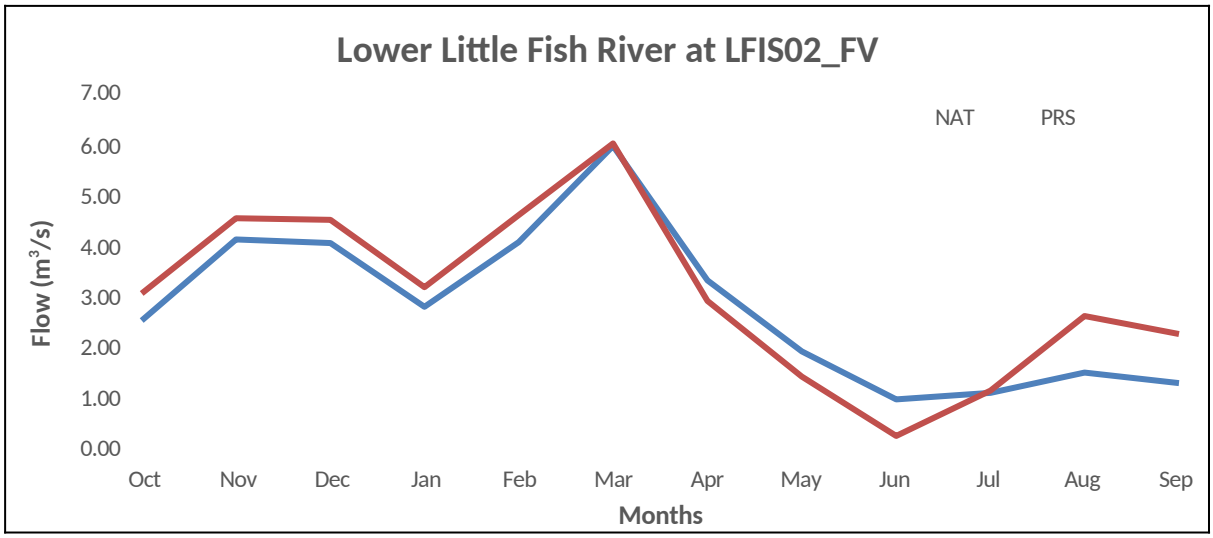


Figure 7-6: Monthly hydrograph for Lower Little Fish River at LFIS02_FV.

This reach was not initially included as a priority, but a field verification was undertaken to provide some indication of the present state of the river. Again, the minimum flows that are specified in the table below are on a desktop level with some information from the field verification that was undertaken and based on the natural flows. The possible changes to operation will be further addressed as part of the ecological consequences and trade-offs tasks of this study. The final EWR for this site for a REC of C is specified in **Table 7-6** below.

Table 7-6: Lower Little Fish - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q80G
nMAR at EWR site	88.9
Recommended Ecological Category (REC)	C
Total EWR	16.786 (18.88 %MAR)
Maintenance Low flows	6.475 (7.28 %MAR)
Drought Low flows	2.265 (2.55 %MAR)
Maintenance High flows	10.310 (11.59 %MAR)
Overall confidence	Low

7.7 FISH01_FV: Upper Great Fish River

Site Name	FISH01_FV	**Reserve Level Assessment**	**Field Verification**
River	Upper Great Fish	**IUA**	IUA_Q01
Quaternary catchment	**Q21B**	**IUA description**	Upper Fish
Latitude	-31.919527	**Longitude**	25.390974
Level 1 EcoRegion	Drought Corridor	**Level 2 EcoRegion**	18.01
SQ Reach	Q21B-06817	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 7-7: Site photographs of the Upper Great Fish EWR site.

This EWR site on the Upper Great Fish is upstream of the Orange-Fish transfer and provides some indication of the natural characteristics of the river before the transfer scheme began. The site is also at the outlet of IUA_Q01 for the evaluation of scenarios to determine the class. Although the river is perennial, it has some seasonal tendencies with very low flows during dryer periods. The final EWR for this site for a REC of D is specified in **Table 7-7** below.

Table 7-7: Upper Great Fish - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q21B
nMAR at EWR site	18.0
Recommended Ecological Category (REC)	D
Total EWR	2.225 (12.35 %MAR)
Maintenance Low flows	0.517 (2.87 %MAR)
Drought Low flows	0.477 (2.65 %MAR)
Maintenance High flows	1.708 (9.48 %MAR)
Overall confidence	Low

7.8 LFIS01_FV: Upper Little Fish River

Site Name	LFIS01_FV	Reserve Level Assessment	Field Verification
River	Upper Little Fish	IUA	IUA_Q01
Quaternary catchment	Q80B	IUA description	Upper Fish
Latitude	-32.50617	Longitude	25.42683
Level 1 EcoRegion	Drought Corridor	Level 2 EcoRegion	18.03
SQ Reach	Q80B-7445	PES (DWS, 2014)	B
Ecological Importance	High	Ecological Sensitivity	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		Downstream	

Figure 7-8: Site photographs of the Upper Little Fish EWR site.

This EWR site on the Upper Little Fish is upstream of De Mistkraal Dam (Q8R001) and the transfer and provides some indication of the natural characteristics of the river before the transfer scheme began. The site is also at the outlet of IUA_Q01 (IUA_Q01 has two outlets, namely Upper Great Fish and Upper Little Fish) that will be used for the evaluation of scenarios to determine the class. Although the river is perennial, it has some seasonal tendencies with very low flows during dryer periods. The final EWR for this site for a REC of B/C is specified in Table 7-8 below.

Table 7-8: Upper Little Fish - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	Q80B
nMAR at EWR site	24.3
Recommended Ecological Category (REC)	B/C
Total EWR	5.757 (23.72 %MAR)
Maintenance Low flows	2.600 (10.71 %MAR)
Drought Low flows	0.649 (2.67 %MAR)
Maintenance High flows	3.157 (13.01 %MAR)
Overall confidence	Low

7.9 BOES01_D: Boesmans River

Site Name	BOES01_D	**Reserve Level Assessment**	**Desktop**
River	Boesmans	**IUA**	IUA_P01
Quaternary catchment	**P10G**	**IUA description**	P primary catchment
Latitude	-33.543899	**Longitude**	26.391105
Level 1 EcoRegion	South Eastern Coastal Belt	**Level 2 EcoRegion**	20.01
SQ Reach	P10G-08723	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		**Downstream**	

Figure 7-9: Site photographs of the Boesmans EWR site.

This site on the Boesmans River was a priority to undertake an Intermediate assessment. However, the river was dry during both the surveys and had to be assessed on a desktop level. This system is naturally seasonal to ephemeral and more flood driven. The low or no flows in the river are further enhanced by water use in the upper catchments. As no surveys were undertaken for this river, the estuarine component will provide some indication as the flows that are required on a higher confidence.

The REC at the site is a B category (from 2014 desktop PES/EIS) that is very high, especially with no flows for long periods of time. However, as no data was available from surveys, it was accepted. The final EWR for this site for a REC of B is specified in Table 7-9 below.

Table 7-9: Boesmans - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	P10G
nMAR at EWR site	32.7
Recommended Ecological Category (REC)	B
Total EWR	8.972 (27.44 %MAR)
Maintenance Low flows	3.893 (11.91 %MAR)
Drought Low flows	0.183 (0.56 %MAR)
Maintenance High flows	5.079 (15.53 %MAR)
Overall confidence	Very low
Estuary downstream	P10G, approximately 30-40 km downstream of EWR site

7.10 SUND01_FV: Upper Sundays River

Site Name	SUND01_FV	Reserve Level Assessment	Field Verification
River	Upper Sundays	IUA	IUA_LN01
Quaternary catchment	N22E	IUA description	Groot to Kouga confluence, Upper Sundays to Darlington Dam
Latitude	-33.07812	Longitude	25.01548
Level 1 EcoRegion	Great Karoo	Level 2 EcoRegion	21.05
SQ Reach	N22C-08199	PES (DWS, 2014)	C
Ecological Importance	Moderate	Ecological Sensitivity	Moderate
Site Photographs: Survey 1 (September 2022)			
			
Upstream		Downstream	

Figure 7-10: Site photographs of the Upper Sundays EWR site.

This EWR site on the Upper Sundays is approximately 25 km upstream of Darlington Dam (N2R001) and the transfer from the Fish River. This site provides some indication of the natural characteristics of the Sundays River before the transfer scheme began and is at the outlet of IUA_LN01 that will be used for the evaluation of scenarios to determine the class. The river was dry during the surveys as it is naturally seasonal to ephemeral and more floods driven. Thus, the results are based on limited information based on field verifications with no hydraulic cross-section and biotic information. The final EWR for this site for a REC of C is specified in Table 7-10 below.

Table 7-10: Upper Sundays - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	N22E
nMAR at EWR site	148.0
Recommended Ecological Category (REC)	C
Total EWR	27.011 (18.25 %MAR)
Maintenance Low flows	9.306 (6.29 %MAR)
Drought Low flows	1.610 (1.09 %MAR)
Maintenance High flows	17.705 (11.96 %MAR)
Overall confidence	Low

7.11 GRT01_D: Groot River (L70G)

Site Name	GRT01_D	**Reserve Level Assessment**	**Desktop**
River	Groot (L70G)	**IUA**	IUA_LN01
Quaternary catchment	**L70G**	**IUA description**	Groot to Kouga confluence, Upper Sundays to Darlington Dam
Latitude	-33.743359	**Longitude**	24.613965
Level 1 EcoRegion	Southern Folded Mountains	**Level 2 EcoRegion**	19.02
SQ Reach	L70G-08902	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate

This EWR site, together with the site on the Upper Sundays forms the two outlets of IUA_LN01 and will be used to evaluate scenarios for trade-offs to determine the class. The Groot River is naturally perennial to seasonal with high variable flows between years and large flooding events. The final EWR for this site for a REC of B is specified in Table 7-11 below.

Table 7-11: Groot (L70G) - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	L70G
nMAR at EWR site	185.7
Recommended Ecological Category (REC)	B
Total EWR	55.562 (29.91 %MAR)
Maintenance Low flows	30.113 (16.21 %MAR)
Drought Low flows	7.086 (3.81 %MAR)
Maintenance High flows	25.449 (13.70 %MAR)
Overall confidence	Very low

7.12 BAVI01_D: Baviaanskloof River

Site Name	BAVI01_D	**Reserve Level Assessment**	**Desktop**
River	Baviaanskloof	**IUA**	IUA_L01
Quaternary catchment	**L81D**	**IUA description**	Kouga to Kouga Dam, Baviaanskloof
Latitude	-33.664914	**Longitude**	24.388605
Level 1 EcoRegion	Southern Folded Mountains	**Level 2 EcoRegion**	19.02
SQ Reach	L81D-08798	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate

The Baviaanskloof is a large tributary of the Kouga River and the EWR is at the confluence with the Kouga River. The river tends to be drier and more seasonal compared to the Kouga River with large flooding events. Although in the same ecoregion level 2 as the Kouga River, the characteristics of the Baviaanskloof is different and no extrapolation was undertaken using the rapid 3 site on the Kouga River. The final EWR for this site for a REC of B is specified in **Table 7-12** below.

Table 7-12: Baviaanskloof - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	L81D
nMAR at EWR site	48.1
Recommended Ecological Category (REC)	B
Total EWR	13.745 (28.58 %MAR)
Maintenance Low flows	6.670 (13.87 %MAR)
Drought Low flows	1.200 (2.49 %MAR)
Maintenance High flows	7.075 (14.71 %MAR)
Overall confidence	Very low

7.13 KOUG02_D: Kouga River

Site Name	KOUG02_D	**Reserve Level Assessment**	**Desktop**
River	Kouga	**IUA**	IUA_L01
Quaternary catchment	**L82H**	**IUA description**	Kouga to Kouga Dam, Baviaanskloof
Latitude	-33.739983	**Longitude**	24.587785
Level 1 EcoRegion	Southern Folded Mountains	**Level 2 EcoRegion**	19.02
SQ Reach	L82H-08862	**PES (DWS, 2014)**	E
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate

The Kouga River at this site is the outlet of IUA_L01. The 2014 desktop PES/EIS has the PES as an E category as the lower reaches of the river is within the Kouga Dam. However, for the purposes of this assessment, the hydronode is just upstream of the backwater of the dam, thus the PES was re-assessed as a C and the REC as a B/C category. The characteristics of the rapid 3 EWR site on the Kouga River in quaternary catchment L82D, upstream of this hydronode, was used to extrapolate the maintenance low flow requirements. The floods as specified for the rapid 3 site were adjusted using the increased nMAR at this site. The final EWR for this site for a REC of B/C is specified in **Table 7-13** below.

Table 7-13: Kouga - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	L82H
nMAR at EWR site	229.3
Recommended Ecological Category (REC)	B/C
Total EWR	36.353 (15.86 %MAR)
Maintenance Low flows	21.164 (9.23 %MAR)
Drought Low flows	9.083 (3.96 %MAR)
Maintenance High flows	15.189 (6.63 %MAR)
Overall confidence	Low

7.14 GROO01_FV: Groot River (K80D)

Site Name	GROO01_FV	Reserve Level Assessment	Field Verification
River	Groot (K80D)	IUA	IUA_K01
Quaternary catchment	K80D	IUA description	Tsitsikamma and headwaters of Kromme to Kromme Dam
Latitude	-34.032091	Longitude	24.195888
Level 1 EcoRegion	South Eastern Coastal Belt	Level 2 EcoRegion	20.02
SQ Reach	K80D-09182	PES (DWS, 2014)	C
Ecological Importance	Moderate	Ecological Sensitivity	High
Site Photographs: Survey 1 (September 2022)			
			
Upstream		Downstream	

Figure 7-11: Site photographs of the Groot (K80D) EWR site.

The Groot River represents drainage region K80 in this IUA. As no surveys were undertaken for any of the rivers in the K80 drainage region, only desktop information is available for the classification of the water resources. Although only a field verification was undertaken at this site due to be in flood during the surveys, macroinvertebrate information for the site (REMP site) was available for interpretation.

Also, the estuarine requirements will possibly drive the final ecological requirements for most of these small coastal rivers. The final EWR for this site for a REC of B/C is specified in Table 7-14 below.

Table 7-14: Groot (K80D) - Summary of the final EWR results (flows in Mm^3 per annum).

Quaternary Catchment	K80D
nMAR at EWR site	47.6
Recommended Ecological Category (REC)	B/C
Total EWR	13.838 (29.09 %MAR)
Maintenance Low flows	9.459 (19.88 %MAR)
Drought Low flows	3.580 (7.53 %MAR)
Maintenance High flows	4.379 (9.20 %MAR)
Overall confidence	Low
Estuary downstream	K80D, approximately 6 km dowmstream of EWR site

8. SIMULIIDAE OUTBREAK WITHIN THE CATCHMENT AREAS

One macroinvertebrate taxon detected in this study, which is of particular concern, was the blackfly larvae (family Simuliidae). Simuliidae are a major agricultural pest and have been observed in their outbreak densities within several of the systems within the Keiskamma, Fish to Tsitsikamma catchment areas. The Great Kei, being the most impacted. Refer to **Figure 8-1** illustrating the outbreak observed during the September 2022 survey, compared to the re-set system in May 2023 – following the floods in February 2023).

Simuliidae outbreak density – September 2022

System re-set owing to recent floods – May 2023

Figure 8-1: Simuliidae outbreak densities in the Great Kei River.

Simuliidae's occur in constant flowing water and, depending on the species, habitats range from highly saline clear trickling desert springs to fast flowing clear or highly turbid rapids in temperate or tropical big river systems (de Moor, 2003). Thus, the primary drivers for blackfly species occurrence and abundances are i) discharge, ii) water clarity, and iii) presence of benthic algae. These pest blackfly adult females will have negative impacts mostly on the agricultural industry in these catchment areas (i.e citrus farms). For the region's livestock (sheep) farming, impacts are also severe, with major financial losses per annum due to sheep deaths, or loss of meat or wool value in poor-condition sheep (Rivers-Moore *et al.* 2014). Although these densities may not be as high as what has been recorded from Prieska all the way downstream to Augrabies falls in the Lower Orange catchment (Rivers-Moore *et al.* 2014), this study has certainly flagged the outbreak potential in this study area and thus should be intensely monitored during the quarterly REMP monitoring (generally picked up during the SASS5 hand picking observations).

With the above mentioned, cognisance of these outbreaks will be taken when quantifying the EWR for those mostly affected sites. The critical periods for controlling population sizes of Simuliidae are generally July to August (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, reduced flows, and lower water levels, during these months is critical to expose the substrate to dry out blackfly larvae and pupae in these months (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). This may potentially avoid the typical spring outbreaks of blackfly's during the end of winter/spring seasonal period (i.e., September). Furthermore, ensuring that the required freshets or floods come through during the months of January, February, March is crucial for the scouring of the substrate and to ensure that the re-set of the systems are applied.

9. CONCLUSIONS

The ecological water requirements as presented in this report for the rivers in the Keiskamma, Fish to Tsitsikamma study area concludes step 4 of the Reserve determination process and aligns with Step 3 of the integrated framework, DWS (2017). The EWRs are based on the REC for all the rivers as determined during the eco-categorisation task of this study (see DWS, 1723a and DWS 1723b). The Present Ecological State, Ecological Importance, Ecological Sensitivity, and operational constraints due to dams, transfers, return flows and water quality were all considered with the determination of the final REC.

The present state of most of the major rivers in the study area as well as some tributaries have been degraded due to water resource developments, water use and water quality impacts. Increased flows due to water transfers within catchment and from other catchments (e.g. Orange-Fish) and releases for hydropower generation resulted in increased and constant flows in some of the rivers, including parts of Great Fish, Little Fish, Middle Mbashe and Lower Mthatha.

A few approaches have been followed to determine the EWRs depending on the specific impacts at the EWR sites, including changed flow patterns, water quality, or the type of river (perennial, seasonal or ephemeral). These approaches include:

i. Habitat Flow Stressor Response (HFSR) for the Intermediate EWR sites;
ii. Verification of the Desktop Reserve Model (DRM)/ Revised DRM within SPATSIM for the integration of data produced from the surveys and Eco-categorisation to quantify the EWRs for the rapid 3 sites;
iii. Desktop EWRs for those EWR sites where little or no information was available from field surveys; and
iv. Extrapolation using the characteristics of Rapid 3 or Intermediate sites where desktop/ field verification sites are in the same ecoregion level 2.

In some of the IUAs, where no Rapid 3 or Intermediate sites were surveyed due to dry rivers or time constraints, the estuarine requirements (pending on the approximaty of the estuary from the EWR site) will be used to provide information during the next step of the study.

The next step (step 4 of the Integrated Framework) is the development of operational scenarios where the feasibility of the implementation of the determined EWRs will be assessed taking system constraints and water use into consideration and provide ecological as well as socio-economic consequences for the final trade-off to determine the Water Resource Classes per IUA.

Please refer to **Table 9-1** for a summary of the REC and proposed EWRs for all the EWR sites (Intermediate, Rapid 3 and Field Verification/ Desktop).

Table 9-1: Summary of the EWR results for Keiskamma, Fish to Tsitsikamma catchment.

IUA	EWR site code	River	Latitude	Longitude	Quat*	PES	REC	MLow (%)	Drought (%)	Floods (%)	Total EWR as %nMAR for REC	nMAR (10^6m^3)
INTERMEDIATE												
IUA_T03	MTHA01_I	Mthatha (Lower)	-31.9262205	29.136473	T20G	C	B/C	23.11	18.19	14.71	37.81	389.2
IUA_T02	MBAS01_I	Mbhashe (Middle)	-31.9580984	28.472238	T13C	C/D	C/D	20.24	7.0	17.78	38.02	673.8
IUA_S02	BKEI01_R	Black Kei	-32.1181953	27.068842	S32K	D/E	D	16.70	11.11	15.33	32.03	187.9
IUA_S03	GKEI01_I	Great Kei	-32.5081188	27.966294	S70A	C/D	C	14.70	4.94	10.27	24.97	897.2
IUA_S01	TSOM01_I	Tsomo	-32.0439765	27.821052	S50G	D	C/D	10.11	4.24	27.38	37.48	196.7
IUA_R02	BUFF01_I	Buffalo (Middle)	-32.9915187	27.640572	R20F	D	D	16.14	5.52	18.32	34.46	83.8
IUA_R01	KEIS01_I	Keiskamma (Upper)	-32.8023332	27.024309	R10E	D	D	13.40	10.19	20.91	34.31	58.8
IUA_Q03	KAT01_I	Kat (Upper)	-32.5696452	26.721852	Q94B	C	B/C	23.38	4.49	20.15	43.53	23.9
IUA_Q02	FISH03_I	Great Fish (Lower)	-33.0837332	26.225273	Q91B	C	C	14.02	4.84	15.70	29.73	331.8
IUA_M01	SWAR01_I	Swartkops	-33.7221648	25.300873	M10C	C	B/C	15.84	1.77	24.13	39.97	27.3
IUA_KL01	GAMT01_I	Gamtoos	-33.7609759	24.693840	L90A	D	D	5.67	4.43	5.14	10.80	427.0
RAPID 3												
IUA_T04	MNGA01_R	Mngazi	-31.608958	29.405132	T70B	C	B/C	19.29	9.06	6.65	25.94	78.2
IUA_T04	NQAB01_R	Nqabarha	-32.091927	28.400234	T90A	D	C	12.69	5.14	21.82	34.51	9.8
IUA_T04	MTEN01_R	Mtentu	-31.130483	29.757179	T60C	C	B/C	34.39	6.15	9.94	44.33	89.6
IUA_T01	MBHA02_R	Mbhashe (Upper)	-31.807857	28.346994	T11H	B/C	B/C	13.96	7.79	8.08	22.05	373.4
IUA_S03	GCUW01_R	Gcuwa	-32.319770	28.136094	S70D	D	D	14.86	2.83	0.00(1)	14.86	67.6
IUA_S01	INDW01_R	Indwe	-32.507220	27.731348	S20D	C/D	C/D	15.65	4.55	9.03	24.69	61.9
IUA_S01	WKEI01_R	White Kei	-31.897077	27.409825	S10J	C/D	C	20.87	4.47	5.30	26.16	155.7
IUA_S03	KUBU03_R	Kubusi (Lower)	-32.003057	27.351052	S60E	C	B/C	14.11	5.07	6.27	20.38	98.1
IUA_R01	KEIS02_R	Keiskamma (Lower)	-33.075316	27.218534	R10L	C	B/C	20.92	8.42	6.93	27.85	107.8
IUA_R01	TYUM01_R	Tyume	-32.910291	26.932242	R10H	C	B/C	25.09	8.41	9.06	34.15	32.6

IUA	EWR site code	River	Latitude	Longitude	Quat*	PES	REC	MLow (%)	Drought (%)	Floods (%)	Total EWR as %nMAR for REC	nMAR (10^6m^3)
IUA_Q03	KOON01_R	Koonap	-33.042856	26.658506	Q92G	D	D	8.93	3.09	8.49	17.14	76.9
IUA_Q03	KAT02_R	Kat (Lower)	-32.890965	26.68407	Q94F	C/D	C/D	9.25	1.92	5.91	15.16	61.8
IUA_N01	SUND02_R	Sundays (Lower)	-33.9370951	24.269058	N40C	D	D	2.95	1.95	2.47	5.42	214.0
IUA_L01	KOUG01_R	Kouga	-33.788449	24.025821	L82D	C	B/C	9.25	3.16	6.53	15.78	155.1
IUA_K01	KROM01_I	Kromme	-33.9370951	24.269058	K90A	D	C	20.61	2.40	16.05	36.66	27.6
FIELD VERIFICATION/ DESKTOP												
IUA_T04	XORA01_D	Xora	-32.135524	28.973139	T80D	B	B	17.33	4.50	13.20	30.53	83.0
IUA_T01	MTHA02_D	Mthatha (Upper)	-31.475254	28.605656	R20A	C	C	11.76	5.64	9.72	21.49	122.5
IUA_R02	BUFF02_R	Buffalo (Lower)	-32.991768	27.775910	R20G	D/E	D	16.14	5.51	16.69	32.83	91.9
IUA_Q02	TARK01_FV	Tarka	-32.283315	25.759280	Q44C	D	D	2.63	2.53	9.57	12.21	63.3
IUA_Q02	FISH02_R	Great Fish (Middle)	-32.604885	25.751772	Q50B	D	D	3.11	3.11	9.39	12.50	201.9
IUA_Q01	LFIS02_FV	Little Fish (Lower)	-33.09345	25.82152	Q80G	C	C	7.28	2.55	11.59	18.88	88.9
IUA_Q01	FISH01_FV	Great Fish (Upper)	-31.919527	25.390974	Q21B	D	D	2.87	2.65	9.48	12.35	18.0
IUA_Q01	LFIS01_FV	Little Fish (Upper)	-32.50617	25.42683	Q80B	C	B/C	10.71	2.67	13.01	23.72	24.3
IUA_P01	BOES01_FV	Boesmans	-33.543899	26.391105	P10G	B	B	11.91	0.56	15.53	27.44	32.7
IUA_LN01	SUND01_FV	Sundays (Upper)	-33.07812	25.01548	N22E	C	C	6.29	1.09	11.96	18.25	148.0
	GRT01_D	Groot (L70G)	-33.743359	24.613965	L70G	B	B	16.21	3.81	13.70	29.91	185.7
IUA_L01	BAVI01_D	Baviaanskloof	-33.664914	24.388605	L81D	B	B	13.87	2.49	14.71	28.58	48.1
	KOUG02_D	Kouga	-33.739983	24.587785	L82H	C	B/C	9.23	3.96	6.63	15.86	229.3
IUA_K01	GROO01_FV	Groot (K80D)	-34.032134	24.195684	K80D	C	B/C	19.88	7.53	9.20	29.09	47.6

(1) Freshets and floods to be confirmed during development of operational scenario for raised Gcuwa Dam

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11. APPENDICES

Appendix A: Detail flood requirements and motivations for Intermediate EWR sites

Table A1: Flood requirements for lower Mthatha River at EWR site MTHA01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	14	Breeding and migratory cues for fish species moving from estuary and scouring of riffle habitat of algae	15	Breeding and hatching cues, clear out fine silt, ensure high velocities over cobbles biotope with the aim to scour these substrates of algae, silt and sediments	14	This within-year event activates marginal zone grasses and floods a portion of the indicator (1m)	13	Inundate inset benches, deposit sand on inset benches (1m), remove sand from cobble habitat in main channel
	Daily average/ peak	Average		Average		Average		Average	
	Frequency					4 events per wet season		within year	
	Number of days	5		5		4		4	
	Months	Oct, Nov, Dec, Jan, Mar		Oct, Dec, Feb and Apr		Oct, Nov, Dec, Jan		Oct, Jan, Feb Mar	
Class 2	m^3/s	25	Breeding and migratory cues for fish species moving from estuary; activation of some marginal	24	Highest VFCS activated (53%). Breeding and hatching cues, inundate some marginal vegetation, clear out fine silt,	30	This annual event floods about a third of marginal zone vegetation, mainly scattered tufted grasses (1.25m)	49	Inundate bars and lower flood benches. Mobilise coarse gravel on bed - d50 of 52mm and d84 of 100mm (1.5m)
	Daily average/ peak	Average		Average		Peak		Average	
	Frequency					annual event		annual	
	Number of days	5		5		5		5	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
	Months	Dec, Jan, Feb	vegetation within cross-section	Annual	ensure high velocities over cobbles, and aim to reduce the embeddedness of this substrate, scour these substrates of algae, silt and sediments	Feb or Mar		Mar	
Class 3	m^3/s					140	This event every 2-3 years floods the flood features and within- channel vegetation (2.1m)	212	Mobilise gravel on gravel bar/flood bench (2.4m)
	Daily average/ peak					Peak		Peak	
	Frequency					1:2-3 yr		1:2-3 yr	
	Number of days					5		5	
	Months					wet season		Mar	
Class 4	m^3/s					340	This event floods to the shrub / tree line and prevents woody domination of the within-channel features (2.8m)	1318	Inundate higher flood bench, deposit fine sand on higher flood bench (4.3m). Reset channel morphology
	Daily average/ peak					Peak		Peak	
	Frequency					1:5 yr		1:10 yr	
	Number of days					7		7	
	Months					Mar		Mar	

Table A2: Flood requirements for middle Mbashe River at EWR site MBAS01_I.

Floods	Units	Fish	Fish justification	Inverts	Inverts justification *	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	45	Breeding and migratory cues for fish species moving from estuary and scouring of riffle habitat of algae.	37	Breeding and hatching cues for the macroinvertebrates, mobilisation of sand to scour the large boulders of any algae and sediment. Mobilisation course gravels which have lodged within the interstitial spaces between the boulders.	52	Inundates marginal zone sedges and reed clumps, although vegetation is scattered and sparse in the zone (1.8m)	41	Inundate inset bench, deposit sand on inset bench (1.7m). Initiate gravel movement and winnow sand from coarser habitat
	Daily average/ peak	Average		Peak		Peak		Average	
	Frequency			Freshet		4 events per wet season		Freshet	
	Number of days	5		5		5		5	
	Months	Nov, Dec, Jan, Feb		Oct, Nov, Mar		Oct, Nov, Dec, Jan		Nov, Dec, Jan, Feb, Mar	
Class 2	m^3/s					212	Inundates grasses growing on the flood bench, mostly *Agrostis lachnantha*. (2.8m)	364	Overtop lower part of flood bench (3.3m), transport coarse gravel along bed - d50 of 28mm and d84 of 66mm
	Daily average/ peak					peak		peak	
	Frequency					annual event		Annual	
	Number of days					5		5	
	Months					Feb or Mar		Feb	
Class 3	m^3/s					1258	Activates the lowest limit of riparian obligate trees (*Combretum caffrum*) (4.8m)	1347	Inundate entire flood bench, deposit fine sand on flood bench (4.9m)
	Daily average/ peak					Peak		peak	
	Frequency					1:2/3		1:5	
	Number of days					5		5	
	Months					Feb or Mar		Feb	
Class 4	m^3/s					2633	Activates the lowest limit of terrestrial trees		NA
	Daily average/ peak					Peak			

Floods	Units	Fish	Fish justification	Inverts	Inverts justification *	Veg	Veg justification	Geomorph	Geomorph justification
	Frequency					1:5 yr	(*Vachellia karroo*). Prevents terrestrialisation (6.3m)		
	Number of days					7			
	Months					Mar			

* Important to note along the Mbhashe is the constant flows owing to the hydropower scheme and the associated outbreak of the Simuliidae larvae, which was observed during the September 2022 survey. The critical periods for controlling population sizes are July–August (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, we should aim to reduce flows (will assess this during the trade off phase), and water levels during these months to expose the substrate to dry out blackfly larvae and pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September time, as what was observed in September 2022.

Table A3: Flood requirements for Black Kei River at EWR site BKEI01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	8	Breeding and migratory cues for fish species moving from estuary and scouring of riffle habitat of algae.	7	Breeding and hatching cues for the macroinvertebrates, mobilisation of sand to scour the large boulders of any algae and sediment. Mobilisation course gravels	4.6	Inundates 10% of the marginal zone graminoids (*Miscanthus ecklonii*) and activates marginal zone indigenous woody vegetation (*Salix mucronata*) including saplings (0.95m)	7	Flush fine sediment from riffle and initiate movement of coarse gravel along bed - d50 of 28mm and d84 of 66mm (1.05m)
	Daily average/ peak	Average		Peak		peak		Average	
	Frequency			Freshet		4 events per wet season		4 events per wet season	
	Number of days	5		5		6		5	
	Months	Nov, Dec, Jan, Feb		Oct, Nov, Mar		Oct, Nov, Dec, Jan		Oct, Nov, Dec, Jan	
Class 2	m^3/s					8.5	Inundates 20% of the marginal zone graminoids (*Miscanthus ecklonii*) and 5% of marginal zone indigenous woody evgetation (*Salix mucronata*) and activates floodbench grasses (1.1m)	32	Inundate lower flood benches and deposit sand on lower benches (1.7m)
	Daily average/ peak					peak		Peak	
	Frequency					1 event		Annual	
	Number of days					7		5	
	Months					Feb or Mar		Feb/Mar	
Class 3	m^3/s					28	Inundates 50% of the marginal zone graminoids (*Miscanthus ecklonii*) and 60% of marginal zone indigenous woody evgetation	216	Transport coarse gravel along bed - d50 of 28mm and d84 of 66mm (3.2m)
	Daily average/ peak					peak		Peak	
	Frequency					annual		1:2/3	
	Number of days					5		5	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
	Months					Feb or March	(*Salix mucronata*) and 20% of floodbench grasses (1.65m)	Feb	
Class 4	m^3/s					90	Activates the riaprian tree line (*Celtis africana* and *Salix babylonica*), prevents woody encroachment of lower features.	425	Deposit sand on floodplain and reset active channel (4.0m)
	Daily average/ peak					Peak		Peak	
	Frequency					1:2		1:5/10	
	Number of days					5		6	
	Months					Feb or Mar		Feb	
Class 5	cumec					340-425	Floods the floodplain which is dominated by indigenous grasses (*Miscanthus ecklonii*), although also supports alien woody species that are also riparian (*Salix fragilis*).		
	daily average/peak					Peak			
	frequency					1:5/10			
	Number of days					5			
	Months					Feb or Mar			

* . Important to note along the Black Kei was the Simuliidae outbreak in Sep 2022. This is likely owing to the constant high flows and limited flow variability in the system. The critical periods for controlling population sizes are Jul–Aug (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, during times of low flows and when the stress sets in for the indicator taxon, may in fact be a positive impact as it will aid in drying out the blackfly larvae and pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). However, this needs to be aimed for in Jul and Aug. Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September.

Table A4: Flood requirements for Great Kei River at EWR site GKEI01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	30	Breeding and migratory cues for fish species moving from estuary and scouring of riffle habitat of algae.	45	Breeding and hatching cues for the macroinvertebrates, mobilisation of sand to scour the large boulders of any algae and sediment. Mobilisation course gravels.	38	Inundates 40% of the marginal zone graminoids, 20% of marginal zone indigenous woody vegetation (*Gomphostigma virgatum*) and 100% of marginal zone sedges (*Cyperus longus*) (1.25m)	27	Initiate movement of coarse gravel along riffle - d50 of 45mm and d84 of 90mm (1.1m)
	Daily average/ peak	Average		Peak		Peak		Average	
	Frequency					4 events per wet season		4 events per wet season	
	Number of days	5		5		6		5	
	Months	Oct, Nov, Dec, Jan, Feb		Oct, Nov, Mar, Sep		Oct, Nov, Dec, Jan		Oct, Nov, Jan, Mar	
Class 2	m^3/s					112	Floods 95% of marginal zone graminoids, 47% of marginal zone woody vegetation (*Gomphostigma virgatum*), 100% of marginal sedges (*Cyperus longus*) and activates flood bench woody saplings (*Ficus sur*). (1.8m)	95	Initiate movement of coarse gravel along gravel and cobble bar - d50 of 45mm and d84 of 90mm (1.7m)
	Daily average/ peak					Peak		Peak	
	Frequency					Annual event		Annual	
	Number of days					6		5	
	Months					Feb or Mar		Feb or Mar	
Class 3	m^3/s					320	Inundates *Vachellia karroo* saplings and young adults on flood	293	Inundate and deposit fine sediment on
	Daily average/ peak					Peak		Peak	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
	Frequency					1:2/3	features, prevents terrestrialisation (2.6m).	1:2/3	inset benches (2.5m)
	Number of days					5		5	
	Months					Feb or Mar		Feb or Mar	
Class 4	m^3/s					550-780	Activates the terrestrial tree line (mature adults, mostly *Vachellia robusta* and alien species) at 550 and inundates 10% at 780, prevents terrestrial encroachment. (3.1-3.5m)	717	Inundate flood bench; transport coarse gravel along bed - d50 of 45mm and d84 of 90mm (3.4m); reset active channel morphology
	Daily average/ peak					Peak		Peak	
	Frequency					1:5		1:5/10	
	Number of days					5		6	
	Months					Feb or Mar		Feb or Mar	

* Important to note that the Great Kei was the worst impacted site with the Simuliidae outbreak which occured in Sep 2022. This is likely owing to the constant high flows and limited flow variability in the system. The critical periods for controlling population sizes are Jul–Aug (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, during times of low flows and when the stress sets in for the indicator taxon, may in fact be a positive impact as it will aid in drying out the blackfly larvae and pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). However, this needs to be aimed for in Jul and Aug. Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September.

Table A5: Flood requirements for Tsomo River at EWR site TSOM01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s		No freshetts / floods specified due to alien non-native fish species dominating the system and the large weir and dams upstream - migration barrier	10	Breeding and hatching cues for the macroinvertebrates, mobilisation of sand to scour the large boulders and cobbles of any filamentous algae and sediment. Mobilisation course gravels.	8	Activates and floods a small portion (about 10%) of marginal zone sedges (*Schoenoplectus corymbosus*) (0.95m).	11	Inundate and deposit fine sediment on inset bench; scour sand and initiate movement of coarse gravel along bed - d50 of 25mm and d84 of 55mm (1m)
	Daily average/ peak			Peak		Peak		Average	
	Frequency			Freshet		4 events per wet season		Feshet	
	Number of days			5		6		5	
	Months			Oct, Nov, Mar, Sep		Oct, Nov, Dec, Jan		Nov, Jan Feb, Mar	
Class 2	m^3/s			20	Important to note along the Tsomo was the Simuliidae outbreak in Sep 2022. This is likely owing to the constant high flows and limited flow variability in the system.	31	Activates tufted grasses (*Miscanthus ecklonii*) on RB and inundates the same on the LB flood bench (1.4m)	38	Inundate and deposit fine sediment on flood bench; transport coarse gravel along bed - d50 of 25mm and d84 of 55mm (1.5m)
	Daily average/ peak			Peak		Peak		Peak	
	Frequency			Freshet		Annual event		annual	
	Number of days			5		6		5	
	Months			Sep		Feb or Mar		Feb/Mar	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Class 3	m^3/s					80	Begins to inundate *Vachellia karroo* saplings encroaching, as well as young adult *Senegalia caffra* and floods about 85% of the *Schoenoplectus corymbosus* population. Will help prevent terrestrialisation. (1.9m)	243	Inundate and deposit fine sediment on higher flood zone; Reset active channel geomorphology (2.7m)
	Daily average/ peak					Peak		Peak	
	Frequency					1:2		1:2/3	
	Number of days					5		5	
	Months					Feb or Mar		Feb/Mar	
Class 4	m^3/s					274	Activates the terrestrial tree line (mature adults, mostly *Vachellia karroo* and *Senegalia caffra*). Prevents terrestrialisation in riparian zone (2.8m).		
	Daily average/ peak					peak			
	Frequency					1:5			
	Number of days					5			
	Months					Feb or Mar			

* The critical periods for controlling population sizes are Jul–Aug (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, during times of low flows and when the stress sets in for the indicator taxon, may in fact be a positive impact as it will aid in drying out the blackfly larvae and

pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). However, this needs to be aimed for in Jul and Aug. Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September.

Table A6: Flood requirements for middle Buffalo River at EWR site BUFF01_I.

Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
m^3/s	4	Cues for upstream movement of fish, assist movement over weir, prevent fish kills during warmer summer season, activate marginal vegetation as a spawning habitat	3.9	Breeding and hatching cues for the macroinvertebrates, mobilisation of course gravel to scour the large boulders and cobbles which become covered in algae and sediment and thus to ensure the habitat is cleaned for the colonisation of macroinvertebrates. Mobilise the gravels locked within the interstitial spaces between the cobbles/boulders.	4.1	Inundates 100% of the marginal zone sedges and broad-leaf vegetation (*Cyperus dives*, *Cotula nigellifolia*,*Cyperus textilis*) and 40% of marginal zone grasses (*Hemarthria altissima*), also floods a portion of *Sesbanea punicea* (1m)	5.3	Flush fine sediment from riffle habitat; transport coarse gravel along bed - d50 of 22mm and d84 of 65mm (1.1m); inundate inset bench to allow fine sediment deposition
Daily average/ peak	Average		Average		Peak		Average	
Frequency					4 events per wet season		Within year	
Number of days	5		5		6		10	
Months	Oct, Nov, Dec, Jan, Feb		Oct, Nov, Mar		Oct, Nov, Dec, Jan		Oct, Nov, Jan, Feb, March	
m^3/s			22	Important to note along the Middle Buffalo River - there was a Simuliidae outbreak in Sep 2022 and May 2023. This is likely owing to the constant high flows at the time and limited flow variability in the system.	12	Inundates 100% of the marginal zone grasses (*Hemarthria altissima*) and activates the lowest limit of terrestrial shrubs (*Searsia pyroides*) (1.5m)	20	Inundate and deposit fine sediment on flood bench; transport gravel on gravel and cobble bar/inset bench (1.8m)
Daily average/ peak			Peak		Peak		Average	
Frequency			Annual		Annual event		Annual event	
Number of days			5		6		5	
Months			Nov		Nov or Mar		Nov or Mar	
m^3/s					30	Inundates flood feature vegetation (shrubs, grasses and sedges) but moer importantly floods the		
Daily average/ peak					Peak			
Frequency					1:2			

Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Number of days					5	alien, *Sesbanea punicea*, to 0.5m (2.1m)		
Months					Nov, Feb or Mar			
m^3/s					120	Activates tall tree along the top of the bank, in this case *Afrocarpus falcatus*, a forest species that also prefers riparian zones (or other wetter areas), also prevents terrestrialisation (3.45m)	244	Activate flood channel along left bank and higher flood zones; reset active channel (4.5m)
Daily average/ peak					peak		peak	
Frequency					1:5/10		1:5	
Number of days					5		5	
Months					Nov, Feb or Mar		Nov or Mar	

* The critical periods for controlling population sizes are Jul–Aug (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, during times of low flows and when the stress sets in for the indicator taxon, may in fact be a positive impact as it will aid in drying out the blackfly larvae and pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). However, this needs to be aimed for in Jul and Aug periods. Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September time. The maximum velocity for this discharge is 1.9m/s with VFCS at 20% and with the aim to flush the larvae off the cobbles/boulder biotopes.

Table A7: Flood requirements for upper Keiskamma River at EWR site KEIS01_I.

Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
m^3/s	10	Flush fine sediment from riffle habitat, cues for upstream movement of fish, activate/inundate marginal vegetation for Enteromius anoplus breeding	10	Remove any fine sediment from instream cobbles. The maximum velocities at this discharge is 1.65m/s.	7.3	Inundates 100% of the marginal zone graminoids (sedges and broad-leaf vegetation; *Cyperus dives*, *Cotula nigellifolia*,*Cyperus longus*) and 100% of marginal zone grasses (*Ishaemum fasiculatum*). (0.69m)	11	Flush fine sediment from riffle habitat; initiate movement of coarse gravel along riffle - d50 of 54mm and d84 of 86mm (0.9m), Inundate inset bench
Daily average/ peak	peak		Peak		Peak		Peak	
Frequency	Freshett		Freshett		5 events per wet season		Freshet	
Number of days	4		3		3		4	
Months	Nov, Dec, Jan, Feb		Oct, Nov, Mar		Oct, Nov, Dec, Jan, Feb		Nov, Dec, Jan, March	
m^3/s			21	Mobilisation of course gravel to scour the cobbles which become covered in algae and sediment and thus to ensure the habitat is cleaned for the colonisation of macroinvertebrates. Mobilise the gravels locked within the interstitial spaces between the cobbles/boulders. The maximum velocities at this discharge is 2m/s. There was no Simuliidae larvae outbreak on the cobbles biotope at this EWR site. Thus the freshett will primarily be for scouring and cleaning the instream	14	Inundates 100% of the marginal zone vegetation (*Cyperus dives*, *Cotula nigellifolia*, *Cyperus longus*, *Ishaemum fasiculatum*) and flood the inset bench sedges (*Cyperus textilis*) and more importantly the *Vachellia karroo* saplings, which will prevent terrestrialisation on the inset bench (1m)	34	Inundate inset bench to allow fine sediment deposition; flush fine sediment from riffle habitat; transport coarse gravel along riffle - d50 of 54mm and d84 of 86mm (1.4m)
Daily average/ peak			Peak		Peak		Peak	
Frequency			Annual		Annual event		Annual	
Number of days			3		5		5	
Months			Mar		Nov or Mar		Nov or Mar	

Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
				biotopes for macroinvertebrates colonisation.				
m^3/s					28	This event activates the lowest limit of the riparian and terrestrial woody vegetation (*Combretum caffrum* and *Vachellia karroo* respectively). Prevents terrestrialisation on lower-lying inset benches and marginal zone and maintain riparian woody obligates. (1.35m)		
Daily average/ peak					Peak			
Frequency					Annual or 1:2			
Number of days					4			
Months					Nov			
m^3/s					145	Floods into the terrestrial tree line (mature adults *Vachellia karroo*) up to 1m depth, important to keep terretrialisation in check (2.5m)	194	Inundate higher flood zones (2.8m), reset the channel morphology
Daily average/ peak					Peak		Peak	
Frequency					1:5		1:3/5	
Number of days					5		5	
Months					Nov or Mar		Nov or Mar	

Table A8: Flood requirements for upper Kat River at EWR site KAT01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	3.0	Inundate marginal vegetation for spawning of fish, removal of fine sediment from riffle	6	Remove any fine sediment from instream cobbles. The maximum velocities at this discharge is 1.44m/s.	2.5	Inundates marginal zone grasses (*Miscanthus ecklonii*) and sedges (*Cyperus textilis*) to their upper limit, and will drown out terrestrial tree seedlings since these are encroaching at this site. (0.67m)	8	Inundate inset bench and activate secondary channel, scour fine sediment along riffle (0.8m)
	Daily average/ peak	Average		Peak		Peak		Peak	
	Frequency	Freshet		Freshet		4 events per wet season		Freshet	
	Number of days	4		3		4		4	
	Months	Oct, Nov, Dec, Jan		Oct, Nov, Mar		Oct, Nov, Dec, Jan		Nov, Dec, Jan, Mar	
Class 2	m^3/s					12-20	Inundates flood bench vegetation (same as marginal zone species) and activates the riparian (*Combretum caffrum*) and terrestrial tree / shrub line. (>0.9m)	22	Inundate inset bench, initiate movement of small cobble along riffle - d50 of 77mm and d84 of 112mm (1.05m)
	Daily average/ peak					Peak		Peak	
	Frequency					Annual event		Annual	
	Number of days					5		4	
	Months					Nov or Mar		Feb/Mar	
Class 3	m^3/s					60	Floods large proportion of riparian bank trees (*Combretum caffrum* mostly) as	181	Inundate flood bench and reset channel morphology; Transport small
	Daily average/ peak					Peak		Peak	
	Frequency					1:3/5		1:5/10	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
	Number of days					5	well as terrestrial species. Without these events encroachment will occur, as is evident at the site which has recently had a 6-year period without spills from the dam (1.35m)	5	cobble along riffle - d50 of 77mm and d84 of 112mm (1.8m)
	Months					Nov, Feb or Mar		Feb/Mar	

Table A9: Flood requirements for lower Great Fish River at EWR site FISH03_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	15	Breeding and migration cues for fish, inundation of marginal vegetation for breeding of Enteromius mandelai (if at all present due to presence of large non-native species) and Labeo umbratus	15	Breeding and hatching cues for the macroinvertebrates, mobilisation of sand to scour the large boulders of any algae and sediment. Mobilisation course gravels which have lodged within the interstitial spaces between the boulders. The maximum velocity at this discharge is measured at 2.2m3/s.	12	Inundates 30% of marginal zone reeds (*Phragmites australis*) and sedges (*Cyperus textilis*) to an average maximum water depth of 0.4m. (1m)	19	Inundate and deposit fine material on inset bench; transport coarse gravel along riffle - d50 of 31mm and d84 of 65mm (1.2m)
	Daily average/ peak	Peak		Peak		Peak		Peak	
	Frequency					4 events per wet season		4 events per wet season	
	Number of days	5		5		6		5	
	Months	Oct, Nov, Dec, Jan		Oct, Nov, Mar		Oct, Nov, Dec, Jan		Oct, Dec, Jan, Mar	
Class 2	m^3/s			27	Although no Simuliidae larvae were recorded during either of the surveys - may have been owing to accessibility constraints instream. However, various studies on the Great Fish and with the understanding of the Simuliidae larvae outbreaks that have and do occur within this system, we take cognisance and have aimed to set a flood to ensure the scouring and flushing of such potential outbreaks.	45	Inundates 80% of marginal zone reeds (*Phragmites australis*) and 60% of sedges (*Cyperus textilis*) to an average maximum water depth of 1.1m. (1.7m)		
	Daily average/ peak			Peak		Peak			
	Frequency			Annual		Annual event			
	Number of days			5		4			
	Months			Nov		Feb or Mar			
Class 3	m^3/s					96	Inundates 100% of reeds (*Phragmites australis*) and sedges (*Cyperus*	85	Inundate and deposit fine material on inset bench; mobilise
	Daily average/ peak					Peak		Peak	
	Frequency					1:2/3		1:1/2	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification*	Veg	Veg justification	Geomorph	Geomorph justification
	Number of days					3	*textilis*) in the marginal zone and flood bench to an average maximum water depth of 1.6m. (2.2m)	5	coarse gravel along margins - d50 of 31mm and d84 of 65mm (2.1m)
	Months					Feb or Mar		Feb or Mar	
Class 4	m^3/s					135	Activates and inundates a portion of the terrestrial trees and shrubs and *Pennisetum macrourum*, and prevents terrestrialisation of marginal zone and flood bench (2.5m).	182	Inundate and deposit fine material on flood bench (2.8m)
	Daily average/ peak					Peak		Peak	
	Frequency					3		1:5	
	Number of days					1:5		5	
	Months					Mar		Feb or Mar	

* The critical periods for controlling population sizes are Jul–Aug (winter months) when most of the population is present in the larval or pupal phase (O'Keeffe and de Moor, 1988). Thus, during times of low flows and when the stress sets in for the indicator taxon, may in fact be a positive impact as it will aid in drying out the blackfly larvae and pupae by exposing substrate (de Moor, 1982b, 1997; O'Keeffe and de Moor, 1988). However, this needs to be aimed for in Jul and Aug period. Should the above be achieved, the provided freshets/floods coming through will scour the cobbles biotopes and avoid the typical spring outbreaks of blackfly larvae within this system during September. The maximum velocity at this discharge is 2.6m/s and 40% of the VFSC will be activated.

Table A10: Flood requirements for Swartkops River at EWR site SWAR01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	0.5 - 1	Clear spawning habitat in preparation of spawning period for Pseudobarbus afer; breeding cues	1	Slight scour of the cobbles to remove some algae over the cobbles. The maximum velocities at this discharge is 1.0m/s.	1.5	Inundates 100% of the marginal zone creeping grass (*Leersia hexandra*), about 50% of the tufted marginal and upper zone grass *Miscanthus ecklonii*, and activates the marginal zone shrub *Cliffortia strobilifera*, which provides substantial overhanging habitat for instream biota. (0.8m)	0.5-2	Flush fine sediment from riffle; mobilise and transport coarse gravel along riffle - d50 of 35mm and d84 of 98mm (0.5-0.9m)
	Daily average/ peak	Peak		Peak		Peak		Peak	
	Frequency					4 events per wet season		4 events per wet season	
	Number of days	3		3		5		4	
	Months	Aug, Sep		Nov, Mar		Nov, Mar, Apr, May		Aug, Sep, Nov and Mar	
Class 2	m^3/s					6	Inundates 100% of the *Miscanthus ecklonii* population and activates the terrestrial tree / shrub line (e.g. *Searsia lucida*), some of which are forest species	8.5	Inundate and deposit fine sediment on flood bench (1.6m)
	Daily average/ peak					Peak		Peak	
	Frequency					Annual event		Annual event	
	Number of days					4		4	
	Months					Aug or Sep		Aug, Sep, Nov or March	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
							(*Afrocarpus falcatus*). (1.4m)		
Class 3	m^3/s					13	Inundates a portion of terrestrial shrub species (*Euclea divinorum*, *Olea europaea* subsp. *africana*) and activates the lower lying Fynbos elements (*Erica caffra* var. *caffra*). (1.9m)	40.6	Inundate and deposit fine sediment on floodplain (3m)
	Daily average/ peak					Peak		Peak	
	Frequency					3		4	
	Number of days					1:2/3		1:2/3	
	Months					Aug or Sep		Aug, Sep, Nov or Mar	
Class 4	m^3/s					31	Inundates portion of Fynbos shrub elements (*Erica caffra var. caffra*) along the LB growing on cobble / boulder floodplain (2.7m)	88	Transport coarse gravel on floodplain; reset channel morphology (4.1m)
	Daily average/ peak					Peak		Peak	
	Frequency					3		4	
	Number of days					1:5		1:5/10	
	Months					Aug or Sep		Aug, Sep, Nov or March	

Table A11: Flood requirements for Gamtoos River at EWR site GAMT01_I.

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
Class 1	m^3/s	7	Breeding and migration cues for fish	9	The average and maximim velocity will be 0.4m/s and 1.14m/s respectively, thus the movement of gravel will aid in scrouring the cobbles and mobilise algae over this substrate having a positive impact on the abundance of the indicator taxon, and others, as it will increase the quality of cobbles available.	3.2	Inundates 100% of marginal zone species (*Persicaria lapathifolia*, *Ishaemum faciculatum*,*Cotula nigellifolia)* and 30-50% of flood feature vegetation (*Phragmites australis*, *Cyperus textilis*)	7	Flush fine sediment from riffle; mobilise coarse gravel along riffle - d50 of 29mm and d84 of 90mm; Inundate and deposit fine sediment on inset bench (0.9m)
	Daily average/ peak	Peak		Peak		peak		Peak	
	Frequency	freshet		Freshet		4 events per wet season		Freshet	
	Number of days	4		3		5		5	
	Months	Nov - March		Aug, Sep, Nov and March		Aug, Sep, Nov and March		Aug, Sep, Nov and Mar	
Class 2	m^3/s					9.6	Inundates at leats 80% of reeds (*P. australis*) and flood feature sedges (*C. textilis*), and 100% of riparian shrub	41	Transport coarse gravel along riffle - d50 of 29mm and d84 of 90mm; Inundate and
	Daily average/ peak					peak		Peak	
	Frequency					2 events per wet season		Annual	

Floods	Units	Fish	Fish Justification	Inverts	Invert Justification	Veg	Veg justification	Geomorph	Geomorph justification
	Number of days					5	community (*Pluchea dioscoridis)*	5	deposit fine sediment on lower floodplain (1.6m)
	Months					Aug, Sep, Nov or March		Aug, Sep, Nov or Mar	
Class 3	m^3/s					13	Inundatesmost riparian vegetation (obligates) and prevents encraochment by terrestrial species (*Vachellia karroo*, *Gymnosporia senegalesnsis*)		
	Daily average/ peak					Peak			
	Frequency					annual			
	Number of days					5			
	Months					Aug, Sep, Nov or March			
Class 4	m^3/s							161	Transport coarse gravel along floodplain - d50 of 29mm and d84 of 90mm (2.5m); reset channel morphology
	Daily average/ peak								
	Frequency							1:2/3	
	Number of days								
	Months							Aug, Sep, Nov or Mar	