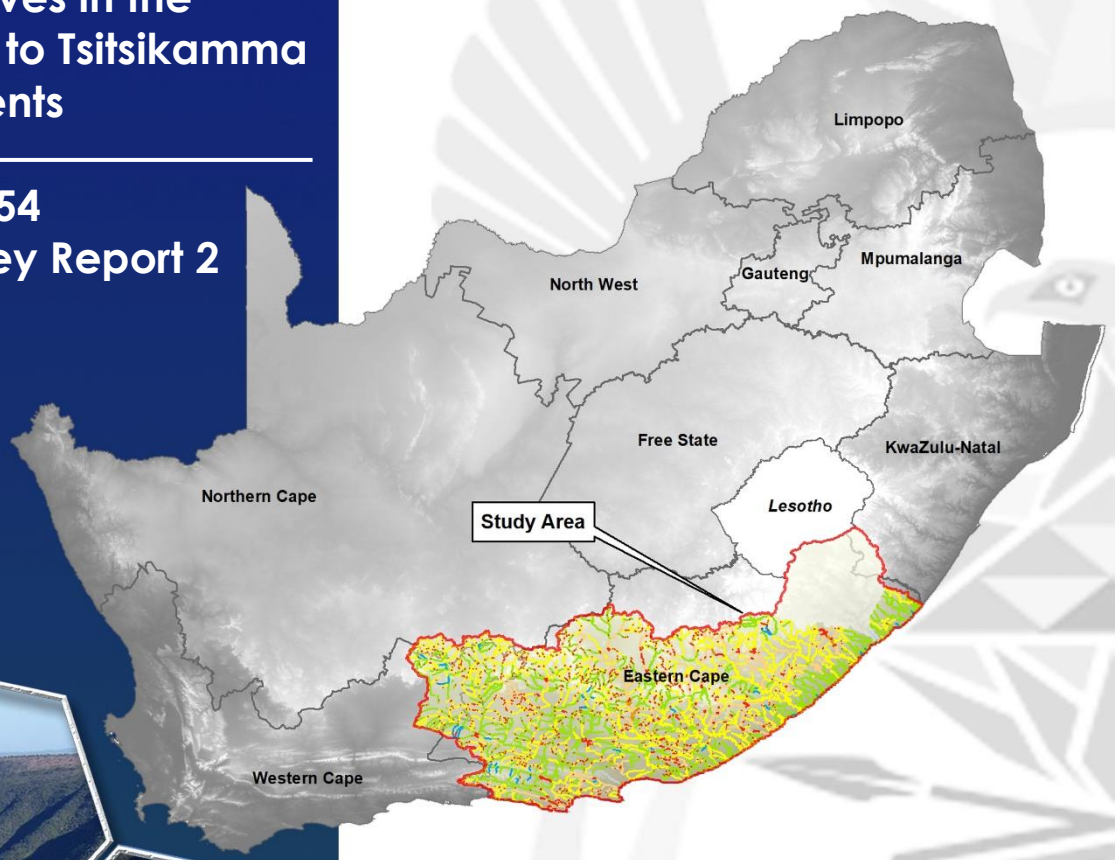
DEPARTMENT OF WATER AND SANITATION

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

WP11354
River Field Survey Report 2



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LIST OF ACRONYMS

BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
DWS	Department of Water and Sanitation
EI	Ecological Importance
ES	Ecological Sensitivity
EWR	Ecological Water Requirements
FRAI	Fish Response Assessment Index
FD	Fast Deep
FS	Fast Shallow
GAI	Geomorphology Driver Assessment Index
GSM	Gravel, Sand Mud
IUA	Integrated Unit of Analysis
MIRAI	Macroinvertebrate Response Assessment Index
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
RQO	Resource Quality Objectives
RU	Resource Units
SD	Slow Deep
SS	Slow Shallow
SIC	Stones-In-Current
SOOC	Stones-Out-Of-Current
Veg	Vegetation
VEGRAI	Riparian Vegetation Response Assessment Index
WWTW	Wastewater Treatment Works
WMA	Water Management Area
WRCS	Water Resources Classification System

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 rivers, wetlands, groundwater and estuaries. The Reserve determination include both the water quantity and quality of the Ecological Water Requirements (EWR) and Basic Human Needs (BHN). This will ensure the availability of water required to protect aquatic systems and that the essential needs of individuals that are directly dependent on these water resources.

1.2 Purpose of this study

The Keiskamma and Fish to Tsitsikamma catchments within the Mzimvubu to Tsitsikamma Water Management Area (WMA7) are amongst many waters 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 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 appropriate 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 (DWS, 2017),
- undertake the 7-step process to determine and set RQOs, and
- determine the Reserve for the water resources of the study area.

This will ultimately assist the DWS in the management of the water resources in the study area and making informed decisions regarding the authorisation of future water use and the magnitude of the impacts of proposed developments.

1.3 Purpose of this report

This report provides an overview of the second river field surveys undertaken from 3 – 15 May 2023 and which can be read in conjunction to the first survey report (Report No. WEM/WMA7/00/CON/RDM/0722). This second report continues to provide information for all Intermediate sites re-surveyed, along with those sites which were downgraded from an Intermediate to a Rapid 3 owing to mostly being dry at the time of the September 2022 survey.

2. METHODOLOGY

The following section provides an overview of the methodology adopted. It should be noted that this fieldwork report should be read in conjunction with Resource Units Prioritisation Report (WEM/WMA7/00/CON/RDM/0422), which highlights the selection process for the river RUs, and as such, the methodology associated with the selection process has not been repeated in this report.

Appropriate procedures as prescribed by the Department of Water and Sanitation (DWS) required for the undertaking of the intermediate, rapid level 3 and field verification Reserve determinations, including the field surveys was followed. These levels of assessment are described as follows:

(i) **Intermediate** – fish (modelled with the Fish Response Assessment Index – FRAI), macroinvertebrates (modelled with the Macroinvertebrate Response Assessment Index – MIRAI), riparian vegetation (using the Riparian Vegetation Response Assessment Index (VEGRAI), geomorphology (using the Geomorphology Driver Assessment Index – GAI), hydraulics and water quality;

(ii) **Rapid 3** – fish, macroinvertebrates, Index of Habitat Integrity (IHI), hydraulics and water quality where there are specific concerns due to Wastewater Treatment Works (WWTWs) or extensive irrigation; and

(iii) **Field verification** – the objective of these identified reaches is to confirm the desktop PES, EI and/ or ES and to provide specific recommendations for future management of these

smaller tributaries. The components included will be a combination of those for the Rapid 3 and will be confirmed during the in-field surveys.

2.1 Site visit

The first river field survey for this study was conducted from the 6 – 27 September 2022 (first of the two river surveys) to conduct all three Reserve level assessments (intermediate, rapid 3 and field verification) at the identified priority RUs throughout the Keiskamma, Fish to Tsitsikamma catchment areas. Refer to the River Survey Report No. WEM/WMA7/00/CON/RDM/0722 for further information. The second survey (this report) was conducted from 3 – 15 May 2023. Refer to Appendix A for the field survey programme which was followed.

3. PRIORITY RESOURCE UNITS AND RESERVE LEVEL ASSESSMENT CONDUCTED DURING THE FIELD SURVEY

For the second survey, please refer to Table 3-1 and Figure 3-1 for the list of sites, along with a reiteration of the reason behind downgrades and/or upgrades of the Reserve levels.

Table 3-1: Intermediate and Rapid 3 survey sites per priority RU

IUA	IUA Description	RU No.	River	Proposed Quaternary catchment	Proposed Reserve Level	Following site selection		
						Surveyed Quaternary catchment	Upgrade and downgrade of Reserve Level	Reason
IUA_T02	Middle Mbashe	R_RU014_I	Middle Mbhashe	T13E	Intermediate	T13E	Intermediate	No change
IUA_T03	Lower Mthatha	R_RU015_I	Lower Mthatha	T20E	Intermediate	T20G	Intermediate	No change
IUA_S01	Upper Great Kei	R_RU011_I	Tsomo	S50G	Intermediate	S50G	Intermediate	No change
IUA_S02	Black Kei	R_RU24_R	Black Kei	S32M	Rapid 3	S32K	Intermediate	Upgraded and re-surveyed in March 2023 owing to numerous impacts observed in the upper catchment
IUA_S03	Lower Great Kei	R_RU012_I	Lower Kubusi	S60B	Intermediate	S60B	Rapid 3	No flow
IUA_S03	Lower Great Kei	R_RU013_I	Great Kei	S70F	Intermediate	S70A	Intermediate	No change
IUA_S03	Lower Great Kei	R_RU26_R	Gcuwa	S70D	Rapid 3	S70D	Rapid 3	No change
IUA_R01	Keiskamma	R_RU09_I	Upper Keiskamma	R10E	Intermediate	R10E	Intermediate	No change
IUA_R02	Buffalo/ Nahoon	R_RU10_I	Middle Buffalo	R10E	Intermediate	R20F	Intermediate	No change
IUA_Q02	Great Fish	R_RU06_I	Lower Great Fish	Q93A	Intermediate	Q91B	Intermediate	No change

IUA	IUA Description	RU No.	River	Proposed Quaternary catchment	Proposed Reserve Level	Following site selection		
						Surveyed Quaternary catchment	Upgrade and downgrade of Reserve Level	Reason
IUA_Q02	Great Fish	R_RU07_I	Middle Great Fish	Q50B	Intermediate	Q50C	Potentially a flow management plan	To high flows for access owing to interbasin transfer and safety risk during both surveys.
IUA_Q03	Koonap and Kat	R_RU08_I	Upper Kat (d/s dam)	Q94B	Intermediate	Q94B	Intermediate	No change
IUA_P01	P primary catchment	R_RU05_I	Kariega	P30B	Intermediate	P30B	Rapid 3	Site was dry at the time of the September 2022 survey owing to drought and dams upstream with no releases. The Kariega lower down was sampled in May 2023.
IUA_P01	P primary catchment	R_RU10_R	Boesmans	P10G	Rapid 3	P10G	Desktop	Site dry and only desktop assessment will be undertaken
IUA_M01	M primary catchment	R_RU03_I	KwaZungu/ Swartkops	M10A	Intermediate	M10C	Intermediate	No change
IUA_KL01	Kromme from Kromme Dam to estuary and Gamtoos	R_RU02_I	Gamtoos	L90B	Intermediate	L90A	Intermediate	No change

IUA	IUA Description	RU No.	River	Proposed Quaternary catchment	Proposed Reserve Level	Following site selection		
						Surveyed Quaternary catchment	Upgrade and downgrade of Reserve Level	Reason
IUA_K01	Tsitsikamma and headwaters of Kromme to Kromme Dam	R_RU01_I	Upper Krom	K90B	Intermediate	K90B	Rapid 3	Downgraded as was not surveyed in September 2022.
IUA_R02	Buffalo/ Nahoon	R_RU20_R	Lower Buffalo	R20G	Rapid 3	R20F	Rapid 3	Site not assessed – previous hydraulic data will be used and biological conducted in March 2023.

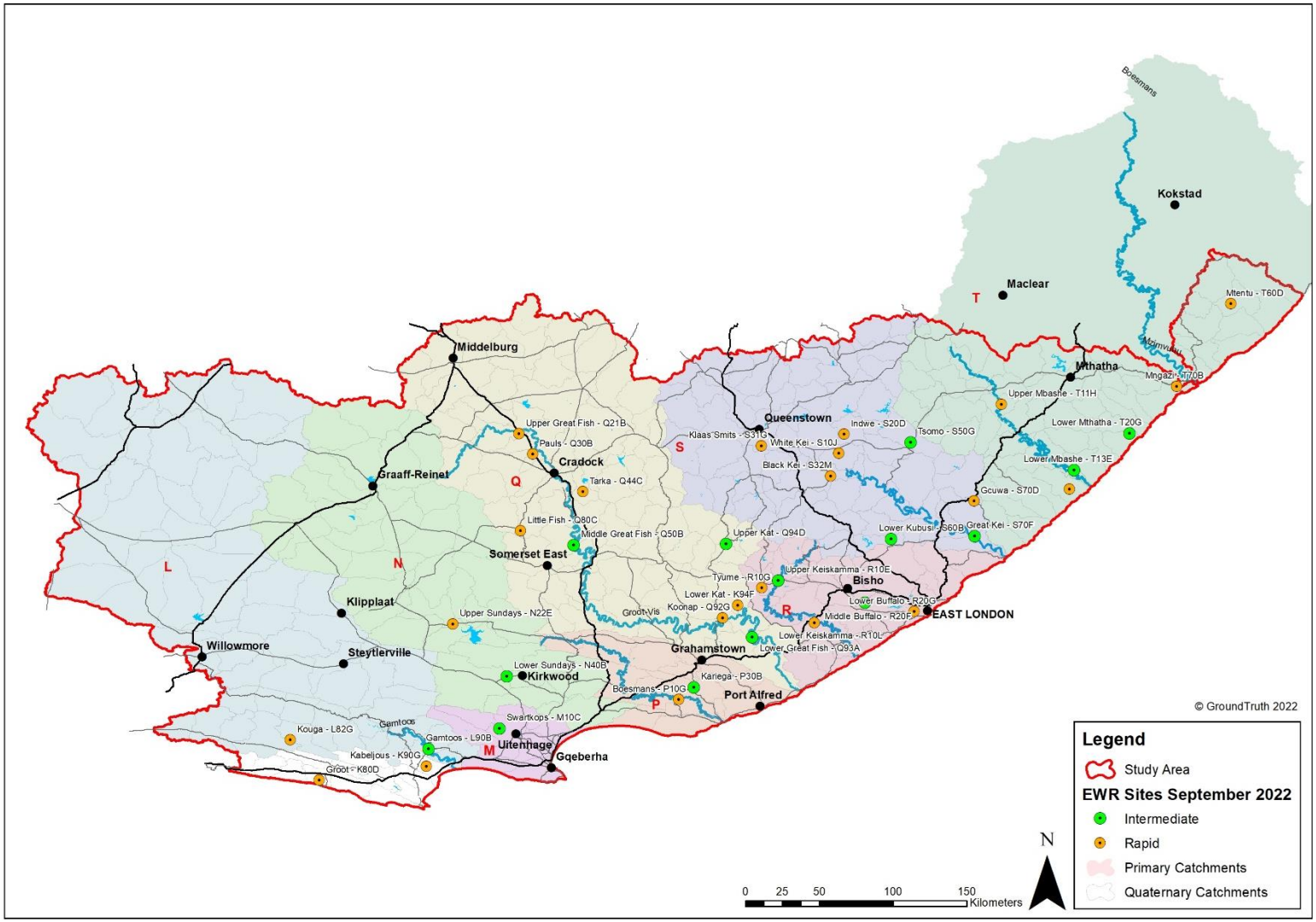


Figure 3-1: Map illustrating the EWR sites – of which the intermeidate sites were survyed during the river field survey 2 in May 2023

4. RIVER SURVEY TEAMS

Table 4-1 includes the list of specialists which conducted the survey, along with a team of DWS members for capacity building purposes.

Table 4-1: River survey teams

Specialist team	DWS team	Additional capacity building officials
Trevor Pike	Tinyiko Mpete	Eric Qonya: Eastern Cape Economic Development, Environmental Affairs and Tourism Yolokazi Galada: Department. of Forestry, Fisheries and the Environment
Khwezi Mncwabe	Lawrence Mulangaphuma	
James Mackenzi	Rendani Makhwedzha	
Byron Grant	Lisakhanga Sichatane	
Kylie Farrell	Lungile Gaulana	
	Rehlokometsoe Lebelom	
	Portrait Tshatshu	
	Lwando Dayimani	
	Anda Galoshe	
	Zanele Nyamende	
	Nqabisa Gwentshe	
	Ncamile Dweni	
	Zandile Naka	
	Siyabonga Ngcobos	
	Elliot Weni	
	Musa Nyambi	
	Nompilo Mahlobo	
	Fundiswa Pakkies	
	Sifiso Maseko	

5. RIVER SURVEY SITE DETAILS: INTERMEDIATE SITES

5.1 Mthatha River (Lower)

Owing to constant rainfall conditions at the time of the May 2023 survey, saw the Mthatha River in flood and burst banks. Consequently, only water and slope levels could be measured, and the riparian vegetation assessed.

Sample Date	14 May 2023	**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
Longitude	29.136048	**Latitude**	-31.925698
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
Components sampled: Riparian vegetation, water and slope measurements			
Site Photographs: Survey 1 (September 2022)			


Site Photographs: Survey 2 (May 2023)
Drone images could not be taken owing to the rainfall conditions at the time of the survey.


Upstream	Downstream

Site Description:

The site is located near the Ntshilini Catholic Church and Sidabadabeni and is 6km from the coastline.

The site is located along a partly confined valley setting with a single channel and narrow flood features. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle reach type and is dominated by boulder, cobble and gravel sediment types. Large gravel and cobble bars alternate along the active channel. Benches are composed of silt and sand. There is low embeddedness along riffles, runs and pools. There are signs of erosion along the channel margins and on the flood benches, with very little signs of sediment deposition. A silt drape is visible on the boulder, cobble and gravel where velocities are low in pool habitats.

Owing to constant rainfall conditions at the time of the May 2023 survey, saw the Mthatha River in flood and burst banks. Consequently, the biological component could not be conducted, nor could the cross-section or discharge be remeasured. Only slope and water levels were measured, and the riparian vegetation component conducted.

Biota habitats available
During the September 2022 survey, all biotopes, except for marginal and in-stream aquatic vegetation, was present. The marginal vegetation was limited owing to undercut banks along both banks. Fish habitats included slow-shallow (SS), slow-deep (SD), fast-shallow (FS) and fast-deep (FD).

Riparian vegetation

Owing to the system being flooded at the time of assessment, the marginal zone was inundated and not visible, with portions of the flood benches on both banks also flooded. Vegetation protruding from the water surface included *Miscanthus ecklonii, Sesbanea punicea, Gomphostigma virgatum* and sedges. Flood benches were overgrazed with *Cynodon dactylon* and *Hemarthria altissima* forming lawns, and were heavily invaded by alien weeds, *S. punicea,* and *Senna didymobotrya*. *Miscanthus eckloniii* also occurred along flood benches and toward the channel. Vegetation surrounding upstream pool habitats included overhanging *Ficus sur, Combretum caffrum* and *Cestrum laevigatum*, with some mud drapes also visible. The gently sloping macro-channel banks were highly disturbed and severely invaded by perennial alien species, including *S. punicea, S. didymobotrya, Lantana camara, C. laevigatum* and vegetation removal was high.

Site impacts:

- Upstream towns and villages
- WWTW
- Bridge
- Alien invasive plant species (riparian zone) (lantana)
- Upstream weir
- Algae and fine silt layer over stones biotope
- Erosion
- Cattle trampling and grazing

Preliminary Results

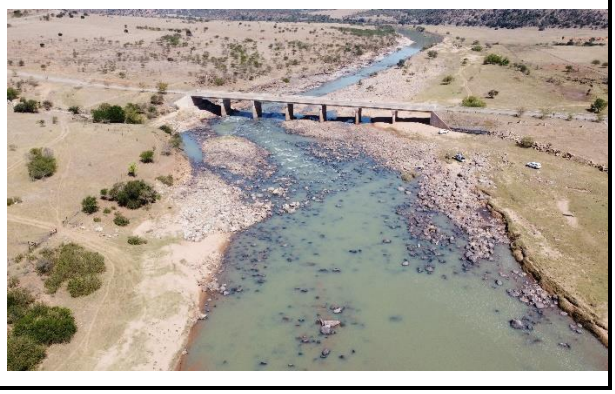
***In situ* water quality:**

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.77	*Was not measured as system was in flood*
EC (uS/cm)	764.1	
TDS (g/l)	0.3362	
DO (mg/l)	7.67	
DO% (%)	85.8	
Clarity (cm)	45	
Temperature (°C)	20.8	
Salinity (ppt)	0.25	

	Survey 1 (September 2022)	Survey 2 (May 2023)
Discharge (m3/s)	0.96	*Was not measured as system was in flood*

5.2 Mbhashe River (Middle)

Sample Date	13 May 2023	**Reserve Level Assessment**	Intermediate
Site Name	MBAS01_I	**IUA**	IUA_T02
River	Mbhashe	**IUA description**	Lower Mbashe
Altitude (m.a.s.l.)	392	**Prioritised RU**	R_RU14_I
Longitude	28.472236	**Latitude**	-31.958131
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	T13E
Level 2 EcoRegion	31.01	**SQ Reach**	T13C-06941
Geomorphological zone	E (Slope 0.003)	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			



Site Photographs: Survey 2 (May 2023)

Drone images could not be taken owing to the rainfall conditions at the time of the survey.

Upstream

Downstream

Site Description:

The site is located near the eMgudwane and is 4km (straight distance) from the N2.

The site is located along a partly confined valley setting with a single channel and narrow flood features. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle or pool-rapid reach type, often with long pools, and is dominated by boulder, cobble and sand sediment types. Benches are composed of silt and sand. There is high embeddedness along riffles, runs and pools. There are signs of erosion and deposition along the channel margins and on the flood benches. Large sand bars form along the pools and there is a fine sand or silt drape across boulder and cobble habitats where flow velocities are low. Grazing and trampling takes place along the banks and flood features.

Biota habitats available

Biotopes available for aquatic macroinvertebrates were dominated by the boulders, SIC and SOOC habitat, GSM was available in pockets along the right banks, as well as within the interstitial spaces amongst the SOOC. Sand benches (mud) were mostly along the right bank. There was no instream aquatic vegetation, and very limited marginal vegetation. Varying flow velocity and depth classes were available for fish, namely SD, SS, FS and FD.

Riparian vegetation

The marginal zone and portions of the flood benches had been scoured or removed from recent floods. Marginal zone vegetation was sparse and scattered and comprised clumps of *Phragmites mauritianus, Cyperus longus* or scattered remnants of *Gomphostigma virgatum.* Flood benches were a mix of scoured bedrock/boulder/cobble, mostly unvegetated and consolidated alluvia with overgrazed lawns dominated by *Cynodon dactylon.* The left bank was steep, with *C. dactylon, Agrostis lachnantha,* scattered trees, mostly *Combretum caffrum* or *Vachellia karroo* and a band of *V. karroo* seedlings and saplings. The right bank had been altered with artificially piled rocks and incised by a lateral tributary feeding into the main channel just upstream of the site. As such, vegetation was artificially aligned and comprised mostly alien shrub species including *Sesbanea punicea, Lantana camara, Senna didiymobotrya* and *Solanum torvum.*

Site impacts:

- Erosion
- Cattle trampling and grazing
- Upstream water transfer from Ncora Dam (Tsomo River in S5) to Collywobbles hydropower downstream
- Sediment mining
- Upstream rural settlements and town

Preliminary Results

In situ water quality:

Parameter	**Survey 1 (September 2022)**	**Survey 2 (May 2023)**
pH	8.50	8.49
EC (uS/cm)	231.8	305.0
TDS (g/l)	0.1666	0.237
DO (mg/l)	8.22	8.96
DO% (%)	90.8	91.6
Clarity (cm)	77	22
Temperature (°C)	20.0	16.36
Salinity (ppt)	0.12	0.18

	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m^3/s)	5.81	20.83

5.3 Black Kei River

Sample Date	10 May 2023	**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_R
Longitude	27.068903	**Latitude**	-32.118266
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			
			

Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located near Tylden, about 4 km upstream from the N6.

The site is located in a partly confined valley setting with a single channel and narrow flood features. The channel is straight to wandering, incised into the surrounding landscape and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by boulder, cobble, gravel and sand sediment types at the site. There are significant bedrock sections with localised bedrock steps. Benches are composed of sand. There is embeddedness of cobble and

gravels where flow velocities are lower. There is widespread grazing along the banks and flood zones, with trampling evident at the site.

Following the flood event that took place in February 2023, clear evidence of bank collapse and further bank erosion was observed, particularly along the left bank. This was exasperated by the continued cattle trampling and grazing along that bank.

Biota habitats available
Biotopes available for aquatic macroinvertebrates included a combination of bedrock, SIC and SOOC. Marginal vegetation was limited in September 2022, and owing to further extensive bank erosion following the floods, there was no marginal vegetation to sample in May 2023. GSM was sampled along the banks (mostly mud). Fish habitats included SD, SS, FD and FS.

Riparian vegetation
The site was heavily disturbed by overgrazing, trampling and vegetation clearing and as such has extensively eroded, especially along the marginal zone, during the recent floods. Most of the marginal zone has been scoured or removed by floods or is denuded due to trampling disturbance. That which remains is dominated by non-woody sedges or grasses, with a small population of *Salix mucronata* that has remained on the right bank. Banks, inset benches and flood benches are similarly impacted by trampling and grazing, have become fragmented and are eroding or slumping in several areas. Most bank woody species have been removed or are alien. Alien species include *Salix fragilis, S. babylonica, Melia azedarach, Lantana camara* and *Gleditsia tracanthos*. The floodplain is dominated by *Miscanthus ecklonii,* with extensive deposition of new sediments from the recent floods and is highly invaded by alien plant species, mainly *S. fragilis* and *Arundo donax.*

Site impacts:

- Water quality impacts (sewage)
- Erosion
- Cattle trampling and grazing
- Abstraction and irrigation
- Dams on tributaries
- Exotic vegetation within the riparian zone (*Salix* sp., Honey Locust, Syringa)

Preliminary Results

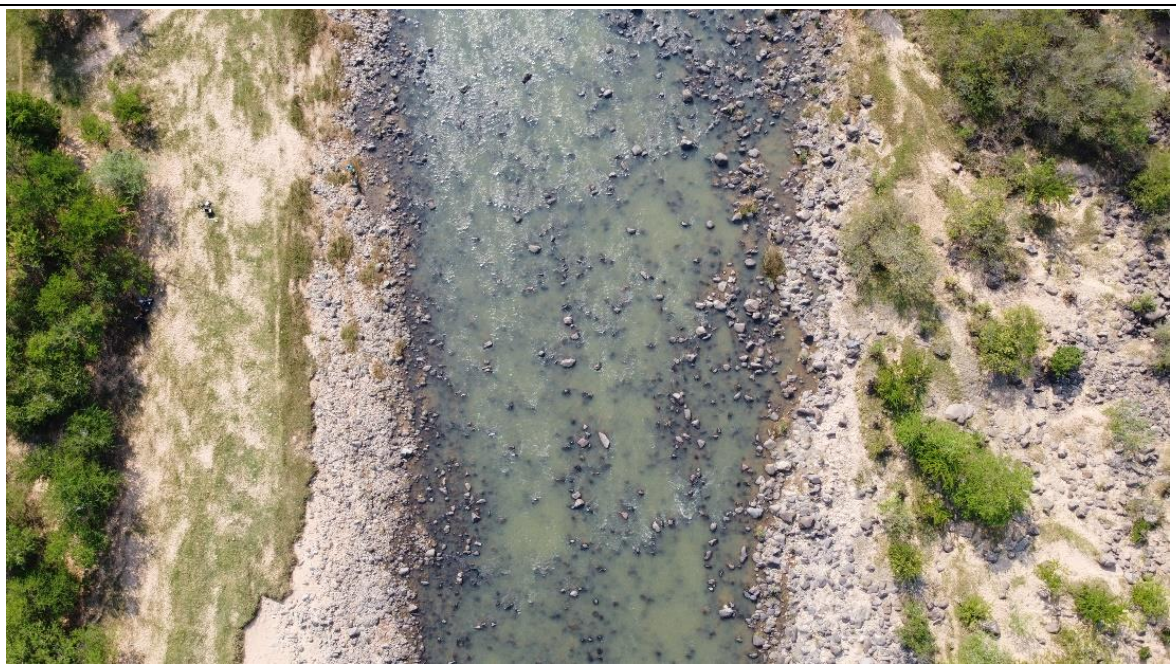
In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.57	8.69
EC (uS/cm)	434.7	808
TDS (g/l)	0.3272	0.633
DO (mg/l)	7.16	10.07
DO% (%)	75.6	102.4
Clarity (cm)	15	51

Temperature (°C)	17.8	16.07
Salinity (ppt)	0.24	0.48
	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m^3/s)	1.11	3.76

5.4 Great Kei River

Sample Date	12 May 2023	**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
Longitude	27.966289	**Latitude**	-32.508100
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			



Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located near KwaDlephu, 1.3 km upstream of the Great Kei N2 bridge.

The site is located along a confined valley setting with a single channel and narrow flood features. The channel is straight to wandering and follows the sinuous valley alignment. Localised braid bars form multi channels associated with steeper boulder habitats. It follows a pool-riffle or pool-rapid reach type, often with long pools, and is dominated by boulder, cobble, sand and silt sediment types. Benches are composed boulder and cobble bars with thick sand deposits. There is high

embeddedness along the margins of the riffles with silt drapes across the bed sediment along runs and pools. There are signs of erosion and deposition along the channel margins and on the flood benches, grazing and trampling is widespread.

Following the flood event which took place in February 2023, it was clearly observed that this reach of the Great Kei has been positively reset. Considerable sediment deposits were observed along both banks and terrestrial species (i.e *Vachellia robusta (Splendid* Thorn) flooded out along the riparian marginal zone. The boulders and SIC, SOOC have been scoured and a considerable difference in the population of Simuliidae larvae, which previously smothered and dominated the biotopes.

Biota habitats available
All biotopes were available for macroinvertebrates, although marginal vegetation was limited owing to undercut banks along both banks during both surveys. Fish habitats included SS, SD, FS and FD.

Riparian vegetation
The marginal zone had been mostly scoured out by recent floods with only remnants of vegetation clumps scattered between bedrock/boulder/cobble with newly deposited alluvia in-between. Vegetation comprised mostly *Cyperus longus, Gomphostigma virgatum* and *Hemarthria altissima,* although the latter had been grazed to form lawns. Flood benches and the floodplain were extensively covered by new, mostly unvegetated sediment deposits from recent floods and flood damage and flood-related plant deaths were extensive. The *Vachellia robusta* population which had dominated the floodplain before has been vastly reduced, although much remained, and dominance persisted. Other floodplain species included *Ficus sur, Combretum caffrum, Gymnosporia buxifolia* and *Lantana camara.* The banks were dominated by thickets of *L. camara* and wood removal and overgrazing were extensive.

Site impacts:

- Cattle trampling and grazing
- Sand mining
- Vegetation removal
- Agriculture and irrigation upstream
- Exposed banks and bank erosion including eroded gullies

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.75	8.63
EC (uS/cm)	474.2	533
TDS (g/l)	0.3384	0.399
DO (mg/l)	8.02	8.90
DO% (%)	84.0	94.5
Clarity (cm)	59	27

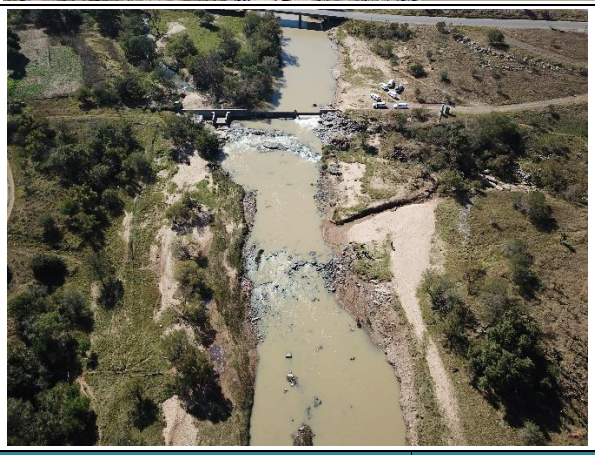
Temperature (°C)	20.3	18.14
Salinity (ppt)	0.24	0.30
	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m^3/s)	3.84	17.37

5.5 Tsomo River

Sample Date	11 May 2023	**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
Longitude	27.821557	**Latitude**	-32.04492
Level 1 EcoRegion	South Eastern Uplands	**Quaternary catchment**	S50G
Level 2 EcoRegion	16.06	**SQ Reach**	S50G-07011
Geomorphological zone	E (slope 0.004)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			

Site Photographs: Survey 1 (September 2022)

Site Photographs: Survey 2 (May 2023)



Upstream	Downstream

Site Description:

The site is located near Tsomo, just downstream of the R409 and gauging weir S5H002.

The site is located in a confined valley setting with a single channel and flood benches along both banks. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by boulder, cobble, gravel and sand sediment types. The boulder, cobble and gravel sediment are largely fixed with small pockets with mobile gravel. There are bedrock sections with localised bedrock steps. It has localised islands where the channel bifurcates around boulder bars or bedrock. Benches are composed of silt and

sand. There is low embeddedness along riffles and rapids, but significant embeddedness along pools or the margins of faster habitats where velocity is lower. Thick organic rich deposits were covering gravel pockets along the riffle where velocities were lower. Bank erosion is widespread, largely due to trampling and grazing. There are recent fine sand deposits along the flood benches, with sand mining along the higher flood features.

Biota habitats available
Aquatic Macroinvertebrate biotopes were dominated by bedrock and boulders, with some SIC, SOOC and GSM. A small pocket on aquatic instream vegetation was sampled in September 2022, however following the floods, part of this biotope was flushed downstream and the rest remained with undercut banks. There was limited to no marginal vegetation owing to lower water levels and undercut banks during both surveys. Varying fish habitats comprised FD, FS, SD and SS.

Riparian vegetation
The site is close to a weir and therefore has a high degree of scour and flood disturbance. Much of the marginal zone has been scoured out as well as a portion of the flood bench on the left bank. The marginal zone is comprised of pockets of sedges scattered across the rapid area or a narrow band around the edges of pools. *Gomphostigma virgatum* is also present in less disturbed cobble areas closer to the pool. The flood bench is also dominated by non-woody vegetation (mainly *Cyperus longus* and *Schoenoplectus*) with extensive areas of newly deposited, unvegetated alluvia from recent floods. A distinct treeline (*Salix mucronata, C. caffrum* and *Senegalia caffra*) marks the end of the flood bench and the start of the banks that are grassed (*Cynodon dactylon*) or have tall trees (*C. caffrum, Celtis africanum, A. mearnsii, A. dealbata*), scattered and in low density. Grazing and trampling pressure is moderate, as is invasion by alien plants species.

Site impacts:

- Upstream weir and water works
- Water quality issues (algae)
- Localised water abstraction
- Macroplastics (nappies)
- Cattle trampling and grazing
- Erosion and bare soils

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.75	8.48
EC (uS/cm)	309.8	268
TDS (g/l)	0.2287	0.211
DO (mg/l)	8.48	9.39
DO% (%)	95.1	94.7
Clarity (cm)	47 cm (estimate)	21

Temperature (°C)	18.8	15.83
Salinity (ppt)	0.17	0.16
	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.48	1.35

5.6 Buffalo River (Middle)

Sample Date	9 May 2023	**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
Longitude	27.640550	**Latitude**	-32.991584
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located downstream of Laing Dam and 1.5 km upstream of Bridle Drift Dam.

The site is located in a partly confined valley setting with a single channel and narrow flood features within a deeply incised macro channel. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by boulder, cobble, gravel and silt sediment types. The banks and benches are composed of cobble, gravel, sand and silt. The gravels and cobbles along the riffle margin have a moderate extent of silt cover, indicating higher silt loads during higher flows. This can be seen in the pools with thick silt drapes

across the various low velocity habitats. Livestock grazing and trampling is widespread. There is widespread erosion along the banks and inset benches. Very localised sand deposition takes place on the lower flood features, with widespread evidence of recent erosion.

Biota habitats available
The biotopes available for aquatic macroinvertebrates included both SIC, SOOC and some marginal vegetation, although limited owing to undercut banks and low flows. The GSM biotope was also limited. Fish habits included SS, FS and SD.

Riparian vegetation
The site has been highly disturbed by both scour from its close proximity to the weir and high grazing and trampling pressure, and also comprises a high degree of invasion by alien plant species, notably *Sesbanea punicea.* The marginal zone is narrow with woody overhang in the pool areas and dominated by non-woody sedges and grasses (*C. textilis, M. ecklonii*) along the riffle/rapid areas and *E. crassipes* (Water Hyacinth) is present in the channel. The flood bench is scoured with scattered tufted grasses (*M. ecklonii*) and a high infestation of alien shrubs (*S. punicea*). Banks are denuded in places, with tall alien species such as Wattle (*Acacia mearnsii, A. dealbata*) and Syringa (*Melia azedarach*), some *Combretum caffrum* and several terrestrial tree and shrub species

Site impacts:

- Weir
- Alien invasive aquatic macrophytes (*Eichhornia crassipes* - Hyacinth)
- Nutrients (algae)
- Bank erosion (left bank)
- Pump station (right bank)
- Cattle trampling and grazing

Preliminary Results

In situ water quality:

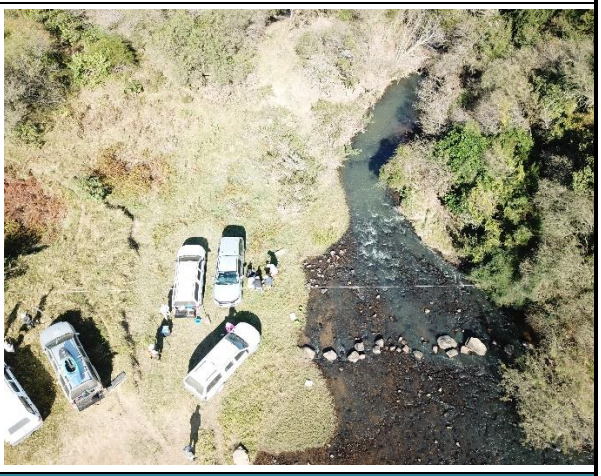
Parameter	**Survey 1 (September 2022)**	**Survey 2 (May 2023)**
pH	8.30	8.16
EC (uS/cm)	562	615
TDS (g/l)	0.4052	0.445
DO (mg/l)	9.24	8.30
DO% (%)	102.1	91.0
Clarity (cm)	30	Approx. 70
Temperature (°C)	19.9	19.72
Salinity (ppt)	0.3	0.33

	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.11	0.12

5.7 Keiskamma River (Upper)

Sample Date	8 May 2023	**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
Longitude	27.024092	**Latitude**	-32.802217
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)



Upstream	Downstream

Site Description:

The site is located near the Fort Cox Agricultural College, about 3 km (straight distance) from the R63.

The site is located in a partly confined valley setting with a single channel and narrow flood features within a deeply incised macro channel. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by cobble, gravel and silt sediment types. The banks and benches are composed of sand and silt. The gravels

and cobbles along the riffle have a significant silt component, indicating high silt loads during higher flows. This can be seen in the pools with thick silt drapes across the various low velocity habitats. Livestock grazing and trampling is widespread, with localised sand mining along the flood features. There are moderate levels of erosion along the banks, but is more severe at the causeway due to altered flow patterns. Woody encroachment is evident along the channel, with sandy lee bars forming behind thick vegetation. Sand deposition takes place on the lower flood features.

Biota habitats available
Good availability of SIC, SOOC and GSM. Marginal vegetation was limited owing to undercut banks. Varying fish habitats comprised FS, SD and SS.

Riparian vegetation
In most places the marginal zone is restricted to a narrow band along the wetted edge, mostly unvegetated due to shading by overhanging woody vegetation rooted on the banks. Where sediment has been deposited and stabilised by vegetation, mainly in the vicinity of the low level crossing, marginal zone vegetation was dominated by non-woody species, mostly sedges (*C. textilis*) and grasses (*I. faciculatum*) that were heavily grazed. Woody marginal vegetation was represented by a single *Salix mucronata* sapling. Inset benches supported similar vegetation with the addition of *Persicaria* and *C. dives*. Alien species were limited to *X. stromarium* seedlings. Flood benches comprised a mix of woody and non-woody vegetation with a high degree of alien invasion (mainly annual and bi-annual weeds, but also *Melia azedarach* and *Sesbanea punicea*) and terrestrialisation (*V. karroo* and *S. caffra*). Erosion was high, as was grazing, disturbance and wood removal. The macro channel bank was steep, confined and dominated by tall, dense and extensive woody vegetation, with terrestrial species in excess of 50%. Recruitment of riparian tree species along the banks was largely absent.

Site impacts:

- Low water bridge
- Cattle trampling and grazing
- Bank erosion
- Nutrient enrichment (algae)
- Silt

Preliminary Results

In situ water quality:

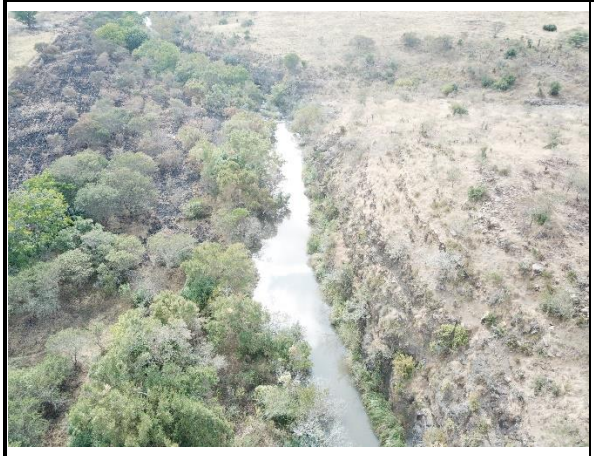
Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.37	8.01
EC (uS/cm)	185.0	188
TDS (g/l)	0.1402	0.146
DO (mg/l)	9.77	9.06
DO% (%)	102.2	92.8
Clarity (cm)	73	Approx. 70

Temperature (°C)	17.6	16.45
Salinity (ppt)	0.10	0.11
	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.37	0.53

5.8 Kat River (Upper)

Sample Date	8 May 2023	**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
Longitude	26.722041	**Latitude**	-32.569705
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)



Upstream	Downstream

Site Description:

The site is located near Hertzog, about 1 km (straight distance) from the R67.

The site is located in a confined valley setting with a single channel and narrow flood features within a deeply incised macro channel. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by boulder, cobble, gravel and silt sediment types. The banks and benches are composed of sand and silt, with bedrock cliffs along the outer bends. The channel has dense tree and grass vegetation with some

localised trampling where livestock cross the channel. Bank erosion is localised and the bed along the riffle has a limited gravel and sand deposits, possibly due to sediment starvation. Siltation takes place along the pools with a silt drape covering slow flowing habitats. There are numerous weirs along the river, increasing pool type habitats.

Biota habitats available
A good availability of aquatic macroinvertebrate biotopes. These included SIC, SOOC, some bedrock along the right bank. Marginal vegetation and some in-stream aquatic macrophytes. The GSM biotope was slightly limited. Varying fish habitats comprised FD, FS, SD and SS.

Riparian vegetation
Pool and riffle habitats restricted on the right bank (RB) by cliffs. Pool margins were narrow on the RB, comprised of shrubs (*C. strobilifera*) and grasses (*Miscanthus ecklonii*), while the left bank (LB) had taller trees (*Combretum caffrum*) with overhanging cover. Aquatic vegetation was absent. *Gomphostigma virgatum* was growing in fast flowing water in cobble areas of the riffle, where marginal zone species were dominated by grasses (*M. ecklonii*) and sedges (*C. textilis, Kyllinga elatior*) with scattered *C. caffrum* individuals. Grazing and trampling pressure was evident in the zone. Bank species were dominated by riparian (*C. caffrum*) and terrestrial (*Senegalia caffra*) trees with a shrub layer (*Gymnosporia senegalensis*) and a well-developed understorey. Alien plant species were low in abundance but included some invasive species (*Mellia azedarach, Opuntia ficus-indica*) which have the potential to increased and cause deterioration of the site.

Site impacts:

- Alien invasive plants within riparian zone
- Upstream dam (Kat River Dam)
- Downstream weir
- Cattle trampling, grazing, crossings
- Local villages

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	7.76	8.16
EC (uS/cm)	123.3	123
TDS (g/l)	0.1002	0.097
DO (mg/l)	7.30	8.91
DO% (%)	71.7	89.5
Clarity (cm)	40	Approx. 30cm
Temperature (°C)	14.5	15.52
Salinity (ppt)	0.07	0.07

	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.03	0.05

5.9 Great Fish River (Lower)

Sample Date	7 May 2023	**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
Longitude	26.225285	**Latitude**	-33.083607
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
Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located at the Carlisle Bridge along the R350.

The site is located in a moderately confined valley setting with a single channel and narrow flood features within a deeply incised macro channel. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by boulder, cobble, gravel and silt sediment types. The banks and benches are composed of fine sand and silt, with bedrock along rapids and along the outer bends. The channel has dense sedge, reed and tree vegetation with some localised trampling where game cross or drink from the channel. Bank erosion is localised and the bed along the riffle has a limited gravel and sand deposits, due to increased flow levels. Siltation takes place along the pools with a silt drape covering slow flowing habitats.

Biota habitats available
Aquatic macroinvertebrate biotopes available were SIC and marginal vegetation, with limited SOOC and GSM. Fish habitats included FD, FS, SD and SS.

Riparian vegetation
The marginal zone appeared scoured with extensive undercutting of reedbeds and an absence of dicotyledonous forbs such as *Persicaria* and *Ludwigia.* The zone was narrow and confined and dominated by *Phragmites australis* and *Cyperus textilis.* The flood bench was also dominated by non-woody vegetation, notably *Phragmites australis, C. textilis, C. sexangularis* and *Paspalum distichum*, but with scattered *Vachellia karroo* saplings and young adults. The macro-channel bank was dominated by dense, tall woody vegetation, mainly *V. karroo*, but also *Searsia lancea.* Alien invasive plant species were minimal and comprised mainly *Opuntia ficus-indica* and *Ricinus communis*, as well as annual weed species such as *Tagetes minuta, Bidens pilosa* and *Conyza bonariensis*.

Site impacts:

- Interbasin Transfer scheme (flow modification)
- Drainage channel
- Cattle trampling and grazing
- Upstream town (Cradock)
- High sedimentation (highly turbid)

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	8.61	8.26
EC (uS/cm)	891	1205
TDS (g/l)	0.716	0.928
DO (mg/l)	8.25	8.01
DO% (%)	81.9	82.9
Clarity (cm)	11	Approx. 10
Temperature (°C)	15.0	16.83
Salinity (ppt)	0.55	0.72

	Survey 1 (September 2022)	Survey 2 (May 2023)
Discharge (m3/s)	3.5	5.70

5.10 KwaZungu / Swartkops River

Sample Date	6 May 2023	**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
Longitude	-33.722183	**Latitude**	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

Components sampled: Fish, aquatic macroinvertebrates, *in situ* water quality, diatoms, riparian vegetation, cross-section, discharge

Site Photographs: Survey 1 (September 2022)


Site Photographs: Survey 2 (May 2023)


Drone prohibited owing to conservation area

Upstream	Downstream

Site Description:

The site is located in Groendal Natrue Reserve, about 5 km (straight distance) downstream of the Groendal Dam.

The site is located in a partly confined valley setting with a single channel and floodplain along the left bank. The active channel has narrow flood benches and is deeply incised into the valley floor. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle reach type and is dominated by boulder, cobble, gravel and sand sediment types. The floodplain, banks and benches are composed of boulder, cobble, gravel and sand, with bedrock cliffs or steep hillslopes along parts of the outer bends. The channel is densely vegetated with shrubs, sedges and tall grasses. There were very limited signs of grazing and trampling along the banks. Undercut banks and bank erosion is fairly common and the bed along the riffle and pools have very low embeddedness, possibly due to sediment starvation caused by the Groendal Dam. Small inset benches are forming and are composed of medium sand.

Biota habitats available
All macroinvertebrate biotopes had good availability. Fish habitats only included FS and SD.

Riparian vegetation
The channel was confined and bedrock controlled with some lateral sediment deposition which supported patches of grass (*Leersia hexandra*) and sedge (*Schoenoplectus decipiens*), but the marginal zone was mostly narrow and limited to sedges and waterfern (*Cyclosorus interruptus*) with overhanging shrubs (*Cliffortia strobilifera*). *Prionium serratum* was also present but only small pockets here and there. Banks were either non-vegetated loose cobble or vegetated with mainly shrubs (*C. strobilifera*) and tall trees (*Podocarpus falcatus*). A flood terrace dominated by cobble/ boulder was terrestrial, mainly Fynbos species such as *Erica.*

Site impacts:

- Upstream Groendal Dam
- Limited impacts (conservation area – Groendal Nature Reserve)

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	6.65	7.88
EC (uS/cm)	205.8	211
TDS (g/l)	0.1634	0.172
DO (mg/l)	7.63	7.16
DO% (%)	76.7	74.3
Clarity (cm)	>1m	>1m
Temperature (°C)	15.5	17.01

Salinity (ppt)	0.12	0.13
	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.069	0.096

5.11 Gamtoos River

During the May 2023 survey, the site had no flow, stagnant pool upstream of the bridge and limited water downstream. Consequently, aquatic macroinvertebrates and discharge was not conducted. However, fish , riparian vegetation and water levels were measured, retaining this site as Intermediate.

Sample Date	5 May 2023	**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
Longitude	-33.760983	**Latitude**	24.693677
Level 1 EcoRegion	Southern Folded Mountains	**Quaternary catchment**	L90A
Level 2 EcoRegion	19.02	**SQ Reach**	L90A-08897
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	C
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Components sampled: Fish, *in situ* water quality, diatoms, riparian vegetation, discharge			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located roughly 10 km in an upstream direction from Patensie and 10 km downstream of the Kouga Dam (both straight line distances).

The site is located in an unconfined valley setting with a single channel and floodplain along both banks. The valley floor is composed of cobbles, boulders and gravel with a fairly shallow channel. Inset benches and shallow flood channels are present. Terraces and alluvial fans are common along the valley floor and buffer the channel from the steep hillslopes. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle reach type and is dominated by boulder, cobble, gravel and sand sediment types. The floodplain, banks and benches are composed of boulder, cobble, gravel and sand, with bedrock cliffs or steep hillslopes along parts of the outer bends. The channel margins and flood features are vegetated with small shrubs and sedges. Grazing and trampling takes place along the banks and floodplain. Undercut banks and bank erosion is fairly uncommon at the site and the bed along the riffle and pools have a moderate level of embeddedness. A silt drape is present across coarser sediment in slow flowing habitats, such as pools.

During the May 2023 survey, flow conditions were zero. The water had pooled upstream of the low water bridge, with zero flow and limited water downstream of the bridge. Consequently, macroinvertebrates were not sampled. The rest of the components were conducted.

Biota habitats available
During the September 2022 survey, all biotopes for aquatic macroinvertebrate habitats were available. In September 2022 and May 2023, fish habitats included FS, SD, SS and SS and SD respectively.

Riparian vegetation
The site has a gentle lateral slope and was dominated by non-woody vegetation across all zones, with high aerial cover. Vegetation comprised mainly sedges (notably *Cyperus* textilis) and grasses (mainly *Ischaemum fasciculatum*) with scattered shrubs. The presence of *Typha capensis* and extensive filamentous green algae suggests elevated nutrients in the system. Flow was almost absent with only a trickle remaining, but an aquatic component persisted (*Potamogeton pusillus*) in pooled areas. *Cyperus textilis* had increased in density and extent since the first visit and had encroached to within the main channel. Alien species cover was moderate to high in other areas, mainly *Sesbanea punicea* and *Senna didymobotrya.*

Site impacts:

- Cattle trampling and grazing
- Low water bridge
- Citrus farming
- Irrigation
- Return flows
- Nutrients (high algae content)
- Alien invasive vegetation within the riparian zone (peanut butter cassia)

Preliminary Results

In situ water quality:

Parameter	**Survey 1 (September 2022)**	**Survey 2 (May 2023)**
pH	7.87	8.25
EC (uS/cm)	939	829
TDS (g/l)	0.707	0.578
DO (mg/l)	8.97	12.09
DO% (%)	94.9	136.4
Clarity (cm)	43	Approx. 10
Temperature (°C)	17.8	21.4
Salinity (ppt)	0.54	0.44

	Survey 1 (September 2022)	**Survey 2 (May 2023)**
Discharge (m3/s)	0.06	0.00

6. RIVER SURVEY SITE DETAILS: RAPID 3 SITES

6.1 Kromme River

Sample Date	5 May 2023	**Reserve Level Assessment**	Rapid 3
Site Code	KROMM01_R	**IUA**	IUA_K01
River	Kromme	**IUA description**	Tsitsikamma and headwaters of Kromme to Kromme Dam
Altitude (m.a.s.l.)	239	**Prioritised RU**	R_RU01_I
Longitude	24.2690587	**Latitude**	-33.9370951
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

Components sampled: Fish, aquatic macroinvertebrates, IHI, *in situ* water quality, diatoms, cross-section, discharge

Site Photographs: Survey 2 (May 2023)

Upstream

Downstream

Site Description:

The site is located along the Kromme River valley with cobble-bed or mixed bedrock-cobble bed habitats, with a mix of sand, gravel and cobbles. There are large gravel and cobble bars along the left bank of the channel, with the benches composed of silt and sand. There is very low embeddedness along riffles, runs and pools. This may be owing to sediment starvation from the upstream weir. The active channel has narrow flood benches and is relatively incised into the valley floor. The channel is straight to wandering and follows the sinuous valley alignment The channel is braided in some areas along the reach, and which is densely vegetated with shrubs, sedges and

pockets of peat. There are sections of steep bank erosion, likely owing to the last flood event which took place in 2015.

Biota habitats available
All biotopes for aquatic macroinvertebrate habitats were available. Fish habitats only included FS, SS and SD.

Site impacts:

- Incision of the river channel (flow related);
- Extensive erosion;
- Cattle farming
- Upstream weir
- Irrigation
- Bridge crossing (newly built in 2018)
- Channelled valley-bottom wetland (positive impact)

SUMMARY RESULTS

In situ water quality:

- pH: 7.95
- EC: 198 uS/cm
- TDS: 0.152 g/l
- DO: 8.24 mg/l
- DO%: 84.0 %
- Clarity: >1m
- Temperature: 16.95 °C
- Salinity: 0.11 ppt

Discharge: 0.181 m^3/s

6.2 Gcuwa River

Sample Date	11 May 2023	**Reserve Level Assessment**	Rapid 3
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
Longitude	28.136094°	**Latitude**	-32.319770°
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

Components sampled: Fish, aquatic macroinvertebrates, IHI, *in situ* water quality, diatoms, cross-section, discharge

Site Photographs (May 2023)

Upstream

Downstream

Site Description:

This highly turbid reach of the Gcuwa River is located just upstream of Butterworth town, downstream of the Gcuwa Dam wall. This was the only suitable site upstream owing to significant impacts from raw sewage entering into the Gcuwa River downstream of Butterworth.

The single channel is within a deeply incised channel with extensive bank ersion particularly along the left bank. Upstream of the bridge is a pool receiving the overflow from the Gcuwa Dam, while downstream of the bridge is narrowed and follows a pool-riffle and pool-rapid reach type and is dominated by embedded boulder, cobble, gravel and silt sediment types.

Biota habitats available

The aquatic macroinvertebrate biotopes were dominated by bedrock and boulders, including SIC, SOOC and GSM. Marginal vegetation was limited. Fish habitats only included FS, FD, SS and SD.

Site impacts:
• Upstream dam • Cattle trampling and grazing • Low water bridge • Nutrients (high algae content) • Moderate alien invasive vegetation within the riparian zone • Extensive bank erosion
Preliminary Results
In situ water quality: • pH: 8.41 • EC: 533 uS/cm • TDS: 0.380 g/l • DO: 8.91 mg/l • DO%: 97.3 % • Clarity: 11 cm • Temperature: 19.6 °C • Salinity: 0.29
Discharge: 0.043 m3/s

6.3 Kubusi River (Lower)

Sample Date	10 May 2023	**Reserve Level Assessment**	Rapid 3, high confidence
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
Longitude	27.731348	**Latitude**	-32.50722
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

Components sampled: Fish, aquatic macroinvertebrates, IHI and riparian vegetation species list to increase confidence, *in situ* water quality, diatoms, cross-section, discharge

Site Photographs: Survey 1 (September 2022) (-32.56891, 27.62104)

Site Photographs: Survey 2 (May 2023) (selected Rapid 3 EWR site)

Upstream

Downstream

Site Description:
The site is located off the N6, near Mokalo Private Game Reserve at the DWS REMP site.
The site is located in a confined valley setting with a braided channel and narrow flood features. It has localised islands where bedrock or large boulders form obstructions. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle and pool-rapid reach type and is dominated by cobbles, boulder and sand sediment types. There are several riffle steps down the reach. Benches are composed of silt and sand. There is low embeddedness along riffles and rapids.

Biota habitats available
Boulders and cobbles were the most dominant biotope for the aquatic macroinvertebrates, with SOOC and GSM available in pockets along both banks and within the interstitial spaces of the SIC and SOOC. Abundance of both in-stream aquatic vegetation and marginal vegetation. Varying flow velocity and depth classes were available for fish, namely SD, SS, FS and FD.

Site impacts:

- Bridge
- Agriculture and irrigation
- Alien invasive plants within the riparian zone
- Upstream Tois River contributing to the sediment loads
- Upstream Wiggleswade Dam

Preliminary Results

In situ water quality:

Parameter	Survey 1 (September 2022)	Survey 2 (May 2023)
pH	7.39	8.23
EC (uS/cm)	290.4	342
TDS (g/l)	0.2171	0.259
DO (mg/l)	7.84	7.91
DO% (%)	84.0	82.6
Clarity (cm)	26	72
Temperature (°C)	18.2	17.52
Salinity (ppt)	0.16	0.19

	Survey 1 (September 2022)	Survey 2 (May 2023)
Discharge (m^3/s)	-	0.013

7. RIVER SURVEY SITE DETAILS: SITES WHICH COULD NOT BE SURVEYED

7.1 Kariega River *(Dry)*

Sample Date	7 May 2023	**Reserve Level Assessment**	Desktop
Site Name	KARI01_I	**IUA**	IUA_P01
River	Kariega	**IUA description**	P primary catchment
Altitude (m.a.s.l.)	224	**Prioritised RU**	R_RU05_I
Longitude	WP11354_Keiskamma^J Fish to Tsits_Surv 26.481217°	**Latitude**	-33.468505°
Level 1 EcoRegion	South Eastern Coastal Belt	**Quaternary catchment**	P30B
Level 2 EcoRegion	20.01	**SQ Reach**	P30B-08570
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Components sampled: None – site dry			
Site Photographs: Survey 1 (September 2022)			
			
Site Photographs: Survey 2 (May 2023)			

	
Upstream	**Downstream**

7.2 Boesmans River *(Dry)*

Sample Date	7 May 2023	**Reserve Level Assessment**	Desktop
Site Name	Boes01_R	**IUA**	IUA_P01
River	Boesmans	**IUA description**	P primary catchment
Altitude (m.a.s.l.)	93	**Prioritised RU**	R_RU10_R
Longitude	26.391105°	**Latitude**	-33.543899°
Level 1 EcoRegion	South Eastern Coastal Belt	**Quaternary catchment**	P10G
Level 2 EcoRegion	20.01	**SQ Reach**	P10G-08723
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	B
Ecological Importance	High	**Ecological Sensitivity**	Moderate
Components sampled: None – site dry			
Site Photographs: Survey 1 (September 2022)			
			
Site Photographs: Survey 1 (May 2023)			

	
Upstream	**Downstream**

7.3 Great Fish River (Middle) *(High flows)*

This site still could not be surveyed owing to continued high flows (Fish Interbasin transfer (IBT)) and safety risk. This site was assessed however, the levels continue to be high as the farmers have only 4 weeks left to order water for their dams and irrigation prior to switching the transfer off for maintenance purposes until July 2023. A Flow Management Plan (FMP) may be considered for this reach which is experiencing extensive flow modifications owing to the IBT.

Sample Date	4 May 2023	**Reserve Level Assessment**	FMP/Desktop
Site Name	FISH02_I	**IUA**	IUA_Q02
River	Great Fish	**IUA description**	Great Fish
Altitude (m.a.s.l.)	695	**Prioritised RU**	R_RU07_I
Longitude	25.751772	**Latitude**	-32.604885
Level 1 EcoRegion	Drought Corridor	**Quaternary catchment**	Q50C
Level 2 EcoRegion	18.02	**SQ Reach**	Q50C-07657
Geomorphological zone	E (slope 0.002)	**PES (DWS, 2014)**	D
Ecological Importance	Moderate	**Ecological Sensitivity**	Moderate
Components sampled: None – could not sample owing to too high flows			
Site Photographs: Survey 1 (September 2022)			

Site Photographs: Survey 2 (May 2023)

Upstream	Downstream

Site Description:

The site is located near near the Witmos Primary School and just downstream of the confluence with the Kariega river and 8.5 km downstream of the Fish?? Dam.

The site is located in a partly confined valley setting with a single channel and narrow flood features. The channel is incised into the surrounding landscape. The channel is straight to wandering and follows the sinuous valley alignment. It follows a pool-riffle reach type and is dominated by cobble, gravel, fine sand and silt sediment types. The banks and benches are composed of sand and silt. Dense reeds are stabilising the active channel banks, leading to steep active channel banks. Grazing is absent from the channel banks and flood features, leading to low bank and marginal zone degradation. Finer sediment bars, such as sand and gravel bars, are missing, possibly due to increased transport rates entraining these sediment types, limiting their residence time along the system.

Site impacts:

- Agriculture
- Irrigation and return flows
- Interbasin Transfer scheme (flow modification)
- High turbidity

Preliminary Results

In situ water quality:

Parameter	**Survey 1 (September 2022)**
pH	8.57
EC (uS/cm)	396.7
TDS (g/l)	0.3256
DO (mg/l)	8.12
DO% (%)	79.1
Clarity (cm)	7
Temperature (°C)	14.1
Salinity (ppt)	0.24

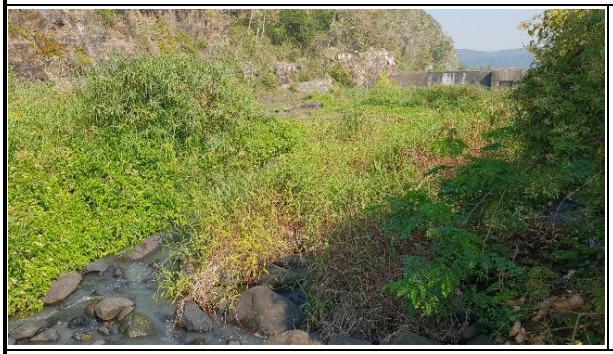
	Survey 1 (September 2022)
Discharge (m^3/s)	10.22

7.4 Buffalo River (Lower) *(Sewage)*

Sample Date	9 May 2023	**Reserve Level Assessment**	Desktop
Site Name	BUFF02_R	**IUA**	IUA_R02
River	Buffalo	**IUA description**	Buffalo/ Nahoon
Altitude (m.a.s.l.)	55m	**Prioritised RU**	R_RU20_R
Longitude	27.775910	**Latitude**	-32.991768
Level 1 EcoRegion	Eastern Coastal Belt	**Quaternary catchment**	R20F
Level 2 EcoRegion	31.02	**SQ Reach**	R20F-08045
Geomorphological zone	D (Slope 0.011)	**PES (DWS, 2014)**	D
Ecological Importance	High	**Ecological Sensitivity**	Moderate

Components sampled: None – could not sample owing to raw sewage flowing into the system and health hazards. Please refer below for further information.

Site Photographs: Survey 1 (September 2022)



Site Photographs: Survey 1 (May 2023)

Not surveyed

Upstream	Downstream

Site impacts:

- Considerate raw sewage inputs from adjacent residential area
- Nutrients (algae) mainly from WWTW pipeline leakage downstream
- Upstream weir
- Water abstraction
- Alien invasive aquatic macrophytes (*Eichhornia crassipes* – Hyacinth)
- Cattle trampling and grazing
- Alien invasive trees within riparian zone (Syringa sp., *Caesalpinia pulcherrima* - Pride of Barbados)
- Downstream of Bridle Drift Dam

Red Flag for actioning from the Department

During the May 2023 survey, evidence of raw sewage flowing directly into the lower reaches of the Buffalo River, where our EWR site is located, was observed. The source of this sewage appears to be sourced from the residential and rural area of Reeston and beyond. The observed flow of raw sewage was higher than what was previously observed in September 2022. The bypassing of the Wastewater

Treatment Works (WWTW), which is located just downstream of this site and adjacent to the water pump house along the River, exacerbates these issues, posing health hazards to both humans and the environment.

Figure 1 illustrates the accumulation of raw sewage in the road and flowing through the vegetated riparian zone and directly into the river where excessive growth of hyacinth can be observed along the margins. This is further illustrated from google earth (Figure 2). The colouration is also an indication of sewage inflow (Figure 3a, b). The DWS also has a monitoring site along this stretch called R2BUFF-ZWELI, which too has not been surveyed owing to raw sewage inputs into the river and its associated health hazards.

At the time of the survey, DWS colleagues observed the raw sewage inputs with the specialist project team, and discussions were had regarding the severity of the current state of this river, emphasizing the need for urgent attention and action to be taken by the Catchment Management Agency (CMA).

Figure 1: Accumulation of raw sewage along the access road to the Lower Buffalo Reach and the concentrated hyacinth along the margins

Figure 2: Google earth imagery of the effects of the raw sewage inputs into the lower Buffalo River

Figure 3a: Sewage inputs

Figure 3b: Sewage inputs

8. CAPACITY BUILDING

An important component of the river surveys is to share expert knowledge and river survey methodologies with members of the DWS (Table 4-1).

A second opportunity was provided to the DWS teams to accompany the river specialist team on the second river survey, which was undertaken in May 2023. Colleagues were again taken through the detail behind what is involved in intermediate and Rapid 3 river level approaches, and the various associated components. This second opportunity further included the riparian vegetation component at all intermediate studies, using the Riparian Vegetation Response Assessment Index (VEGRAI).

Discussions were had around the characteristics of each site, the associated reach features namely, erosion, available biotopes/habits for the biota, flow velocities, algae/eutrophication, surrounding land use practices, sediment loading, hydraulic features, impediments amongst others. Vital components around how sites are selected were discussed. It was reiterated that selected sites were those that would provide the information regarding the variety of conditions in a river reach related to the available habitats. Considerations were further discussed namely, their location within the identified priority RU (stressed areas, hotspots), whether there were upstream gauging weirs with good quality hydrological data, coupled with characteristics of tributaries.

From an ecological perspective, the Level II ecoregions was considered, geomorphological zones, habitat diversity for aquatic organisms, marginal and riparian vegetation, all critical for ecosystem functioning. Furthermore, suitability of the sites for accurate hydraulic modelling, where the range of possible flows, especially low flows, was considered. Each specialist then further took the members through their individual components (i.e. *in situ* water quality, diatoms, fish, aquatic macroinvertebrates, flow/discharge, cross-section and geomorphology) during the surveys. These capacity building sessions included the associated methodologies for each component, identification processes for fish and aquatic macroinvertebrates, and exactly how the cross-sections were conducted, flows/discharge measured and features around the geomorphology.

Overall, the enthusiasm and support from the DWS team was commended and made for a positive learning experience for all involved.

Thank you for an excellent survey DWS colleagues.

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9. APPENDICES

Appendix A: Field Survey 2 Programme

WP11354: Fish to Tsitsikamma - River survey 2 programme: 3 - 15 May 2023						
Day	**Date**	**River**	**Longitude**	**Latitude**	**Quaternary**	**Level**
Wednesday	03-May-23	Travel				
Thursday	04-May-23	Middle Great Fish	25.751772	-32.604885	Q50C	Rapid 3 / FMP
Friday	05-May-23	Kromme	24.2613	-33.925289	K90A	Intermediate
		Gamtoos	24.693677	-33.760983	L90A	Intermediate
Saturday	06-May-23	Swartkops	25.300816	-33.722183	M10C	Intermediate
Sunday	07-May-23	Kariega / Boesmans (dry)	26.481217° / 26.391105°	-33.468505° / -33.543899°	P30B / P10G	Rapid 3
		Lower Great Fish				Intermediate
Monday	08-May-23	Upper Kat	26.722041	-32.569705	Q94B	Intermediate
		Upper Keiskamma	27.024092	-32.802217	R10E	Intermediate
Tuesday	09-May-23	Lower Buffalo	27.77591	-32.991768	R20F	Rapid 3
		Middle Buffalo	27.64055	-32.991584	R20F	Intermediate
Wednesday	10-May-23	Kubusi	27.62104	-32.56891	S60B	Rapid 3
		Black Kei	27.068903	-32.118266	S32K	Intermediate
Thursday	11-May-23	Tsomo	27.821557	-32.04492	S50G	Intermediate
		Gcuwa	28.135849°	-32.319542°	S70E	Rapid 3
Friday	12-May-23	Great Kei	27.966289	-32.5081	S70A	Intermediate
Saturday	13-May-23	Middle Mbashe	28.472236	-31.958131	T13E	Intermediate

WP11354: Fish to Tsitsikamma - River survey 2 programme: 3 - 15 May 2023						
Day	**Date**	**River**	**Longitude**	**Latitude**	**Quaternary**	**Level**
		Xora T80D - FV or Rapid 2 if time provides				
Sunday	14-May-23	Lower Mthata	29.136048	-31.925698	T20G	Intermediate
		FV at Mthatha (T20A) if time provides				
Monday	15-May-23	HOME				