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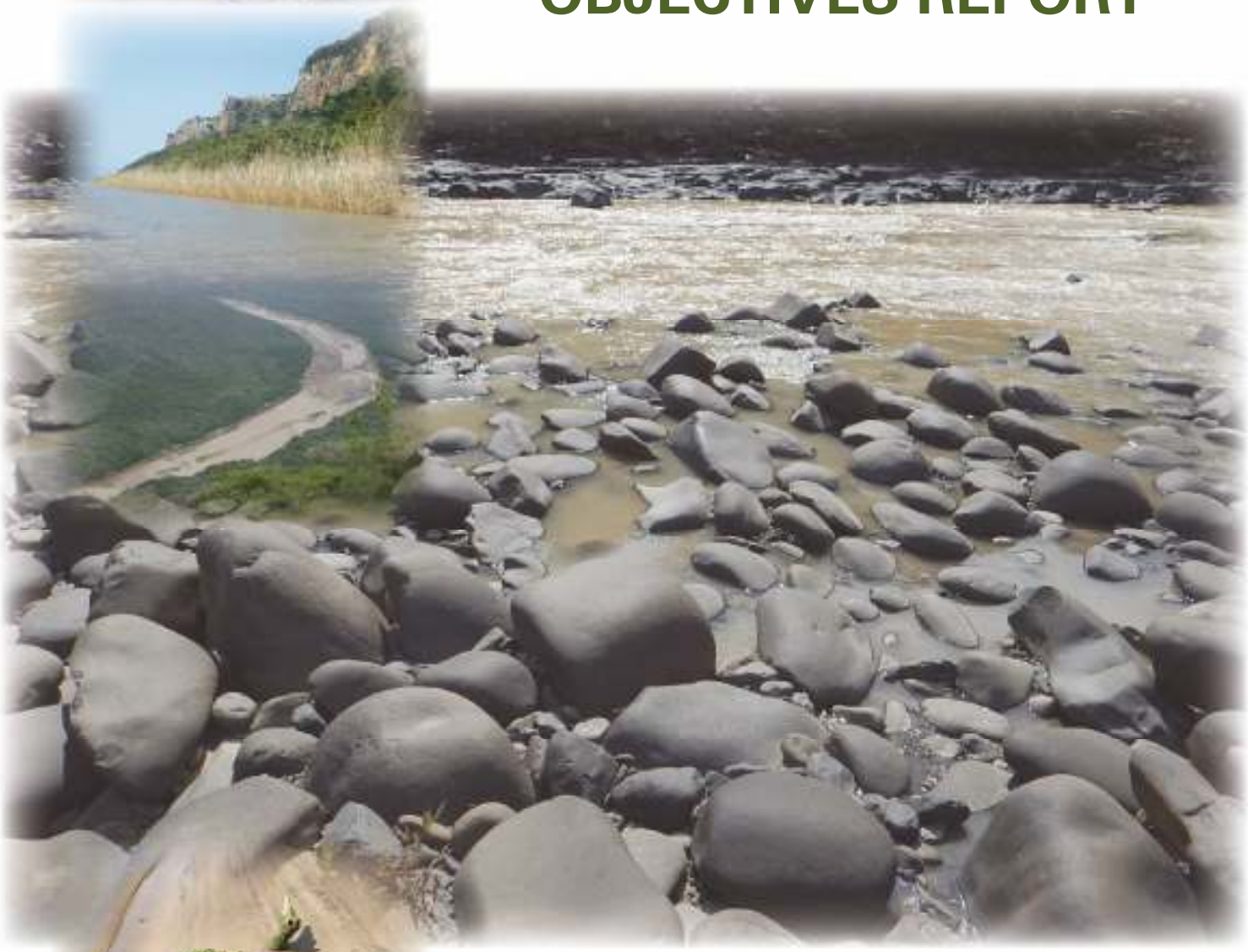
WP 11004

DETERMINATION OF WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES FOR THE WATER RESOURCES IN THE MZIMVUBU CATCHMENT

RIVER AND ESTUARY RESOURCE QUALITY OBJECTIVES REPORT



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Bold indicates this report

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EXECUTIVE SUMMARY

BACKGROUND

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity.

The main aims of the project, as defined by the Terms of Reference (ToR), are to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the Department of Water and Sanitation's (DWS) procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWRs) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

This report provides a summary of the narrative and numerical RQOs for the Mzimvubu catchment's rivers and estuary.

STUDY AREA

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributaries and the estuary at Port St Johns.

RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The *National Water Resource Strategy* (NWRS) stipulates that "Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota".

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios (Sc) to inform the Water Resource Class, and RQOs define and/or describe the Water Resource Class (Figure below).

Links between RQOs and the Water Resource Class and operational scenarios

RIVER RESOURCE UNITS

As part of the classification process, once the Integrated Units of Analysis (IUAs) have been defined, Resource Units (RUs) and biophysical nodes must be identified for the EWR assessment and the setting of RQOs. RUs are sections of a river that frequently have different natural flow patterns, react differently to stress according to their sensitivity, and therefore require individual specifications of the Reserve appropriate for that reach. The guiding principle is that if the hydrology, geomorphic characteristics (i.e. geomorphic zone), physico-chemical attributes and river size remain relatively similar, a RU can be demarcated (DWAF, 2008a).

An IUA can consist of RUs, Management Resource Units (MRUs) or both. RU priority is based on the outcome of the RU priority assessment (DWS, 2017a) (Step 1 of the integrated steps for the NWRC). RUs, MRUs and their priorities have therefore been defined during the initial steps of this study and are documented in the *Delineation and Status Quo Report* for the study, i.e. DWS (2017a). There are four main priority levels, each with the broad type and detail of associated RQOs indicated:

RU priority	RU priority level	Associated RQO
Low	1	Flow RQO unless situated in its total length in a conservation area (formal protected area). Habitat RQO in terms of Present Ecological State (PES) (EcoStatus) and Target Ecological Category (TEC).
Moderate	2	Flow RQO. Habitat and biota RQO (broad).
High	3	If represented by an EWR site, a full suite of EcoSpecs are provided at the EWR site. If not an EWR site, RQOs are at the same level as for 2.
	3(WQ)	Water quality RQOs required as water quality is the driver at these sites. Usually high priority water quality problem areas. Habitat and biota RQO will be at a priority level 2.
Very High	4	If represented by an EWR site, a full suite of EcoSpecs are provided at the EWR site. If not an EWR site, the RQOs are at the same level as for 2.
	4(WQ)	Water quality RQOs required as water quality is the driver at these sites. Usually high priority water quality problem areas. Habitat and biota RQO will be at a priority level 2.

HYDROLOGY RQOs AT RIVER RUs PRESENTED BY DESKTOP BIOPHYSICAL NODES

The tables below provide an indication of the hydrological RQOs in terms of flow at biophysical nodes and EWR sites for the rivers in the study area. These summarised statistics are representative of the required flow regime in the river where the variability is dependent on the seasonal and temporal pattern of natural flow conditions. The mean monthly flows represent low flow requirements of a representative wet (February) and dry (September) month. Percentage points on the monthly low flow frequency distribution continuum at the nodes are defined at 90% (representative of drought conditions) and 60%. MCM/a refer to million m^3/annum.

Desktop biophysical nodes: Summary of hydrological RQOs

RU	Main river	TEC (EWR)	nMAR (MCM)	Low flows (%nMAR)	Total (%nMAR)	Low flows (total flows in MCM/a)			
						Sep		Feb	
						60%	90%	60%	90%
IUA T31 – Upper Mzimvubu									
T31-1	Mzimvubu	B/C	32.73	14.43	23.4	0.04	0.03	0.754	0.302
T31-2	Krom	B	31.33	14.87	23.6	0.06	0.01	0.712	0.296
T31-3	Mngeni	B	87.01	17.50	27.7	0.334	0.192	2.388	0.87

RU	Main river	TEC (EWR)	nMAR (MCM)	Low flows (%nMAR)	Total (%nMAR)	Low flows (total flows in MCM/a)			
						Sep		Feb	
						60%	90%	60%	90%
T31-4	Nyongo	C	8.92	12.38	21.5	0.052	0.029	0.165	0.083
T31-5	Mzimvubu	B	104.92	17.63	27.5	0.33	0.09	2.864	1.057
T31-6	Riet	C	13.98	12.57	19.4	0.05	0.04	0.239	0.124
T31-7	Tswereka	B	12.78	18.18	29	0.115	0.05	0.331	0.131
T31-8	Malithasana	B/C	29.55	15.41	25.1	0.23	0.112	0.641	0.286
T31-9	unnamed	C	4	12.64	21.8	0.026	0.015	0.07	0.035
T31-11	unnamed	B/C	3.71	14.02	24.1	0.031	0.014	0.069	0.027
T31-12	Mzimvubu	C	190.45	14.41	26.4	1.04	0.446	4.325	1.792
T31-13	Mzimvubu	B/C	217.82	16.75	29	1.234	0.47	5.852	2.087
T31-14	Mvenyane	B	23.98	16.27	27.6	0.195	0.082	0.574	0.191
T31-15	Mvenyane	B/C	40.83	13.77	24.1	0.287	0.135	0.813	0.301
T31-16	Mkemane	B	13.61	16.26	27.7	0.111	0.047	0.324	0.105
T31-17	unnamed	B/C	1.3	11.27	21.7	0.008	0.004	0.021	0.011
T31-18	Mkemane	B/C	64.81	9.80	18.6	0.339	0.203	0.893	0.424
T31-19	Mzimvubu	B/C	335.66	16.39	28.7	2.114	0.746	8.821	3.028
IUA T32_a – Mzintlava									
T32-1	Mzintlava	B/C	9.46	13.84	24	0.01	0.006	0.178	0.077
T32-2	Mzintlanga	C	37.6	11.28	17.6	0	0	0.569	0.288
T32-3	Mzintlava	B/C	11.08	13.83	24	0.072	0.034	0.212	0.091
T32-4	Mill Stream	B/C	4.26	14.14	24.3	0.029	0.014	0.082	0.036
T32-5	aManzamnyama	B/C	13.86	14.14	24.2	0.095	0.045	0.267	0.116
T32-6	Mzintlava	B	86.17	16.46	26.2	0.328	0.126	1.958	0.756
T32-7	unnamed	B/C	8.53	14.13	24.2	0.058	0.028	0.164	0.071
T32-8	Droewig	C	18.43	12.06	20.3	0.08	0.06	0.287	0.147
T32-9	Mzintlava	D	98.14	7.90	16.2	0.402	0.289	1.028	0.698
IUA T32_b – Mzintlava									
T32-10	Mzintlava	D	134.49	8.08	15.9	0.304	0.186	1.418	0.962
T32-11	Mvalweni	C	223.24	12.15	23.6	1.141	0.622	3.799	1.857
T32-12	Mzintlavana	B	57.16	12.32	22.9	0.351	0.159	0.864	0.362
T32-13	Mzintlava	B	348.86	12.84	24.7	1.881	0.929	6.185	2.8
IUA T33_a – Kinira									
T33-1	Mafube	B	20.45	15.97	27.5	0.148	0.062	0.515	0.174
T33-2	Kinira	B/C	26.29	13.49	23.9	0.166	0.078	0.549	0.205
T33-3	Kinira	C	97.37	10.96	20.5	0.512	0.279	1.626	0.706
T33-4	Jordan	B	33.94	14.85	26.9	0.206	0.083	0.843	0.27
T33-5	Seeta	B/C	69.76	12.53	23.3	0.37	0.17	1.439	0.516
T33-6	Mabele	C	94.27	10.13	20	0.416	0.221	1.547	0.643
T33-7	Morulane	C	302.96	12.56	24.6	1.437	0.705	6.575	2.367
IUA T33_b – Kinira									
T33-8	Somabadi	C	6.17	11.02	20.7	0.038	0.021	0.091	0.046
T33-9	Rolo	C	368.32	12.81	24.9	1.824	0.902	7.916	2.93
T33-10	Ncome	C	15.58	10.57	20.3	0.082	0.044	0.235	0.116
T33-11	Cabazi	C	14.01	10.53	20.1	0.07	0.038	0.213	0.105
T33-12	Mnceba	B	17.05	10.04	19.8	0.092	0.049	0.204	0.1
T33-13	Caba	B	9.22	10.04	19.8	0.05	0.026	0.11	0.054
T33-14	Mzimvubu	B	Represented by MzimEWR4						
IUA T34_a – Thina									
T34-1	Tinana	B	33.59	14.52	26.6	0.199	0.082	0.797	0.294
T34-2	Zindawa	B	32.91	14.24	26.4	0.172	0.07	0.796	0.292
T34-3	Khohlong	B/C	41.14	12.00	22.9	0.187	0.085	0.83	0.343

RU	Main river	TEC (EWR)	nMAR (MCM)	Low flows (%nMAR)	Total (%nMAR)	Low flows (total flows in MCM/a)			
						Sep		Feb	
						60%	90%	60%	90%
T34-4	Nxotshana	B	68.08	14.27	26.4	0.363	0.149	1.641	0.603
IUA T34_b – Thina									
T34-5	Thina	B/C	123.48	9.83	19.7	0.503	0.267	1.977	0.959
T34-6	Tokwana	C	20.35	10.47	20.2	0.094	0.051	0.333	0.164
T34-7	Luzi	B	45.2	14.43	26.5	0.247	0.101	1.096	0.405
T34-8	Luzi	B/C	84.7	12.47	23.2	0.427	0.197	1.723	0.721
T34-9	Qwidlana	B	27.13	15.76	27.2	0.197	0.082	0.588	0.224
T34-10	Tsilithwa	B	20.07	15.70	27.2	0.143	0.06	0.435	0.166
T34-11	Ngcothi	B	11.86	15.69	27.2	0.084	0.035	0.257	0.097
IUA T35_a – Tsitsa									
T34-12	Mvuzi	C	18.25	10.79	20.3	0.094	0.051	0.266	0.132
T35-1	Tsitsana	B	101.14	17.30	27.9	0.756	0.331	2.547	1
T35-2	Pot	B	79.71	16.74	27.8	0.601	0.26	1.84	0.715
T35-3	Klein Mooi	B	63.69	15.33	26.9	0.282	0.122	1.619	0.615
T35-4	Mooi	C	127.57	10.90	20.3	0.479	0.264	2.173	1.091
MRU Tsitsa B	Tsitsa	C	Extrapolate from MzimEWR1						
T35-5	Gqukunqa	B	46.09	16.56	27.4	0.349	0.149	1.019	0.396
IUA T35_b – Tsitsa									
T35-6	Inxu	B	37.64	16.74	27.6	0.288	0.124	0.87	0.339
T35-7	Gqaqala	B	26.15	17.39	28	0.257	0.11	0.563	0.222
T35-8	Kuntombizininzi	B	14.29	16.74	26.3	0.06	0.03	0.33	0.129
MRU Inxu (EWR1)	Inxu	C	44.4	14.31	17.87	0.345	0.171	0.812	0.369
MRU Gat (IFR1)	Gatberg	B	10.9	17.39	28.10	0.105	0.046	0.235	0.092
IUA T35_c – Tsitsa									
T35-9	Umnga	B/C	35.07	14.39	24	0.254	0.122	0.628	0.277
T35-10	Qwakele	B/C	19.87	11.73	20.7	0.12	0.067	0.288	0.147
T35-11	Ncolosi	C	29.76	10.38	18.6	0.156	0.095	0.393	0.222
T35-12	Culunca	B/C	18.12	11.61	20.6	0.112	0.062	0.254	0.129
T35-13	Tyira	C/D	14.72	10.20	18.6	0.082	0.049	0.181	0.102
T35-14	Xokonxa	C	36.24	11.61	20.6	0.225	0.124	0.507	0.26
T35-15	Ngcolora	C	10.19	8.98	18.9	0.05	0.025	0.108	0.032
T35-16	Ruze	B	13.52	14.77	26.3	0.096	0.039	0.246	0.092
IUA T35_d – Tsitsa									
MRU Tsitsa_D	Tsitsa	B	Represented by MzimEWR1						
IUA T36_a – Mzimvubu									
T36-1	Mzintshana	B	14.34	15.10	28.1	0.153	0.06	0.173	0.068
T36-2	Mkata	B	9.78	15.10	26.1	0.104	0.041	0.118	0.046

Key biophysical nodes (EWR sites): Summary of hydrological RQOs

The following must be noted for the EWR sites impacted by dams of the Mzimvubu Water Project (MWP), i.e. MzimEWR1 (Tsitsa River) and MzimEWR4 (Lower Mzimvubu River). The TEC is a C for both sites. The EWRs associated with the C is provided as two scenarios:

Scenario 1 – MWP does not go ahead and dams are not built:

- Use EWR rule (flow duration table) for MzimEWR1 and MzimEWR4.

Scenario 2 – MWP is implemented and Ntabelanga and Lalini dams are built:

- Scenario 69 flow duration table: It must be noted that Sc 69 includes all flow requirements for downstream users including the EWRs. Due to the nature of of the operation of a system for hydropower, exceedance of the required flows at unacceptable levels may arise, with an associated impact on seasonality. Flows should therefore not exceed the monthly flow distribution according to Sc 69 during the dry season. The wet season is limited to either Sc 69 or the natural flows. If the operating rule changes to flows less than Sc 69, it should at least provide the EWR with an acceptable seasonal distribution.

It must be noted that the TEC will not be achieved if any pulsed releases that cause unseasonal daily fluctuations form part of the operation of the MWP. During this study and the associated MWP studies, it was indicated that pulsed releases do not form part of the planned operating rule.

Summary statistics are shown below for the EWR sites. Flow duration tables are shown in the relevant chapters.

River	Resource Unit (EWR site)	TEC	nMAR (MCM[1])	pMAR[2] (MCM)	% of nMAR	Low flows (MCM)	Low flows (%)	High flows (MCM)	High flows (%)	Total flows (MCM)	Total (%)
Tsitsa	Tsitsa_Ca (MzimEWR1)	C	438.04	413.16	94.32	87.43	20	48.25	11	135.68	31
Thina	Thina_C (MzimEWR2)	C	404.51	393.23	97.21	89.24	22.1	32.41	8	121.65	30.1
Kinira	Kinira (MzimEWR3)	C	407.12	399.3	98.08	82.87	20.3	52.57	12.9	135.44	33.3
Mzimvubu	Mzim (MzimEWR4)	C	2655.13	2532.21	95.37	331.16	12.5	301.3	11.3	632.46	23.8

1 Million Cubic Metres 2 Present Day MAR

HABITAT, BIOTA AND WATER QUALITY RQOs AT HIGH PRIORITY RIVER RUs (EWR SITES)

Information is presented for High Priority EWR sites as a summary table. Water quality limits are according to the Department of Water Affairs and Forestry manual on *Methods for determining the water quality component of the Ecological Reserve* as prepared in 2008.

Component/ Indicator	Target EC	RQO
IUA T33_b: KINIRA **MRU Kinira (MzimEWR3): T33E-05213, T33F-05326, T33G-05395**		
Fish	**C**	Maintain EC. Both expected indigenous fish species estimated to still be present in the reach under PES. Primary indicator fish species for this reach are *Anguilla mossambica* and *Barbus/Enteromius anoplus*.
Invertebrates	**C**	A diverse community but with low abundances of highest scoring taxa. No dominant taxa. Maintain SASS scores at 130-160, ASPT at 6-7+ and MIRAI at 70–77%.
Riparian vegetation	**C/D**	Maintain non-woody vegetation as the dominant vegetation type in the riparian zone, prevent any reed encroachment and perennial alien plant species. Maintain the presence of at least 14 indigenous plant species within the riparian zone.
Geomorphology	**C/D**	Extent of fines must be reduced to prevent deterioration to a D category. Monitor direction of change of sand deposits over boulder bars in relation

Component/ Indicator	Target EC	RQO
		to flow changes. Baseline monitoring necessary.
Water quality	B/C	Ensure that turbidity or clarity levels stay within tolerable limits: A large change from natural with erosion being a known cause of unnaturally large increases in sediment loads and turbidity. Habitat often silted but clears (Aquatic ecosystems: driver).
IUA T34_b: THINA MRU Thina_C (MzimEWR2): T34H-05772, T34H-05838, T34K-05835		
Fish	B/C	Maintain EC. Both expected indigenous fish species estimated to still be present in the reach under PES. Primary indicator fish species for this reach are *Anguilla mossambica* and *Barbus/Enteromius anoplus*. Prevent loss of any indigenous species and the addition of alien/introduced species
Invertebrates	C	Sample should indicate a diverse community; at least 2 of which should score ≥ 12. Maintain SASS scores at 160-190, ASPT at 6.2-7 and MIRAI at ≥ 70%.
Riparian vegetation	C/D	Maintain a PES score of minimum 59% for the riparian zone. Maintain the presence of at least 24 indigenous plant species within the riparian zone, including at least 1 aquatic species. The dominant vegetation type must remain non-woody in the marginal and upper zones, and woody on the Macro Channel Bank.
Geomorphology	C	Keep riffles free of fine sediment and prevent further loss of flood benches. Promote extension of degraded floodbench on right bank, and intact lower flood bench on right bank to support marginal zone vegetation.
Water quality	B	Ensure that turbidity or clarity levels stay within acceptable limits: A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
		Ensure that nutrient levels are within acceptable limits: 50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
IUA T35_d: TSITSA MRU Tsitsa_Ca (MzimEWR1): T35E-05977, T35K-06037, T35K-06098, T35L-05976		
Fish	C	Maintain EC. Both expected indigenous fish species estimated to still be present in the reach under PES. Primary indicator fish species for this reach are *Anguilla mossambica* and *Barbus/Enteromius anoplus*. Prevent addition of aggressive predatory alien species, i.e. *Micropterus salmoides* and *Oncorhynchus mykiss*.
Invertebrates	C	Sample should indicate a diverse community; with at least 4 reference or expected taxa, of which at least 2 should score ≥ 12. Maintain SASS scores at 150-220, ASPT at 6.2-7 and MIRAI at ≥ 70%.
Riparian vegetation	C/D	Maintain a PES score of minimum 59% for the riparian zone. Maintain the presence of at least 19 indigenous plant species within the riparian zone. The dominant vegetation type must remain non-woody in the marginal and upper zones, and woody on the Macro Channel Bank.
Geomorphology	C	Maintain10% to 30% fines among boulder, cobble or coarse gravel. Channel should not change from a single thread channel with pool-rapid morphology.
Water quality	B	Ensure that turbidity or clarity levels stay within acceptable limits: Moderate – Large changes from natural are evident, with erosion and urban runoff processes being known causes of unnaturally large increases in sediment loads and turbidity. Increases are not permanent with clearing of habitats at times (Aquatic ecosystems: driver).
		Ensure that nutrient levels are within acceptable limits: The 50th percentile of the data must be less than 0.015 mg/L (Aquatic ecosystems: driver).
IUA T36_a: MZIMVUBU MRU Mzim (MzimEWR4): T36A-06250, T36A-06354, T36B-06391		
Fish	C	Maintain EC. All nine expected indigenous fish species estimated to still be

Component/ Indicator	Target EC	RQO
		present in the reach under PES. Prevent the addition of alien/introduced species
Invertebrates	C	Sample should indicate a diverse community, with at least 5 indicators or expected taxa, scoring 10+. Maintain SASS scores at 150-220, ASPT at 6.2-7 and MIRAI at ≥ 70%.
Riparian vegetation	C/D	Maintain a PES score of minimum 59% for the riparian zone. Maintain the presence of at least 27 indigenous plant species within the riparian zone. The dominant vegetation type must remain non-woody in the riparian zone.
Geomorphology	C	Maintain 5% to 20% fines among boulder, cobble or coarse gravel. Prevent erosion of lower flood benches on both banks. Channel should not change from a single thread channel with pool-rapid morphology.
Water quality	A/B	Ensure that turbidity or clarity levels stay within acceptable limits: Moderate changes from natural with temporary high sediment loads and turbidity during runoff events. Urban activities and land-use have resulted in temporary but unnaturally high sediment loads and turbidity (Aquatic ecosystems: driver).

MZIMVUBU ESTUARY

As per the DWS methodology, estuaries are sufficiently different in terms of state, functioning and management to form individual RUs. RQOs are set for the short-to medium term (5 to 10-year period) for the the following components:

- Quantity, pattern and timing of instream flow (hydrology)
- Mouth state (hydrodynamics)
- Water quality
- Characteristics and condition of primary producers (e.g. macrophytes)
- Characteristics and condition of biota (e.g. fish)

In the case of the Mzimvubu Estuary, RQOs for the TEC (linked to Scenario 69) were derived from the EcoSpecs and Threshold of Potential Concerns (TPCs) as set for the REC in the EWR study, as the TEC is similar to the REC. In terms of RQOs for recreational use (water quality), the recommended targets proposed for South Africa's coastal marine waters were applied.

The RQOs for the Mzimvubu Estuary, to maintain the TEC (similar to REC), are presented below.

Mzimvubu Estuary: RQOs to maintain the TEC (Category B)

PES/REC/TEC: B Category
Components that require interventions to maintain the TEC: ▪ Return some variability to the mouth dynamics through removal of the access road behind the area formerly known as 'First Beach', which has effectively entrained the estuary mouth. ▪ Reinstating local sediment dynamics (also through the removal of the abovementioned access road). The realistic possibility of reversing the loss of 'First Beach' could potentially re-establish this once-popular recreational beach for the town of Port St Johns. ▪ Institute land-use management regulation within the Estuary Functional Zone (EFZ) that focuses on restricting the loss of further habitat within this zone and the estuary floodplain up to the 10 m contour (or 10 m above mean sea level). ▪ Rehabilitate disturbed areas of the estuary EFZ where impacts are reversible; rehabilitation would significantly enhance the functional integrity and importance of the estuary as a whole. ▪ Establish a programme for invasive alien plant management within the estuary floodplain, which would make a significant contribution towards addressing this and enhancing the functional importance of the floodplain as a feature of the estuary. ▪ Manage fishing pressure in the estuary through the possible partial closure of the estuary to fishing in order to protect important fish stocks and sensitive habitats.

▪ Address possible point-source pollution risks from the canalised creek that flows from the town of Port St Johns, as the study has suggested that this canal may be compromising water quality. ▪ Prevent further disturbance and development of the floodplain habitat.		
Component/ Indicator	**Target EC**	**RQO**
Hydrology	**A**	Maintain Target EC (> 92%). Protect the flow regime to create the required habitat for birds, fish, macrophytes, microalgae and water quality: ▪ Changes in river inflow distribution patterns (i.e. floods and base flows) less than 5% from that of Scenario 96 (i.e. the target flow scenario).
Hydrodynamics	**A**	Maintain Target EC (> 92%). Maintain a mouth conditions to protect estuarine ecosystems and the associated habitat for birds, fish, macrophytes, microalgae and water quality: ▪ Estuary mouth not to close or become very constricted. ▪ Changes in tidal amplitude at the tidal gauge not more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b).
Physical habitat (sediments)	**A/B**	Maintain the Target EC (> 87%). Protect estuarine sediment distribution as suitable habitat for estuarine biota: ▪ River inflow distribution patterns (flood components) not to differ more than 20% (in terms of magnitude, timing and variability) from that simulated for the present state (refer to DWS, 2014a; 2014b and 2017b). ▪ Suspended sediment concentration in river inflow not to deviate by more than 20% of sediment load-discharge relationship of the present state (refer to DWS, 2014a; 2014b and 2017b). ▪ No deviation in sedimentation and erosion patterns in the estuary to occur from the present baseline (refer to DWS, 2014a; 2014b and 2017b).
		Changes in sediment grain size distribution patterns not to cause exceedance tolerance of benthic invertebrates: ▪ Median bed sediment diameter not to deviate by more than a factor of two from levels of the present baseline (refer to DWS, 2014a; 2014b and 2017b). ▪ Sand/mud distribution in middle and upper reaches not to change by more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b). ▪ Changes in tidal amplitude at the tidal gauge not to change more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b). as a result of sediment processes.
Water quality (salinity)	**A/B**	Maintain Target EC (> 87%). Salinity regime to maintain TEC for dependent biotic components. ▪ Salinity in lower reaches higher than 20 for at least 4 to 6 months (i.e. overlapping with winter period). ▪ Salinity in lower reaches higher than 25 and in middle reaches higher than 15 for at least 1 to 2 months (overlapping with winter period).
Water quality (other)	**C**	Maintain the TEC category (≥ 63%). Water quality to be suitable for maintaining the TEC for dependent biotic components. Water quality of river inflow: ▪ pH 7.0 – 8.5. ▪ Dissolved Oxygen (DO) > 6 mg/l. ▪ Turbidity (naturally turbid system). ▪ Dissolved Inorganic Nitrogen (DIN) < 200 µg/l (monthly average). ▪ Dissolved Inorganic Phosphate (DIP) < 30 µg/l (monthly average). *In situ* water quality (in estuary): ▪ pH 7.0 – 8.5 ▪ DO > 6 mg/l. ▪ Turbidity (naturally turbid system in fresher parts). ▪ DIN < 150 µg/l (average across estuary). ▪ DIP < 20 µg/l (average across estuary). ▪ Total metal concentrations in water not to exceed target values as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995 or official future updates thereof). Total metal concentration in sediment not to exceed target values as per

		West Indian Ocean (WIO) Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009 or official future updates thereof for South Africa). For recreational use areas in estuary (see details in DEA, 2012): ▪ Enterococci < 185 counts per 100 ml (90 percentile), and ▪ *E. coli* < 500 counts per 100 ml (90 percentile).
Microalgae	**C**	Maintain the Target EC (> 63%) through: ▪ Maintaining low phytoplankton biomass (average chlorophyll a < 20 µg/l or median chlorophyll a < 3.5 µg/l) and a diversity of phytoplankton groups (cyanobacteria excluded). ▪ Maintain medium intertidal benthic microalgal biomass (median chlorophyll a < 23 mg/m^2). ▪ No observable blooms and scums in the estuary. ▪ Absence of cyanobacteria.
Macrophytes	**C**	Maintain the Target EC (> 63%) through: ▪ Maintaining diversity of macrophyte habitats in estuary as per present baseline (refer to DWS, 2014a, 2014b and 2017b). ▪ Reeds and sedges cover maintainted at ~16 ha. ▪ No more than 50% loss of reed and sedge habitats in non-flood years (e.g. linked to unfavourable salinity regime). ▪ No increase in invasive species in riparian zone. ▪ No colonisation of main water channel by vegetation (linked to sedimentation).
Invertebrates	**A/B**	Maintain the Target EC category (> 87%) through: ▪ Maintaining low-diversity invertebrate community with representation of original freshwater, opportunistic taxa as per present baseline (refer to DWS, 2014a, 2014b and 2017b). ▪ Maintaining invertebrate community structured as per present baseline (refer to DWS, 2014a, 2014b and 2017b) (defined by inherent physico-chemical drivers, specifically periodic high flows resulting in periods of low salinities and sediment instability). ▪ Maintaining invertebrate community structured as per present baseline (refer to DWS, 2014a, 2014b and 2017b) (linked to channel-like nature of estuary with very few intertidal areas characterised by soft sediments supporting only suitably specialised species).
Fish	**B/C**	Maintain the Target EC category (> 72%) through: ▪ Species assemblage to comprise indigenous species only (i.e. no alien species) (refer to DWS, 2014a, 2014b and 2017b) ▪ Maintain abundance (to be defined as average with prediction limits) of estuarine dependence category IIa species (*Solea bleekeri, Acanthopagrus vagus, Pomadasys commersonnii, Agyrosomus japonicus, Rhabdosargus holubi*), present as young juveniles in winter, spring and early summer. None of these species should be absent from estuary for two consecutive years (i.e. entire lower estuary maintained as nursery for estuarine dependence category IIa species with middle reaches of estuary functioning as nursery to these marine spawned species during low flow periods (Jun–Oct), for 4 out of 5 years on average). ▪ Estuarine resident species to represent core group (Glossogobius spp., *Oligolepis* spp. *Ambassis* spp. and *Gilchistella aestuaria*) (also in upper reaches). ▪ Estuarine-dependent marine species (other than mullet) not to occur abundantly in upper reaches (i.e. should remain fresh). ▪ Mullet to occur throughout estuary throughout year, represented by full array of size classes, with no mullet species (to be defined) being absent for two consecutive years. ▪ *Oreochromis mossambicus* (Mozambique tilapia) not to extend into lower estuary for more than two consecutive years. ▪ Maintain good trophic basis for predatory estuarine dependant marine species (most notably *Agyrosomus japonicus* and *Pomadasys commersonnii*).

		▪ Maintain good connectivity down full length of estuary and into transitional marine waters (i.e. offshore estuary). ▪ Catches (*Agyrosomus japonicus* or *Pomadasys commersonnii*) (not related to gear changes or bag limit restrictions) not to decline.
Birds	**C/D**	Maintain the Target EC (> 60%) through: ▪ Maintaining avifaunal community that includes representatives of all original groups as per present baseline (refer to DWS, 2014a, 2014b and 2017b). ▪ Tern roosts observed from time to time. ▪ Number of waterbird species recorded per count remains above 10 for 3 consecutive seasons. ▪ Summer numbers of waterbirds (other than gulls and terns) remain above 50 for 3 consecutive seasons. ▪ A winter threshold should be determined once more data becomes available.

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LIST OF ABBREVIATIONS

AEV	Acute Effects Value
ASPT	Average Score Per Taxon
BHNR	Basic Human Needs Reserve
CPUE	Catch Per Unit Effort
DD	Data Deficient
DEA	Department of Environmental Affairs
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphate
DO	Dissolved Oxygen
DRM	Desktop Reserve Model
DSS	Decision Support System
DWA	Department Water Affairs (Name change from DWAF applicable after April 2009)
DWAF	Department Water Affairs and Forestry
DWS	Department Water and Sanitation (Name change from DWA applicable after May 2014)
EC	Ecological Category
EcoSpec	Ecological Specification
EFZ	Estuarine Functional Zone
EWR	Ecological Water Requirement
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
GAI	Geomorphology Assessment Index
GI	Gastrointestinal
ICM	Integrated Coastal Management
ind/min	Individuals/minute
IUA	Integrated Unit of Analysis
IUCN	International Union for Conservation of Nature
LC	Least Concern
MCB	Macro Channel Bank
MCM	million cubic metres
MIRAI	Macro Invertebrate Response Assessemnt Index
MRU	Management Resource Unit
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NEMP	National Estuarine Management Protocol
nMAR	natural Mean Annual Runoff
NMMP	National Microbial Monitoring Programme
NWA	National Water Act
NWRS	National Water Resource Strategy
PAI	Physico-chemical Driver Assessment Index
PES	Present Ecological State
PESEIS	Present Ecological State, Ecological Importance and Ecological Sensitivity
pMAR	present Mean Annual Runoff
PSC	Project Steering Committe
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RHAM	Rapid Habitat Assessment Method

RQO	Resource Quality Objective
RU	Resource Unit
SASS5	South African Scoring System version 5
Sc	Scenario
SQ	Sub-Quaternary
TEC	Target Ecological Category
TIN	Total Inorganic Nitrogen
ToR	Terms of Reference
TPC	Threshold of Potential Concern
TTG	Technical Task Group
TWQR	Target Water Quality Range
Userspecs	User Water Quality Specifications
VEGRAI	Vegetation Response Assessment Index
WARMS	Water Allocation Registration Management System
WIO	Western Indian Ocean
WMA	Water Management Area
WMS	Water Management System
WQ	Water Quality
WRCS	Water Resources Classification System
WRYM	Water Resource Yield Model
WWTW	Waste Water Treatment Works

SASS5 Sampling biotopes

BR	Bedrock
COBB	Cobbles
GSM	Gravel-Sand-Mud
MV	Marginal Vegetation
SIC	Stones-in-Current
SOC	Stones-out-of-Current
VEG	Vegetation

Velocity Depth Classes: Fish

FD	Fast Deep fish habitat
FI	Fast Intermediate fish habitat
FS	Fast Shallow fish habitat
SD	Slow Deep fish habitat
SS	Slow Shallow fish habitat

Fish species name abbreviations

AAEN	*Awaous aeneofuscus*
ABIC	*Anguilla bicolor bicolor*
ALAB	*Anguilla bengalensis labiata*
AMAR	*Anguilla marmorata*
AMOS	*Anguilla mossambica*
BANO	*Barbus anoplus/Enteromius anoplus*
CCAR	*Cyprinus carpio*
GCAL	*Glossogobius callidus*
GGIU	*Glossogobius giuris*
LMAC	*Lepomis macrochirus*
MSAL	*Micropterus salmoides*
OMOS	*Oreochromis mossambicus*
OMYC	*Oncorhynchus mykiss*

GLOSSARY

Desktop Reserve Model (DRM)	The output from the DRM is an estimated EWR for each Ecological Category, at a desktop level for biophysical nodes other than EWR sites. Due to the large study area, additional EWRs are estimated for every Resource Unit identified which is not addressed by the more detailed EWR assessment at EWR sites. These EWRs are therefore estimated using the DRM.
EcoClassification	EcoClassification (or the Ecological Classification process) refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various physical attributes of rivers relative to the natural reference condition. A range of models are used during EcoClassification, each of which relate to the indicators assessed.
Ecological Category (EC)	ECs are determined for all components of the ecosystem for driver (abiotic) and response (biotic) components. These are integrated into an overall or integrated state called the EcoStatus. This level of information with the entire component ECs is only available when detailed studies are undertaken. For more desktop type studies, only a single EC may be available which represents the EcoStatus. **Whenever an EC is referred to without specifying that it is applicable to a specific component, this will always refer to the EcoStatus.**
Ecological Importance and Sensitivity (EIS)	Key indicators in the ecological classification of water resources. Ecological importance relates to the presence, representativeness and diversity of species of biota and habitat. Ecological sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels and physico-chemical conditions.
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
EWR sites	Specific points on the river as determined through the 'hotspot' and site selection process. An EWR site consists of a length of river which may consist of various cross-sections assessed for both hydraulic and ecological purposes. These sites provide sufficient indicators to assess environmental flows and assess the condition of biophysical components (drivers such as hydrology, geomorphology and physico-chemical conditions) and biological responses (*viz*. fish, macroinvertebrates and riparian vegetation).
Management Resource Units (Rivers)	The purpose of distinguishing MRUs from RUs is to identify a management unit within which the EWR can be implemented and managed based on one set of identified flow requirements. This means that an EWR site in the MRU, according to the EWR site selection criteria in context of the MRU, will provide for the whole MRU. MRUs are usually defined for river reaches only and differ from Resource Units in that is a more detailed assessment.
Present Ecological State (PES)	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology and water quality and biological responses *viz*. fish, macroinvertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.

Recommended Ecological Category (REC)	The Recommended Ecological Category is the future ecological state (Ecological Categories A to D) that can be recommended for a resource unit depending on the EIS and PES. The REC is determined based on ecological criteria and considers the EIS, the restoration potential of the system and attainability thereof.
Resource Quality Objectives (RQOs)	RQOs are numeric or descriptive goals that can be monitored for compliance to the WRC, for each part of each water resource.
Resource Units (RUs)	RUs are delineated during an Ecological Reserve determination study, as each will warrant its own specification of the Reserve, and the geographic boundaries of each must be clearly delineated. These sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach. RUs are nested within IUAs and may contain an Ecological Water Requirement site.
Scenario	Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition.
Sub-quaternary catchments (SQ)	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary or quinary level.
Water Resource Class (WRC)	The Water Resource Class is representative of those attributes that the DWS (as the custodian) and society require of different water resources. The decision-making toward a WRC require a wide range of trade-offs to be assessed and evaluated at a number of scales. Final outcome of the process is a set of desired characteristics for use and ecological condition each of the water resources in a given catchment. The WRCS defines three management classes, Class I, II, and III, based on extent of use and alteration of ecological condition from the predevelopment condition.
Water Resource Classification System (WRCS)	The Water Resource Classification System is a defined set of guidelines and procedures for determining the different classes of water resources (South African National Water Act (Act 36 of 1998) Chapter 3, Part 1, Section 2(a)). The outcome of the Classification Process will be the setting of the Class, Reserve and Resource Quality Objectives by the Minister or delegated authority for every significant water resource (river, estuary, wetland and aquifer) under consideration. This Class, which will range from Minimally used to Heavily used, essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised.

1 INTRODUCTION

1.1 BACKGROUND

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity. These activities will guide the management of the T3 Mzimvubu primary catchment toward meeting the departmental objectives of maintaining, and if possible, improving the present state of the Mzimvubu River and its four main tributaries, namely the Tsitsa, Thina, Kinira and Mzintlava. This project is driven by threatened ecosystem services in the Mzimvubu catchment, due to the variety of inappropriate land uses and alien plant infestation that result in extensive erosion and degradation. Degradation can be observed in soil erosion, damage to infrastructure, water supply shortages and loss of grazing.

The Department of Water and Sanitation (DWS) has initiated a study to determine Classes and associated RQOs for the Mzimvubu catchment in Water Management Area (WMA) 7.

The main aims of the project, as defined by the Terms of Reference (ToR), are to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWRs) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

1.2 STUDY AREA OVERVIEW

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributaries and the estuary at Port St Johns. The river reaches sizeable proportions after the confluence of these four tributaries in the Lower Mzimvubu area, approximately 120 km from its source, where the impressive Tsitsa Falls can be found near Shawbury Mission. The Mzimvubu catchment and river system lies along the northern boundary of the Eastern Cape and extends for over 200 km from its source in the Maloti-Drakensberg watershed on the Lesotho escarpment to the estuary at Port St Johns. The catchment is in Primary T, comprises of T31–36 and stretches from the Mzimkhulu River on the north-eastern side to the Mbashe and Mthatha river catchments in the south. The Mzimvubu river catchment is found in WMA 7, i.e. the Mzimvubu to Tsitsikamma WMA.

1.3 STUDY PROJECT PLAN

The Mzimvubu study is being undertaken according to the Project Plan in **Figure 1.1** with each step broken down into sub-steps. This report pertains to the RQOs part of Step 6.

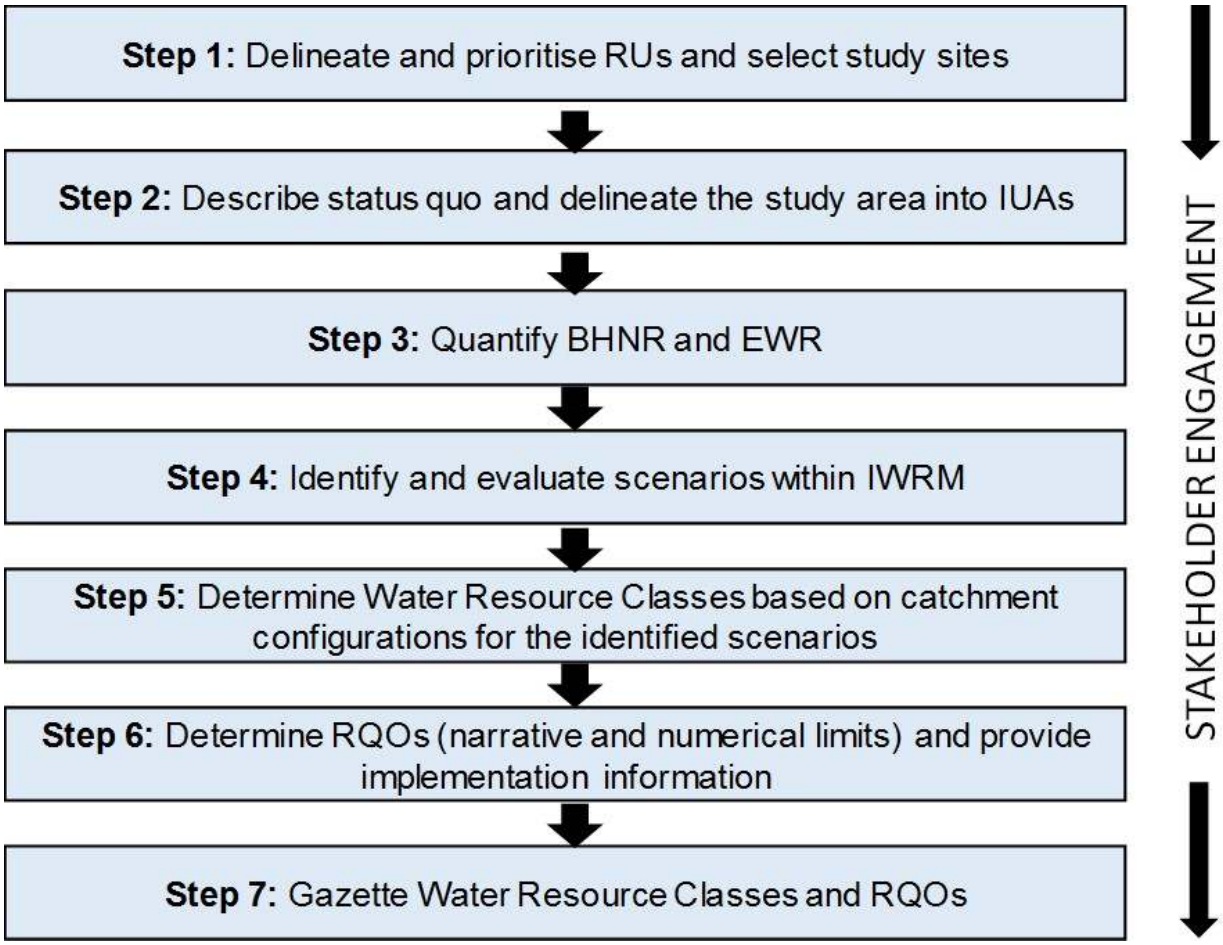


Figure 1.1 Project plan for the Mzimvubu Classification and RQO study

1.4 INTRODUCTION TO RESOURCE QUALITY OBJECTIVES

RQOs are numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its Class. The *National Water Resource Strategy* (NWRS) stipulates that "Resource Quality Objectives might describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota".

1.5 OPERATIONAL SCENARIOS, WATER RESOURCE CLASS AND RQOs

Operational scenarios, Water Resource Classes and RQOs are inherently linked as operational scenarios (Sc) to inform the Water Resource Class, and RQOs define and/or describe the Water Resource Class (**Figure 1.2**).

Figure 1.2 Links between RQOs and the Water Resource Class and operational scenarios

Various scenarios were tested and the selected Water Resource Class and catchment configuration (in terms of Target Ecological Categories (TEC) as reported in (DWS, 2018) are provided in **Table 1.1**.

Table 1.1 TECs and Water Resource Classes

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
T31	II	T31-1	Mzimvubu	26.04	B/C	B/C	B/C
		T31-2	Krom	48.44	B	B	B
		T31-3	Mngeni	48.31	B	B	B
		T31-4	Nyongo	22.72	C	C	C
		T31-5	Mzimvubu	35.71	B	B	B
		T31-6	Riet	34.35	C	C	C
		T31-7	Tswereka	25.36	B	B	B
		T31-8	Malithasana	46	B/C	B/C	B/C
		T31-9		17.61	C	C	C
		T31-10	Tswereka	19.88	D	D	D
		T31-11		17.53	B/C	B/C	B/C
		T31-12	Mzimvubu	46.4	C	C	C
		T31-13	Mzimvubu	119.51	B/C	B/C	B/C
		T31-14	Mvenyane	59.83	B	B	B
		T31-15	Mvenyane	39.64	B/C	B/C	B/C
		T31-16	Mkemane	36.47	B	B	B
		T31-17		6.29	C	B/C	B/C
		T31-18	Mkemane	34.83	C/D	B/C	B/C
		T31-19	Mzimvubu	43.03	B/C	B/C	B/C
T32_a	II	T32-1	Mzintlava	15.08	C	B/C	B/C
		T32-2	Mzintlanga	56.19	C	C	C
		T32-3	Mzintlava	51.53	C	B/C	B/C
		T32-4	Mill Stream	16.72	C	B/C	B/C
		T32-5	aManzamnyama	21.96	B/C	B/C	B/C
		T32-6	Mzintlava	17.7	B	B	B
		T32-7		24.91	B/C	B/C	B/C
		T32-8	Droewig	34.13	C	C	C
		T32-9	Mzintlava	11.09	D	D	D
T32_b	II	T32-10	Mzintlava	36.84	D	D	D
		T32-11	Mvalweni	95.74	C/D	C	C
		T32-12	Mzintlavana	95.88	B/C	B	B
		T32-13	Mzintlava	59.31	C	B	B
T33_a	II	T33-1	Mafube	32.7	B	B	B
		T33-2	Kinira	45.68	B/C	B/C	B/C
		T33-3	Kinira	47.39	C	C	C
		T33-4	Jordan	40.4	B	B	B
		T33-5	Seeta	57.31	B/C	B/C	B/C
		T33-6	Mabele	37.06	C	C	C
T33_b	II	T33-7	Morulane	137.68	C	C	C
		T33-8	Somabadi	17.27	C	C	C
		MRU Kinira (MzimEWR3)	Kinira	103.24	C	C	C

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
		T33-9	Rolo	40.49	C	C	C
		T33-10	Ncome	29.9	C	C	C
		T33-11	Cabazi	23.12	C	C	C
		T33-12	Mnceba	35.88	C	B	B
		T33-13	Caba	30.52	C	B	B
		T33-14	Mzimvubu	161.92	B	B	B
T34_a	I	T34-1	Tinana	67.86	B	B	B
		T34-2	Zindawa	52.59	B	B	B
		T34-3	Khohlong	22.94	B/C	B/C	B/C
		T34-4	Nxotshana	69.88	B	B	B
T34_b	II	T34-5	Thina	18.6	C	B/C	B/C
		T34-6	Tokwana	56.15	C	C	C
		T34-7	Luzi	57.81	B	B	B
		T34-8	Luzi	45.27	B/C	B/C	B/C
		T34-9	Qwidlana	60.89	B	B	B
		MRU Thina_B	Thina	62.97	C	C	C
		T34-10	Tsilithwa	42.25	B	B	B
		T34-11	Ngcothi	18.41	B	B	B
		T34-12	Mvuzi	39.26	C	C	C
		MRU Thina_C (MzimEWR2)	Thina	146.37	C	C	C
T35_a	I	T35-1	Tsitsana	108.14	B	B	B
		T35-2	Pot	93.73	B	B	B
		T35-3	Klein Mooi	46.59	B	B	B
		T35-4	Mooi	68.57	C	C	C
		MRU Tsitsa B	Tsitsa	73.82	C	C	C
		T35-5	Gqukunqa	38.91	B	B	B
T35_b	I	T35-6	Inxu	40	B	B	B
		T35-7	Gqaqala	59.52	B	B	B
		T35-8	Kuntombizininzi	32.15	B	B	B
		MRU Inxu (EWR1)	Inxu	67.36	C	C	C
		MRU Gat (IFR1)	Gatberg	91.79	B	B	B
T35_c	II	MRU Inxu	Inxu	36.43	B/C	B/C	B/C
		T35-9	Umnga	58.55	B/C	B/C	B/C
		T35-10	Qwakele	21.48	C	B/C	B/C
		T35-11	Ncolosi	26.2	C/D	C	C
		T35-12	Culunca	27.66	C	B/C	B/C
		T35-13	Tyira	23.23	C/D	C/D	C/D
		T35-14	Xokonxa	36.12	C	C	C
		T35-15	Ngcolora	35.99	C	C	C
		T35-16	Ruze	25.59	B	B	B
T35_d	II	MRU Tsitsa_Ca (MzimEWR1)	Tsitsa	79.89	C	C	C
		MRU Tsitsa_Cb (EWR1 Lalini)	Tsitsa	19.17	C	C	C
		MRU Tsitsa_D	Tsitsa	47.15	B	B	B
T36_a	I	T36-1	Mzintshana	20.35	B	B	B
		T36-2	Mkata	30.57	B	B	B
		MRU Mzim (MzimEWR4)	Mzimvubu	56.93	C	C	C
T36_b	I	MRU Estuary	Mzimvubu	26.04	B	B	B

It must be noted that the TEC for the scenarios with and without the dam developments associated with the MWP, is the same. This is applicable for Resource Units MRU Tsitsa_Ca, MRU Tsitsa_Cb, MRU Tsitsa _D and MRU Mzim.

1.6 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this document is to provide a summary of the narrative and numerical RQOs for the Mzimvubu catchment's river sites and estuary.

The report outline is as follows:

Chapter 1: Introduction
This chapter provides general background to the project task.

Chapter 2: Prioritising RUs and Indicator Components
This chapter provides an overview of the important Resource Units in the study area, the approach and format of selected RQO components.

Chapter 3: Approach
Outlines the various multi-disciplinary methodologies adopted during this task.

Chapter 4–16: Resource Quality Objectives
These chapters outline the RQOs of the various components per IUA.

Chapter 17: References

2 PRIORITISING RESOURCE UNITS AND INDICATOR COMPONENTS

As part of the classification process, once the Integrated Unit of Analysis (IUAs) have been defined, Resource Units (RUs) and biophysical nodes must be identified for different levels of EWR assessment and the setting of RQOs. RUs are sections of a river that frequently have different natural flow patterns, react differently to stress according to their sensitivity, and therefore require individual specifications of the Reserve appropriate for that reach. The guiding principle is that if the hydrology, geomorphic characteristics (i.e. geomorphic zone), physico-chemical attributes and river size remains relatively similar, a RU can be demarcated (DWAF, 2008a).

Management requirements (DWAF, 1999, volume 3) also play a role in the delineation. An example could be where large dams and/or transfer schemes occur. Furthermore, the type of disturbance/impact on the river plays a role in selecting homogenous river reaches from a biophysical basis under present circumstances. These are called Management Resource Units (MRUs) and the purpose of distinguishing MRUs is to identify a management unit within which the EWR can be implemented and managed based on one set of identified flow requirements. MRUs are homogenous units which are sufficiently different from adjacent areas to warrant a separate EWR assessment being undertaken (Louw and Hughes, 2002). This means that an EWR site in the MRU, according to the EWR site selection criteria in context of the MRU, will provide for the whole MRU. Hydrological changes due to incremental runoff must also be taken into account (DWAF, 2008a).

Therefore an IUA can consist of RUs, MRUs or both. RU priority is based on the outcome of the RU priority assessment (DWS, 2017a). RUs, MRUs and associated priorities were therefore defined during the initial steps of this study and are documented in DWS (2017a). RU priorities and the level of detail for RQOs are provided in **Table 2.1**. Further refinement took place during the course of the study based on additional information, with the final priority ratings provided in **Tables 2.2** and **2.3**. **Table 2.2** provides priority ratings for RUs not represented by EWR sites. **Table 2.3** provides the MRUs which are represented by EWR sites; the highest level of detail must be set for these. EWR sites MzimEWR2 and MzimEWR3 are however located in moderate priority RUs as these sites were selected and used during studies prior to the classification study. As a high level of detail is available for setting RQOs and they represent EWR sites, these have been included in the detailed RQO assessment list.

Figure 2.1 depicts the study area in terms of delineated IUAs, RUs and MRUs priority areas as well as the associated PES and TEC.

Table 2.1 indicates the four levels of RU priority and associated RQOs. Note that priority levels 3 and 4 represent the same level of RQO detail, although the priority level is indicated as High or Very High.

Table 2.1 RU priority level and associated RQO description

RU priority	RU priority level	Associated RQO
Low	1	Flow RQOs unless situated in its total length in a conservation area (formal protected area). Habitat RQOs are in terms of Present Ecological State (PES) and Target Ecological Category (TEC) (EcoStatus).
Moderate	2	Flow RQOs. Habitat and biota RQOs (broad).
High	3	If represented by an EWR site, a full suite of EcoSpecs are provided at the EWR site. If not an EWR site, the RQOs are at the same level as for priority level 2.
	3 (WQ)	Water quality RQOs are required as water quality is the driver at these sites. Usually High priority water quality problem areas. Habitat and biota RQOs will be at a priority level 2.
Very High	4	If represented by an EWR site, a full suite of EcoSpecs are provided at the EWR site. If not an EWR site, the RQOs are at the same level as for priority level 2.
	4 (WQ)	Water quality RQOs are required as water quality is the driver at these sites. Usually High priority water quality problem areas. Habitat and biota RQOs will be at a priority level 2.

Table 2.2 RU priority ratings

RU	SQ number	River	RU priority
T31: MZIMVUBU			
T31-1	T31A-04712	Mzimvubu	2
T31-2	T31B-04745	Krom	2
	T31B-04868	Krom	
	T31B-04873	unnamed	
T31-3	T31C-04796	Mngeni	3
	T31C-04866	Mzimvubu	
T31-4	T31C-04879	Nyongo	2
T31-5	T31D-04926	Mzimvubu	2
	T31D-05076	Mzimvubu	
T31-6	T31D-04936	Riet	2
	T31D-05030	Riet	
	T31D-05060	unnamed	
T31-7	T31E-04836	Tswereka	2
T31-8	T31E-04910	Malithasana	3
	T31E-04931	Tswereka	
T31-9	T31E-05055	unnamed	2
T31-10	T31E-05013	Tswereka	3
T31-11	T31F-05108	unnamed	2
T31-12	T31F-05112	Mzimvubu	3 (WQ)
	T31F-05134	unnamed	
T31-13	T31G-05071	Mzimvubu	3
	T31J-05257	Mzimvubu	
T31-14	T31H-05177	Mvenyane	2
	T31H-05304	unnamed	
T31-15	T31H-05324	Mvenyane	2
T31-16	T31H-05296	Mkemane	2

RU	SQ number	River	RU priority
T31-17	T31H-05445	unnamed	2
T31-18	T31H-05437	Mkemane	2
	T31H-05516	Mvenyane	
T31-19	T31J-05551	Mzimvubu	3
	T31J-05582	Ngwekazana	
	T31J-05588	Mzimvubu	
T32: MZINTLAVA			
T32-1	T32A-04965	Mzintlava	2
T32-2	T32A-04907	Mzintlanga	2
	T32B-05103	Mzintlava	
T32-3	T32B-05116	unnamed	3
	T32B-05184	Mzintlava	
T32-4	T32C-05219	Mill Stream	2
T32-5	T32C-05243	aManzamnyama	3
T32-6	T32C-05273	Mzintlava	4 (WQ)
	T32C-05313	Mzintlava	
T32-7	T32C-05378	unnamed	3
T32-8	T32D-05172	Droewig	2
T32-9	T32D-05352	Mzintlava	3 (WQ)
T32-10	T32D-05373	Mzintlava	3 (WQ)
T32-11	T32E-05446	Mvalweni	4 (WQ)
	T32F-05464	Mzintlava	
T32-12	T32G-05536	Mzintlavana	3
	T32G-05609	Mbandana	
	T32G-05747	Mzintlavana	
T32-13	T32H-05842	Mzintlava	3
T33: KINIRA			
T33-1	T33A-04887	Mafube	2
	T33A-04928	unnamed	
T33-2	T33A-04892	Kinira	3
	T33A-04898	Makomorin	
	T33A-04903	Kinira	
T33-3	T33A-04990	Kinira	3 (WQ)
	T33A-04991	unnamed	
T33-4	T33B-05005	Jordan	2
	T33B-05072	unnamed	
T33-5	T33B-04912	Seeta	3
	T33B-05051	Mabele	
T33-6	T33B-04939	Mabele	2
	T33B-04956	Mosenene	
T33-7	T33C-05131	Morulane	2
	T33D-05063	Kinira	
	T33D-05106	Pabatlong	
	T33D-05150	Kinira	
T33-8	T33E-05367	Somabadi	2
T33-9	T33F-05285	Rolo	2
	T33F-05398	Kinira	
T33-10	T33F-05439	Ncome	2

RU	SQ number	River	RU priority
T33-11	T33G-05587	Cabazi	2
T33-12	T33H-05638	Mnceba	2
T33-13	T33H-05803	Caba	2
T33-14	T33G-05659	Mzimvubu	3
	T33H-05680	Mzimvubu	
	T33H-05821	Mzimvubu	
	T33J-05834	Mzimvubu	
	T33K-06051	Mzimvubu	
T34: THINA			
T34-1	T34C-05168	Tinana	2
	T34C-05238	Phinari	
	T34C-05292	Tinana	
T34-2	T34A-05354	Zindawa	2
	T34A-05362	Vuvu	
	T34A-05394	Vuvu	
	T34A-05404 (MRU Thina_A)	Thina	
	T34A-05415 (MRU Thina_A)	Thina	
T34-3	T34A-05408	Khohlong	2
	T34B-05385 (MRU Thina_A)	Thina	
T34-4	T34B-05269	Nxotshana	2
	T34B-05275	Phiri-e-ntso	
	T34B-05351 (MRU Thina_A)	Thina	
	T34B-05356 (MRU Thina_A)	Thina	
T34-5	T34D-05412	Thina	2
T34-6	T34D-05433	Tokwana	3 (WQ)
	T34D-05462	Khalatsu	
	T34D-05463	Tokwana	
T34-7	T34E-05495	Bradgate se Loop	2
	T34E-05503	Luzi	
	T34E-05507	Luzi	
T34-8	T34F-05512	Luzi	2
	T34F-05585	unnamed	
T34-9	T34G-05504	Qwidlana	2
	T34G-05634	Nxaxa	
T34-10	T34H-05714	Qhanqu	2
	T34H-05769	Tsilithwa	
	T34H-05791	Tsilithwa	
T34-11	T34H-05826	Ngcothi	3
T34-12	T34H-05699	Mvuzi	2
	T34H-05738	Ngcibira	
	T34H-05809	Mvumvu	
T35: TSITSA			
T35-1	T35A-05596	Tsitsana	3
	T35A-05648 (MRU Tsitsa_A)	Tsitsa	
	T35A-05657	Hlankomo	
	T35A-05750 (MRU Tsitsa_A)	Tsitsa	
T35-2	T35B-05709	Pot	3
	T35B-05798	Pot	

RU	SQ number	River	RU priority
	T35B-05815	Little Pot	
T35-3	T35C-05858	Mooi	2
	T35C-05930	Klein-Mooi	
T35-4	T35C-05874	Mooi	3 (WQ)
T35-5	T35E-05780	Gqukunqa	2
T35-6	T35F-05999	Inxu	4
	T35F-06000	Fontana	
	T35F-06080	Inxu	
	T35F-06112	Rondadura	
T35-7	T35G-06135	Gqaqala	4
	T35G-06169	Gqaqala	
	T35G-06179	unnamed	
T35-8	T35F-05973	Kuntombizininzi	4
MRU Inxu EWR1	T35F-06020	Inxu	3 (WQ)
	T35G-06021	Inxu	
MRU Gat IFR1	T35G-06069	Gatberg	4
	T35G-06074	Gatberg	
	T35G-06099	Gatberg	
	T35G-06100	unnamed	
	T35G-06118	Gatberg	
	T35G-06133	unnamed	
MRU NXU	T35H-06024	Inxu	3
	T35H-06053	Inxu	
	T35J-06088	Inxu	
T35-9	T35H-06186	Umnga	2
	T35H-06240	KuNgindi	
	T35H-06282	Umnga	
T35-10	T35H-06158	Qwakele	2
T35-11	T35J-06106	Ncolosi	2
T35-12	T35K-05897	Culunca	2
T35-13	T35K-05904	Tyira	2
T35-14	T35K-06167	Xokonxa	4 (WQ)
T35-15	T35L-06226	Ngcolora	2
T35-16	T35M-06275	Ruze	2
T36: LOWER MZIMVUBU			
T36-1	T36A-06216	Mzintshana	2
T36-2	T36A-06220	Mkata	3

Table 2.3 MRU priority ratings

MRU	SQ number	River	Priority
T33			
MRU Kinira	T33E-05213	Kinira	2
	T33F-05326		
	T33G-05395 (MzimEWR3)		
T34			
MRU Thina_B	T34G-05543	Thina	3
	T34G-05667		

MRU	SQ number	River	Priority
	T34H-05598		
MRU Thina_C	T34H-05772	Thina	3
	T34H-05838		
	T34K-05835 (MzimEWR2)		
T35			
MRU Tsitsa_B	T35D-05721	iTsitsa	4
	T35E-05908		
MRU Tsitsa_Ca (MzimEWR1)	T35E-05977 (MzimEWR1)	Tsitsa	4
	T35K-06037		
	T35K-06098		
	T35L-05976 (part of)		
MRU Tsitsa_Cb (EWR1 Lalini)	T35L-05976 (part of)	Tsitsa	4
MRU Tsitsa_D	T35L-06190	Tsitsa	4
	T35M-06187		
	T35M-06205		
T36A			
MRU Mzim	T36A-06250 (MzimEWR4)	Mzimvubu	4
	T36A-06354		
	T36B-06391		

2.1 FORMAT OF RQO COMPONENTS

RQOs are set for the following components:

- Quantity, pattern and timing of instream flow (hydrology).
- Water quality.
- Geomorphology (EWR sites only).
- Characteristics and condition of riparian habitat and biota.
- Characteristics and condition of instream habitat and biota.

Hydrological RQOs are provided as a flow regime (described by means of a time series) associated with the ecological category (EC) associated with the final Water Resource Classes, i.e. the Target EC or TEC. The output is provided as the following:

- Flow duration table based on a hydrological time series. The full EWR rule is available electronically.
- Summary using various statistics.
- Defined quantity and frequency.

Water quality (WQ) RQOs were set for Moderate (Level 2) priority RUs where identified as an indicator, and all High and Very High (Level 3 and 4) Priority RUs. Note that Level 3 and 4 WQ RUs were also identified as areas where water quality only is considered a high priority.

Habitat and biota is described as the habitat and biota associated with an EC. The EC can be the target resulting from the Water Resource Class that will be implemented or the Recommended Ecological Category (REC). The format of the RQOs depends on the priority level of the RU and the indicator selected for description. The format can range as follows:

- Overall TEC – usually the REC.
- EC for each component.

- EcoSpecs (Ecological specifications) for components (as outcome of the EWR part of the study).
- Ecological objectives for components.

2.2 RIVERS: SELECTION OF RQO COMPONENTS AND INDICATORS

RQO components and RQO indicators were selected for RQO determination. Only relevant indicators (or high priority ones) were selected and the range selected links directly to the priority level of the RU. The indicators can be for different components, sub-components and specific species or taxa.

High and Very High Priority RUs (3 and 4): These require RQOs to be provided in as much detail as available information allows for all components. If an EWR site is present in these RUs, no selection of RQO component indicators are required as EcoSpecs are provided for all relevant components which are:

- Hydrology
- Physico-chemical variables (water quality)
- Geomorphology
- Riparian vegetation
- Fish
- Macroinvertebrates

To provide this level of detail, the RU should include an EWR site as the most detailed level of investigations were undertaken at these sites during the EWR assessment. This identification is undertaken during the first phase of the study as it assists in locating the EWR sites in the key rivers (i.e. high priority RUs).

If there are water quality issues (3 or 4 (WQ)), then user water quality specifications (Userspecs) will also be supplied for selected variables and specific users. Note that these Userspecs are related to users such as domestic use (assumes primary treatment, i.e. water for drinking, laundry, cooking and personal hygiene), agriculture (stock-watering and irrigation), recreation and industry. Userspecs will be different from Ecological Specifications (EcoSpecs), although these can inform the user water quality RQOs. Note that even though the water quality RQOs may be at a high level, the biota and habitat RQOs may still be Moderate priority.

Moderate Priority RUs (2): RQOs will not be provided for all components as done for High Priority RUs. A process of prioritisation for the components to be addressed is followed. Hydrology RQOs are provided as a standard for most RUs as for the High Priority RQOs. The component prioritisation process is therefore relevant for instream and riparian habitat and biota as well as water quality. As a first filter, the specific sources and causes that have caused changes in the state of the ecosystem are used to guide the selection of relevant components. The following guidelines were used to aid the identification of component indicators for which RQOs must be provided for each Moderate priority RU:

- If the causes and sources are non-flow related, then riparian vegetation is likely to be the key indicator component.
- If the system is seasonal, then riparian vegetation is likely to be the key indicator component.
- If causes and sources are flow related, then instream biota and habitat are likely to be the key indicator components.

- If water quality causes and sources are identified as an issue, broad EcoSpecs and/or user water quality RQOs are provided. Note that these are linked to driving variables and if a monitoring database is not yet available, RQOs presented are only predicted or provisional values. These RQOs are not immediately applicable, and only become applicable once monitoring has been conducted and provisional RQOs can be verified.

Tables 2.4 provides the key causes and sources in **Column g** per River System. This column provides the most significant causes and sources, i.e. the highest two ratings (None, Small, Moderate, Large, Serious, Critical) from the PESEIS revised database (DWS, 2017a). That is, if all impacts have been rated and the evaluation provided are for Small, Moderate and Large, then the descriptions associated with the Moderate and Large ratings are provided.

Column h provides the derived indicator components for which RQOs will be determined. **Column i** identifies the water quality role players (or users), while **Column j** lists the primary water quality variables for which water quality RQOs are provided. These may be either immediately applicable or provisional.

Note that naming of the RUs are according to the main (or longest) river in the RU, as some RUs consist of more than one SQ. Should a water quality hotspot (3WQ or 4WQ) be an indicator in the RU, naming will be according to the SQ that the hotspot occurs in as the RQOs have been defined accordingly.

Table 2.4 Key causes and sources and derived components for which RQOs will be set, the water quality users, and water quality variables

a	b	c	d	e	f	g	h	i	j
RU	**Main river**	**Priority**	**PES**	**REC**	**TEC**	**Primary PES drivers**	**Biota, habitat and WQ component indicators**	**WQ sources/users**	**WQ driving variables**
T31-1	Mzimvubu	2	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T31-2	Krom	2	B	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T31-3	Mzimvubu	3	B	B	B	Non-flow.	Riparian vegetation.	Flagged as a priority protection area (drinking water collection from springs).	
T31-4	Nyongo	2	C	C	C	Non-flow. WQ.	Riparian vegetation. Water quality.	Settlement runoff.	Nutrients, turbidity.
T31-5	Mzimvubu	2	B	B	B	Non-flow.	Riparian vegetation.		
T31-6	Riet	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T31-7	Tswereka	2	B	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T31-8	Tswereka	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T31-9	unnamed	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation. Water quality.	Irrigation.	Nutrients.
T31-10	Tswereka	3	D	D	D	Flow, non-flow.	Instream Biota. Riparian vegetation. Water quality.	Dairy irrigation runoff.	Nutrients.
T31-11	unnamed	2	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T31-12	Mzimvubu	3 (WQ)	C	C	C	WQ, non-flow.	Water quality. Riparian vegetation.	Pivot irrigation, erosion and sedimentation.	Nutrients, turbidity.
T31-13	Mzimvubu	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation. Water quality.	Pivot irrigation, erosion and sedimentation.	Nutrients, turbidity.
T31-14	Mvenyane	2	B	B	B	Non-flow.	Riparian vegetation.		
T31-15	Mvenyane	2	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T31-16	Mkemane	2	B	B	B	Non-flow.	Riparian vegetation.		
T31-17	unnamed	2	C	B/C	B/C	WQ, non-flow.	Water quality. Riparian vegetation.	Extensive erosion.	Turbidity.

a	b	c	d	e	f	g	h	i	j
RU	**Main river**	**Priority**	**PES**	**REC**	**TEC**	**Primary PES drivers**	**Biota, habitat and WQ component indicators**	**WQ sources/users**	**WQ driving variables**
T31-18	Mkemane	2	C/D	B/C	B/C	WQ, non-flow.	Water quality. Riparian vegetation.	Extensive erosion.	Turbidity.
T31-19	Mzimvubu	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T32-1	Mzintlava	2	C	B/C	B/C	Flow, non-flow.	Instream Biota. Riparian vegetation. Water quality (priority protection area?).	Franklin vlei (RAMSAR site); irrigation; forestry. Flagged as a water quality priority protection area.	Nutrients, toxics.
T32-2	Mzintlava	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation. Water quality.	Sawmill settlements.	Nutrients, pH, *E. coli*/faecal coliforms.
T32-3	Mzintlava	3	C	B/C	B/C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T32-4	Mill Stream	2	C	B/C	B/C	Non-flow.	Riparian vegetation.		
T32-5	aManzamnyama	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T32-6	Mzintlava	4 (WQ)	B	B	B	WQ, non-flow.	Water quality. Riparian vegetation.	Pivot irrigation, settlements, urban, erosion.	Nutrients, turbidity, toxics, *E. coli*/faecal coliforms.
T32-7	unnamed	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T32-8	Droewig	2	C	C	C	Flow, non-flow.	Instream Biota Riparian vegetation. Water quality7	Pivot irrigation.	Nutrients, toxics.
T32-9	Mzintlava	3 (WQ)	D	D	D	Flow, WQ, non-flow.	Instream Biota. Water quality. Riparian vegetation.	Kokstad WWTW[1]; urban; irrigation.	Nutrients, turbidity, toxics, *E. coli*/faecal coliforms.
T32-10	Mzintlava	3 (WQ)	D	D	D	WQ, non-flow.	Water quality. Riparian vegetation.	Effect of urban impacts; irrigation return flows (pivots)	Nutrients, toxics, salts, *E. coli*/faecal coliforms.
T32-11	Mzintlava	4 (WQ)	C/D	C	C	Non-flow.	Water quality. Riparian vegetation.	Mount Ayliff WWTW high risk, extensive erosion, rural settlements, dryland cultivation, Insizwa (nickel) Mine (status unknown).	Nutrients (Total Inorganic Nitrogen (TIN) and phosphate), turbidity, *E. coli*/faecal coliforms, salts.
T32-12	Mzintlavana	3	B/C	B	B	Non-flow.	Riparian vegetation.		
T32-13	Mzintlava	3	C	B	B	Non-flow. WQ	Riparian vegetation.	Flagstaff WWTW, but appears to not be discharging to the river.	
T33-1	Mafube	2	B	B	B	Non-flow.	Riparian vegetation.		
T33-2	Kinira	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		

a	b	c	d	e	f	g	h	i	j
RU	**Main river**	**Priority**	**PES**	**REC**	**TEC**	**Primary PES drivers**	**Biota, habitat and WQ component indicators**	**WQ sources/users**	**WQ driving variables**
T33-3	Kinira	3 (WQ)	C	C	C	WQ, non-flow.	Water quality. Riparian vegetation.	Matatiele WWTW discharge into streams, piggery north of WWTW, sand mining. Upstream unnamed SQ: Rural settlements with many crossing and dryland cultivation.	Turbidity, nutrients, *E. coli*/faecal coliforms.
T33-4	Jordan	2	B	B	B	Non-flow.	Riparian vegetation.		
T33-5	Seeta	3	B/C	B/C	B/C	Non-flow.	Riparian vegetation.	Flagged as a water quality priority protection area as a drinking water source (weir).	
T33-6	Mosenene	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T33-7	Morulane	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T33-8	Somabadi	2	C	C	C	WQ, non-flow.	Water quality. Riparian vegetation.	Erosion and sedimentation.	Turbidity.
T33-9	Kinira	2	C	C	C	WQ, non-flow.	Water quality. Riparian vegetation.	Erosion and sedimentation.	Turbidity.
T33-10	Ncome	2	C	C	C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T33-11	Cabazi	2	C	C	C	WQ, non-flow.	Riparian vegetation. Water quality.	Erosion and sedimentation.	Turbidity.
T33-12	Mnceba	2	C	C	C	Non-flow.	Riparian vegetation.		
T33-13	Caba	2	C	B	B	WQ, non-flow.	Riparian vegetation. Water quality.	WWTW; extensive settlements.	Nutrients, *E. coli*/faecal coliforms.
T33-14	Mzimvubu	3	B	B	B	WQ, non-flow.	Riparian vegetation. Water quality.	Access roads, sand mining.	Turbidity
T34-1	Tinana	2	B	B	B	Non-flow.	Riparian vegetation.		
T34-2	Thina	2	B	B	B	Non-flow.	Riparian vegetation.		
T34-3	Khohlong	2	B/C	B/C	B/C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T34-4	Thina	2	B	B	B	Non-flow.	Riparian vegetation.		
T34-5	Thina	2	C	B/C	B/C	Flow, WQ, non-flow.	Instream Biota. Water quality. Riparian vegetation.	Settlements, erosion; assumed discharge from Cacudi WWTW.	Turbidity, E. coli/faecal coliforms, nutrients.

a	b	c	d	e	f	g	h	i	j
RU	**Main river**	**Priority**	**PES**	**REC**	**TEC**	**Primary PES drivers**	**Biota, habitat and WQ component indicators**	**WQ sources/users**	**WQ driving variables**
T34-6	Tokwana	3 (WQ)	C	C	C	Flow, WQ, non-flow.	Instream Biota. Water quality. Riparian vegetation.	Mount Fletcher WWTW (high risk); urban impacts, crossings.	Nutrients, turbidity, toxics, *E. coli*/faecal coliforms.
T34-7	Luzi	2	B	B	B	Non-flow.	Riparian vegetation.		
T34-8	Luzi	2	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T34-9	Nxaxa	2	B	B	B	Non-flow.	Riparian vegetation.		
T34-10	Tsilithwa	2	B	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T34-11	Ngcothi	3	B	B	B	Non-flow.	Riparian vegetation.		
T34-12	Ngcibira	2	C	C	C	WQ, non-flow, flow.	Water quality. Instream Biota. Riparian vegetation	Dryland cultivation; settlements; crossings and erosion.	Turbidity; nutrients; *E. coli*/faecal coliforms.
T35-1	Tsitsa	3	B	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T35-2	Pot	3	B	B	B	Non-flow.	Riparian vegetation.		
T35-3	Klein Mooi	2	B	B	B	Non-flow.	Riparian vegetation.		
T35-4	Mooi	3 (WQ)	C	C	C	Flow, WQ, non-flow.	Instream Biota. Water quality. Riparian vegetation.	Maclear WWTW, urban impacts, cultivation/irrigation.	Nutrients, toxics, *E. coli*/faecal coliform.
T35-5	Gqukunqa	2	B	B	B		Water quality	Nessie Knight Hospital WWTW, settlements.	Nutrients, *E. coli*/faecal coliform.
T35-6	Inxu	4	B	B	B	Non-flow.	Riparian vegetation.		
T35-7	Gqaqala	4	B	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T35-8	Kuntombizininzi	4	B	B	B	Flow	Instream Biota.		
MRU Inxu EWR 1	Inxu	3 (WQ)	C	C	C	WQ, non-flow.	Water quality. Riparian vegetation.	Ugie low risk WWTW, urban impacts, irrigation downstream.	Nutrients, toxics, *E. coli*/faecal coliforms.
MRU Gat IFR1	Gatberg	4	B/C	B	B	Flow, non-flow.	Instream Biota. Riparian vegetation.		
MRU Inxu	Inxu	3	B/C	B/C	B/C	WQ, non-flow.	Riparian vegetation.		
T35-9	Umnga	2	B/C	B/C	B/C	Non-flow.	Riparian vegetation.		
T35-10	Qwakele	2	C	B/C	B/C	Non-flow.	Riparian vegetation.		

a	b	c	d	e	f	g	h	i	j
RU	**Main river**	**Priority**	**PES**	**REC**	**TEC**	**Primary PES drivers**	**Biota, habitat and WQ component indicators**	**WQ sources/users**	**WQ driving variables**
T35-11	Ncolosi	2	C/D	C	C	WQ, non-flow.	Riparian vegetation. Water quality	Erosion and sedimentation.	Turbidity
T35-12	Culunca	2	C	B/C	B/C	Flow, non-flow.	Instream Biota. Riparian vegetation.		
T35-13	Tyira	2	C/D	C/D	C/D	Flow, WQ, non-flow.	Instream Biota. Water quality. Riparian vegetation.	Settlements; erosion and sedimentation.	Turbidity, nutrients, *E. coli*/faecal coliforms.
T35-14	Xokonxa	4 (WQ)	C	C	C	Flow, non-flow. WQ	Water quality. Instream Biota. Riparian vegetation.	Tsolo WWTW (critical risk), urban impacts (incl. Tsolo Agricultural College, St Lucy's and Dr Maliza Mphehle Memorial hospitals), crossings, dryland cultivation.	Nutrients, turbidity, toxics, *E. coli*/faecal coliforms.
T35-15	Ngcolora	2	C	C	C	Non-flow.	Riparian vegetation.		
T35-16	Ruze	2	B	B	B	Non-flow.	Riparian vegetation.		
T36-1	Mzintshana	2	B	B	B	Non-flow.	Riparian vegetation.		
T36-2	Mkata	3	B	B	B	Non-flow.	Riparian vegetation.		

[1] Waste Water Treatment Works

Figure 2.1 The study area in terms of delineated IUAs, RUs and MRUs priority areas as well as the associated PES and TEC per RU

3 APPROACH

3.1 RIVERS

3.1.1 Biota and habitat EcoSpecs, TPCs and RQOs

For the purpose of RQO determination, the following differentiation is made between biota and habitat EcoSpecs and RQOs.

EcoSpecs are associated with the Ecological Reserve process and are usually provided at EWR sites. As explained in **Chapter 2**, EWR sites are situated in High Priority SQs (hotspots) and therefore High Priority RUs requiring detailed RQOs. EcoSpecs are seen as detailed RQOs as they are quantifiable, measurable, verifiable and enforceable to ensure protection of all components of the resource, which make up ecological integrity (DWA, 2009a). Therefore, EcoSpecs are numerical and can be used for monitoring. Thresholds of Potential Concern (TPCs) are upper and lower levels along a continuum of change in selected environmental indicators and are used and interpreted according to the following guidelines (Rogers and Bestbier, 1997) and are linked to EcoSpecs. When setting EcoSpecs input is usually based on fieldwork that has been undertaken, meaning a monitoring baseline is therefore available and monitoring to determine whether the specifications are being achieved (or Ecological Category) can be undertaken.

Biota and habitat RQOs are usually determined for the Moderate Priority RUs (Level 2) rather than EcoSpecs. The requirements for Moderate Priority RUs are that the RQOs should be broader or less detailed than High Priority RUs and this is inherently the case as fieldwork has not been undertaken. A monitoring baseline is therefore also not available and EcoSpecs cannot be determined. Monitoring at Moderate Priority RUs will be of lower priority than at EWR sites in High Priority RUs. As sufficient data are not available to set specifications, only broad objectives for the EC are provided. RQOs in this format cannot be used in monitoring as is. It therefore follows that if monitoring must be undertaken for some or other reason at some stage, then the objectives must be translated into EcoSpecs based on field surveys and the establishment of a monitoring baseline.

3.1.2 Water quality

General approach

The approach to User Water Quality tasks is encapsulated in DWS (2016), which is a document containing all water quality tools and standardized inputs and outputs currently used for the operationalizing of Resource Directed Measures (RDM). During Steps 1 and 2 and associated sub-steps of the Integrated framework (DWS, 2016) and Project Plan for the Mzimvubu study (**Figure 1.1**), data is gathered on the following to inform the water quality process for both ecological water quality and users:

- Identify water quality users or role players and associated uses, and water quality issues/problems that impact on use.
- Identify pollution priority areas, or water quality hotspots.
- Identify driving variables responsible for water quality state.
- Gather information on users, issues and driving variables from stakeholders at Technical Task Group (TTG) and information meetings and prepare water quality users spreadsheet. These meetings were undertaken in January and March 2017 for the Mzimvubu study.

- Test information with stakeholders (this information feeds into Integrated Step 6, the selection of RQOs for water quality).
- Catchment water quality (status quo) and processes.

The output of these two steps is a spreadsheet or tables containing the following information for Moderate Priority RUs, as information for all variables is required at EWR sites located in High Priority RUs:

- Study area delineated into SQ catchments, clustered into RUs or Management Resource Units (MRUs), and within the framework of Integrated Units of Analysis (IUAs).
- Water quality priority resource units.
- Water quality role players/users and their locations within RUs/MRUs.
- Driving users/role players in terms of water quality.
- Water quality variables that drive water quality state or requirements.

Where objectives for aquatic ecosystems were not available from a Reserve study and the Reserve water quality manual (DWAF, 2008b), water quality guidelines were used (DWAF, 1996a–e). Note that guidelines are not linked to an Ecological Cateory, but rather a level of protection, e.g. a Target Water Quality Range (TWQR; which is equivalent to an A category).

Water quality RQOs that are immediately applicable are ONLY those where monitoring data are available for comparative purposes. Monitoring recommendations and provisional RQOs are set for identified driving variables for which RQOs are not immediately applicable, but for which a database needs to be developed. Once an adequate dataset has been produced, evaluate the provisional RQOs provided and set the RQOs for the driving variables identified during this classification study.

In addition to information from meetings, literature reviews and identified stakeholders, spreadsheet and GIS data were received from Dr N Muller of Amatole Water, who interrogated the DWS WARMS database to set up an inventory of WWTW authorisations. This included the identification of municipal WWTWs, as well as those of prisons (Department of Public Works) and hospitals (Department of Health).

Setting numerical and narrative RQOs

Numerical and narrative RQOs were therefore produced using all existing data sources for identified monitoring points. Note that Reserve data available as A–F categories were converted to Ideal to Tolerable categories (required for water quality gazetting purposes), as follows:

Categories A and A/B: Ideal
Categories B, B/C and C: Acceptable
Categories C/D and D: Tolerable

To summarise, the user water quality state per relevant RU and IUA was evaluated by determining the driving water quality variables linked to the primary water quality user(s). Note that although the aquatic ecosystem is the **resource base** rather than a “user”, it was grouped and evaluated with other users for purposes of this step of the classification process. The driving user and set of variables were identified and the water quality RQOs set accordingly.

Note that RQOs that are *immediately applicable* (and will therefore be gazetted) are only for those sites and variables where monitoring is currently taking place. Other RQOs are *provisional* and can only be evaluated and confirmed once adequate monitoring data are available.

Priority levels

Water quality RQOs were set for Moderate (Level 2) priority sites where identified as an indicator, and all High (Level 3) and Very High (Level 4) Priority sites. Note that Level 3(WQ) and 4(WQ) sites were also identified, which are sites where water quality only is considered a high priority.

The water quality component of developing Level 2 and 3 RQOs was undertaken as follows:

Moderate (Level 2) Priority RQOs: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources were used.

High (Level 3(WQ)) and Very High Priority (4(WQ)) RQOs: Detailed RQOs were produced for water quality using any existing information as these are high priority water quality sites. Note that a water quality assessment was normally not available for these sites, unless also an EWR site or monitoring has been conducted and were available to the study.

High (Level 3) and Very High (Level 4) Priority RQOs: Detailed water quality assessments have been conducted for Reserve studies using methods such as the Physico-chemical Driver Assessment Index (PAI models) (DWAF, 2008b). Historical Reserve assessments were used where available.

Assumptions/rules when setting RQOs

The following set of assumptions and rules were developed and followed when setting RQOs. Rules were tested and developed further with stakeholders at TTG meetings in January and March 2017, and at Project Steering Committee (PSC) meetings.

a) Dams

RQOs were not set for dams.

b) Format of values used for setting RQOs

Values used for setting RQOs were linked to standard DWS methods and procedures, i.e. the manner in which variables are analysed and curated on DWS's Water Management System (WMS) database (e.g. NO_2 and NO_3-N and PO_4-P), and Reserve methods for water quality in rivers (DWAF, 2008b). It is acknowledged that different ways of evaluating nutrients are available (e.g. Total Phosphate), but standard DWS approaches were followed.

c) Data availability

RQOs were set based on real data where available and used for assessing water quality state at EWR sites, i.e. monitoring data available and verified at the time of writing the reports. Note that monitoring data to be collected for measurement against RQOs that are immediately applicable and to be gazetted should be collected from the monitoring sites as identified in the water quality Reserve documentation, if possible.

Where data were not available (e.g. at Priority Level 2 or 3 and 4(WQ) sites), extrapolation from real data were undertaken where possible, or land-use and all other available information sources used. It is acknowledged that these RQOs are PROVISIONAL and will only become applicable once a database of information has been set up through monitoring, to evaluate whether the RQO is valid and appropriate, or needs adjusting.

d) Data quality

Standard DWS methods (e.g. DWAF, 2008b) have been followed for the analysis of water quality data and preparation of RQOs. Although the use of percentiles is acceptable practise, it is necessary to define data quality and length of an acceptable data record when calculating percentiles. When compliance to a percentile is evaluated, it is important to know the associated statistical confidence of the data, and therefore the confidence in the result. The following guidelines regarding data frequency and hence quality are taken from DWAF (2008b).

The general rule for data selection is the following:
*Select the RC (or Reference Condition/natural state) data as the **first** 3–5 yrs (**minimum of 60 data points for high confidence, 25 samples for moderate confidence and 12 samples for low confidence**) of the data record, and the PES as the **last** 3–5 years of data (again a minimum of 60, 25 or 12 data points for difference confidence levels). The monitoring point suitable for Reference Condition must therefore either be in an unimpacted tributary (this can be in an adjacent catchment, but in the same Level II EcoRegion) or a very early data record (e.g. from the 1960s – early 1980s). It is possible to use the same monitoring point for Reference Condition and PES data, if the appropriate data record is available.*

Note that although a low confidence desktop assessment can be run using 12 data points, these points should preferably be spread across the hydrological cycle. Alternatively, weekly monitoring over a 60 day period can be undertaken.

It is difficult to specify a time window of observation, as the frequency of monitoring would be dependent on the implementing agent undertaking and financing the monitoring, but it is acceptable to say that at least 12 data records over a different range of hydrological regimes should be available to test percentiles against with any level of confidence (which would be low confidence, in this instance). Note that DWAF (2008b) states the following regarding confidence in water quality data for conducting a Reserve assessment in High or Very High EIS systems. The same rule should apply to testing compliance against RQOs at EWR sites.

Note: If inadequate data exists for an assessment in a *High / Very High* EIS area **(i.e. n < 25)**, recommend that monitoring is initiated (preferably over one hydrological cycle) before a Reserve can be determined, including at the Desktop level. This constraint may be waived if sufficient biological monitoring and site-specific information is available.

Note that data collected for compliance monitoring at EWR sites must be taken from the same site used for the Reserve study, as a general rule. It is possible that a DWS monitoring site might be discontinued as a better site becomes available; the data from the "new" site should then be used. Comparisons of data against Reserve EcoSpecs (so the ecological water quality RQOs) must be

done with care. Note that if the monitoring points are within the same Level II EcoRegion, RQOs and monitoring data should be comparable.

Data used for the derivation of percentiles could include baseline monitoring data, as the sampled time windows then increase, with an associated increase in statistical power. Although a smaller data set would be more sensitive to short-term variation, it would also have a shorter "memory" for historic non-compliance than a larger data set. However, a smaller data set is more prone to being affected by natural variation, and sampling and laboratory error. In contrast, a larger monitoring data set will comprise samples drawn from a longer time-frame. Together with the greater statistical power implicit in a larger sample size, such a larger data set will amalgamate data over a longer time-frame and, in this way, the impact of short term variations in water quality will be decreased (Griffin and Palmer, 2011).

e) Microbial compliance targets

Although microbial compliance targets for WWTW should be specified in the water use license for the discharge, an objective for *E. coli* and faecal coliforms was set below each WWTW, town and large settlement. As a clear relationship has been reported between the concentration of *E. coli* in a particular water sample and the probability of gastroenteritis symptoms in humans exposed to the water through drinking or full-contact recreation, *E. coli* is used as a microbial indicator organism.

In areas where concentrations are already non-compliant to full or partial contact recreational guidelines (e.g. swimming, DWAF (1996a): 0–130 counts/ml), without a possibility of reducing significantly in the short term, risk level guidelines used by the National Microbial Monitoring Programme (NMMP) of South Africa, were adopted.

The NMMP measures *E. coli*, pH and turbidity at a number of sites across the country, based on a site prioritisation system (Kühn et al., 2000). Although turbidity does not in itself have direct health effects, it is one of the indicators of microbiological water quality. Depending on the nature of the origin of the suspended matter causing the turbidity, there may be associated health effects. Suspended clay particles, often a major contributor to turbidity in surface waters, provide large surfaces for colonisation by bacteria and other micro-organisms.

The following NMMP objectives were used for this study, largely due to the dearth of information on faceal coliform concentrations, and on what and where recreational or other activities are taking place in the study area. There are also localised instances of faceal coliform and *E. coli* pollution, which cannot easily be addressed in the short-term. A phased approach may be necessary in many areas to improve faecal coliform and *E. coli* conditions. RQOs for faecal coliforms and *E. coli* have therefore been written as an evaluation again potential health risk rather than achieving absolute values (i.e. 0–130 counts/ml). A risk warning and acknowledgement of risk is considered an appropriate first step to improving coliform state. It is assumed that this microbial parameter will also be addressed in license conditions for effluent discharge points, e.g. at WWTWs.

Narrative RQO	Numerical RQO		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*.	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

Run-of-river objectives for *E. coli* and faecal coliforms are therefore focused on *partial* e.g. angling, or *full-contact recreational and other uses*, e.g. swimming and boating, and not water used for drinking. Full contact use has been expanded to include full-body immersions, e.g. baptisms. It is assumed that run-of-river water is not used for domestic use UNLESS primary treatment has been undertaken. Objectives for domestic use, such as drinking untreated water from the river, are therefore not covered in the water quality RQOs.

f) Toxics

Broad numerical guidelines for *toxics* are not suitable for areas where specific information on toxics are not available, or where the identity of contaminants are not known. In certain areas where reference condition data are not available, and values of metals could not be quantified, biotic response and biological monitoring are used to indicate toxicity. The default state should be to eliminate toxics from rivers, but again it is acknowledged that this may require a phased approach, and that the first step is to be aware of instances where toxics are, or seem to be, problematic.

g) Aquatic ecosystems driver

It can be seen from the detailed RQOs in the report that the driver is often *aquatic ecosystems*. This seems suitable as often the water quality data is linked to the maintenance or reaching of a particular water quality category, which is part of a specific EC, catchment configuration and Water Resource Class.

h) Immediately applicable vs. Provisional RQOs

As previously mentioned, not all RQOs mentioned in this report are linked to a current monitoring programme or can be immediately applicable. The first step with all water quality RQOs listed in this report is to assess whether sites are part of a monitoring programme and whether the variable of interest is being monitored by that programme. If not, or if insufficient data are available to test compliance, a monitoring database must be developed before the RQO can be evaluated and applied.

3.1.3 Geomorphology

General approach

The approach to setting RQOs for the Mzimvubu EWR sites was similar to that described by Rountree for the Inkomati River (DWA, 2010). In line with the Inkomati study, EcoSpec and TPC metrics were generated in relation either to the geomorphological character of the site – the condition of the site as could be assessed from morphological features and key processes, or to the condition of critical habitats that are determined by the geomorphology. The Inkomati study also related metrics to the Rapid Habitat Assessment Method (RHAM) (DWA, 2009b). This was not available for the Mzimvubu study.

RQOs for geomorphology were only set at priority sites – the four EWR sites on the Tsitsa, Thina, Kinira and Mzimvubu rivers. They were based on desktop studies of Google Earth and black and

white historic aerial imagery undertaken prior to site visits and on data collected during site visits. Data collection methods at the four EWR sites was modified to fit the time available, which was never more than four hours at a site and in the case of MzimEWR2 and MzimEWR3, significantly less. This meant that much of the assessment was based on qualitative observations based on time spent walking over the site.

The data used to set EcoSpecs and TCPs at all four EWR sites were as described below.

Bed sediment

Bed sediment has a direct effect on habitat quality for instream aquatic organisms and is likely to change in the short term in response to flood events that distribute sediment sourced from upstream and from the catchment. Two metrics were selected: the particle size distribution of mobile bed material (generally < 63 mm) and embeddeddnes, determined as the percentage of fines (< 4mm) covering the area of a 1 x 1 m quadrat (or similar area). Up to 100 clasts of potentially mobile bed material were sampled from accessible deposits within the active channel; embeddedness was surveyed in critical fast flowing habitats such as runs, riffles or rapids. The EcoSpec metric was given in terms of the D50 and D16 particle size as the D50 provides a central measure and the D16 a measure of fine material that can cause infilling of coarse substrate. The embeddedness metric was expressed as the percentage area covered by fines.

Channel cross section

The channel cross section was surveyed at one transect at each site across critical riffle or rapid habitat. Changes to channel width would impact on the total availability of instream or channel bank habitat. It would also impact the long-term hydraulic relationship between discharge, water depth and velocity. Noticeable changes to channel width therefore flag likely changes to other habitat variables. The EcoSpec was given in terms of the channel width between significant lateral features such as inset benches and the top of the channel banks. Widths were measured from the surveyed transect.

Cross section changes are likely to take place over the long term (5–10 years) or following extreme events. A resurvey of the transect will be required in order to measure the extent of change.

Transects were not surveyed through pools at any of the sites. The EcoSpecs for pools were derived from Google Earth imagery taken at low flow. Channel width and the presence of exposed sand bars were used as metrics.

Flood benches

Flood benches provide habitat for riparian vegetation. The EcoSpec was based on presence/ absence of indicator benches and presence/absence and extent of fine sediment deposits. Changes to flood benches should also be detected from resurveys of the cross section transects.

Flood benches could be removed or develop in response to changes in the balance of lateral erosion and deposition. Erosional changes would be most likely to occur following a disturbance such as a large flood whereas increased deposition will be a more ongoing process in response to reduced flood flows and/or increased sediment loads.

Channel pattern

Channel pattern determines the assemblage of habitat types within the channel and riparian zone. It is the response to the external drivers of flow discharge and sediment load and calibre and to local conditions of channel gradient and valley confinement. Although a change in channel pattern is unlikely, any observed change would flag a serious TPC. Channel pattern was classified at the reach scale from aerial imagery and the site visit according to categories given in the Geomorphology Assessment Index (GAI) assessment manual (Rowntree, 2013).

3.1.4 Fish

High priority rating (3) RUs: The RQOs and EcoSpecs as developed during the Reserve Determination studies were primarily used during this process. The information was adapted and simplified where possible and all other available and relevant information (e.g. PESEIS project – DWS, 2014c) was used to update and expand the descriptions to be relevant for the EWR reach as well as the entire management unit. RQOs and EcoSpecs were described for different metrics, such as PES, species richness, migratory requirements, alien species and for specific habitat features (such as fast shallow habitats, rocky substrates). Indicator species were identified for all these various metrics and primary indicator species (that would best provide indication of potential concern, especially in terms of flow and flow-related water quality) was then highlighted.

The following codes are used in the fish EcoSpec table and are applicable for all tables:

- FREQUENCY OF OCCURRENCE (FROC):
  - 0 = Absent.
  - 1 = Present at very few sites (< 10%).
  - 2 = Present at few sites (> 10–25%).
  - 3 = Present at about > 25–50% of sites.
  - 4 = Present at most sites (> 50–75%).
  - 5 = Present at almost all sites (> 75%).
- Indicator: Primary species or variable used as indicator for relevant metric.
- Migratory guilds:
  - *Catadromous*: Fishes which spend most of their lives in freshwater and migrate to the sea (or saline reaches of estuaries) to breed as adults (e.g. eels – catchment scale migrations).
  - *Potamodromous*: Truly migratory species whose entire life cycle is completed within freshwater and that undertake migrations within freshwater zones (between SQ reaches) of rivers for a variety of reasons, such as for spawning, feeding, dispersion after spawning, colonisation after droughts, for over-wintering, etc.

Moderate priority rating (2) RUs: The available information, as provided in the PESEIS project (DWS, 2014c) was used as the primary fish information source for RUs with a level 2 priority rating. This information, together with other relevant available information was used to determine the expected species that may occur in the reach/es under present ecological condition. Based on this information, species richness, primary and secondary indicator species were identified and used to describe the narrative and numerical RQOs for each of this sub component indicators for the reach.

3.1.5 Macroinvertebrates

The setting of RQOs relied substantially on the outputs of a model developed by Birkhead and Uys in 2013 (in Birkhead et al., 2013) to predict occurrence of aquatic macroinvertebrates in SQs of the Water Management Areas of the Eastern Cape (then WMA 12 and 15). This formed part of the revision of the PESEIS project (DWS, 2014c).

The rationale for the model, and a brief description of the approach, are provided below. The output of the model is a prediction of the likelihood of occurrence of the South African Scoring System version 5 (SASS5) listed taxonomic groups per SQ, at one of three different confidence levels:

- 1 = Present, low confidence. This taxon had not been recorded in the sub-quaternary, however, based on the local "pool" of taxa, the PES, the sensitivity and the similarity of the sub-quaternary to others in which the taxon is known to occur (on the basis of Level 2 EcoRegion, Geozone, altitude and habitats available), is expected to be present.
- 3 = Present, moderate confidence. The species has not been recorded recently in the SQ, but based on the PES and species sensitivity it is expected to be present. Where the general PES for the SQ has changed, there are still sections suitable for habitation by the species.
- 5 = Present, high confidence. The species has recently been recorded in the SQ. The PES has not changed to such extent that it would be expected to be absent.
- Blank = Absent.

Approach for setting RQOs for macroinvertebrates per desktop node

The method used to set the RQOs per node was as follows:

1. A suite of indicator taxa were selected from all possible taxa occurring in a river. These are taxa known to occur throughout the catchment and with a preference for the type of habitat typical to the upper, middle and lower reaches of the Mzimvubu River. Flow dependent macroinvertebrate taxa are the most important of these indicator taxa as they indicate the critical flow habitat.
2. These indicator taxa are listed in **Table 3.1** with their respective preferences for velocity, habitat and water quality (these preferences are extracted from a spreadsheet in the Macro Invertebrate Response Assessment Index (MIRAI) model of Thirion (2007)).
3. The model of Birkhead and Uys was checked for the occurrence of these indicator taxa, for each of the SQs occurring in the relevant node.
4. These taxa were tabulated together with the confidence in their occurrence (e.g. 1,3, and 5).
5. The likelihood of each taxon actually occurring at the node was considered based on the PES of the node in question.
6. All information was tabulated.
7. RQOs were developed on the basis of these indicator taxa and their velocity, habitat and water quality preferences. These RQOs are both qualitative and broadly quantitative.

Table 3.1 Selected indicator taxa and their preferences for flow velocity, physical habitat and water quality. Increasing numbers indicate increasing preference.

Taxon	Score	< 0.1	0.1-0.3	0.3-0.6	>0.6	BR	COB	VEG	GSM	WATER	WQ
Perlidae	12	1	1	1	5	1	4	1	0	0	HIGH
Baetidae >2spp	12	2	2	2	2	2	2	2	2	1	HIGH
Ephemeridae	15	2	2	3	2	0	1	0	4	0	HIGH
Heptageniidae	13	1	1	3	2	1	4	1	0	0	HIGH
Oigoneuridae	15	0	0	1	5	2	3	1	1	1	HIGH
Leptophlebiidae	9	3	2	2	1	1	3	2	0	0	MOD
Prosopistomatidae	15	1	1	2	3	1	4	1	0	0	HIGH
Telagonodidae	12	0	0	2	4	1	4	1	0	0	HIGH
Trichorythidae	9	0	1	1	4	1	4	1	0	0	MOD
Coenagrionidae	4	1	2	3	1	0	1	4	1	0	LOW
Aeshnidae	8	1	2	2	2	0	3	2	0	0	MOD
Gomphidae	4	0	2	3	0	0	1	0	5	0	LOW
Hydropsychidae > 2spp	12	0	1	2	4	2	3	1	0	0	HIGH
Elmidae / Dryopidae	8	0	0	4	2	1	4	1	0	0	MOD
Psephenidae	10	0	1	3	4	1	4	1	0	0	MOD
Athericidae	10	0	1	2	2	1	4	1	1	0	MOD
Corbiculidae	5	2	3	1	0	0	2	0	4	0	LOW
Sphaeriidae	3	2	3	1	0	0	2	0	4	0	NONE

Abbreviations: SCORE: SASS5 Score in range 0-15, BR – Bedrock, COBB – Cobbles, VEG – Marginal /instream vegetation, GSM – Gravel/Sand/Mud, WATER – Water Column, WQ – Water quality

Overview of Birkhead and Uys Model development for the 2013 PESEIS project (Birkhead et al., 2013)

- All macroinvertebrate data collected by the macroinvertebrate specialist on the PESEIS Eastern Cape team, Mandy Uys, and any other specialists, were collated and forwarded to DWS: Resource Quality Information Services (Pretoria) for input into the National Database.
- It transpired that aquatic macroinvertebrate data were only available for 174 of the 1782 SQs in WMA 12 and 15. The data were problematic in that some only comprised species lists a few taxa listed, there were scant sampling details in the records, and there were often no sampling dates or comprehensive site coordinates.
- It was considered critical to devise a structured, systematic and standardised approach to assist the required prediction of macroinvertebrate occurrences for the 1608 SQ for which there were no data, and to supplement those data sets which were considered inadequate.
- The scanning of Google Earth © to assess catchment and river condition and to predict an macroinvertebrate community for these data-free catchments was considered a good starting point, but simply not sufficient for this task.
- An approach was developed for predicting the potential presence of aquatic macroinvertebrate taxa per SQ, using similarities between SQs in which there was actual data (based on samples) and SQs in which limited, or no historical records existed.
- The following relevant ecological, hydrological and physical parameters were used to assess the degree of similarity between SQs: Ecoregion level II, hydrology (perenniality), stream order, geomorphological zone, natural cover and habitat modification (e.g. sedimentation,

presence of hydraulic structures, flow modification, physico-chemical modification, and direct modification such as trampling).

- For each of these parameters, a certain degree of similarity had to be met in order for an SQ with no data to be considered sufficiently similar to one or more SQs with data, and therefore to potentially be inhabitated by similar aquatic macroinvertebrates.
- On the basis of this similarity approach, a preliminary macroinvertebrate data set was estimated by the model, at different levels of confidence, for each SQ with no data.
- These data provided a repeatable point of departure for assessing macroinvertebrate communities.
- The rivers in each of the WMA 12 and 15 SQs were then investigated at a desktop level using Google Earth ©.
- Ratings for habitat modification and flow modification were determined on the basis of the map-search, existing and available information, and specialist experience.
- These ratings, plus that for physico-chemical modification (Dr Patsy Scherman, *Pers. comm*.) were used to determine the preliminary PES for the macroinvertebrates of the relevant SQ.
- Once the preliminary PES had been determined for the SQ, the model-generated likelihood of occurrence of aquatic macroinvertebrate taxa for that SQ was assessed and refined manually by addition or deletion of taxa, based on the information derived from the Google Earth © mapping exercise, specialist experience, and known macroinvertebrate preferences for different physical and hydraulic habitats. This was done as far as possible on Google Earth ©, through visual assessment of the presence/absence of geomorphic units (e.g. rapids, riffles and pools) and marginal vegetation.

Approach for setting RQOs for macroinvertebrates at EWR sites

For the EWR sites, quantitative Ecospecs and TPCs were required for macroinvertebrates for the PES category concerned. For the parameter “Community composition and balance”, three states were considered: Baseline, Ecospec and TPC. The sample itself supplied the “Baseline” information. The Ecospec and TPC were set on the basis of the PES and in reference to an idealised “Reference state” and expected indicator taxa. Indicator taxa had already been determined (in consultation with the aforementioned model of Birkhead and Uys), for the purposes of PES determination using the MIRAI model, and the EcoClassification process. For each of the three states, detailed information was supplied (e.g. SASS5 score range, Average Score per Taxon (ASPT) range, MIRAI score range). In the setting of these detailed Ecospecs and TPCs, a conservative approach was taken, based on specialist experience of this type of river, habitat, water quality, PES and invertebrate resilience, and with awareness of the likely deviation of the site from Reference Condition (also referred to as REFERENCE).

3.1.6 Riparian vegetation

High priority RUs

The following vegetation components, when assessed together, satisfactorily describe the overall state of the riparian zone:

- Invasion by perennial (and in some cases annual) alien species.
- Terrestrialisation (the disproportionate abundance of terrestrial species within the riparian zone).
- General vegetation structure and composition as shown by proportions of riparian woody species, reeds and non-woody species (grasses, sedges and dicotyledonous forbs).

Please note the hypotheses that underpin the RQOs need to be refined by the Decision Support System (DSS) (ideally each hypothesis should be tested in a research environment).

Invasion of the riparian zone by alien species

The hypothesis relating aerial cover of alien species to the EC of the riparian zone is shown in **Table 3.2**. Data from the Crocodile and Sabie rivers were used to establish the hypothesis. The relation of the EC (as determined by an overall approach using the Vegetation Response Assessment Index (VEGRAI – Kleynhans et al., 2007) of a site/reach to the permissible aerial cover of perennial alien species is a general rule of acceptance rather than a deterministic relationship, since the overall EC is a function of multiple deviations from the reference condition, and not merely the abundance of alien species.

Table 3.2 Hypothesis for the acceptance levels (% aerial cover) of perennial alien species within the riparian zone, given the overall EC of the zone

EC	% Cover (perennial aliens)
A	0
A/B	1– 5
B	5–10
B/C	10–15
C	15–20
C/D	20–30
D	30–50
D/E	50–60
E	60–70
E/F	70–80
F	> 80

Terrestrialisation

Terrestrialisation is the disproportionate abundance, density or occurrence of terrestrial species within the riparian zone. Under reference conditions woody terrestrial species are not expected in the marginal zone; are expected to be transient (if any) in the lower zone due to frequent flooding disturbance; and are expected to occur in the upper zone in numbers concurrent with natural flooding frequency, magnitude and duration for the reach (i.e. hydrologically controlled abundance). In cases where RQOs were set for the riparian obligate/terrestrial species mix, it was always for the upper zone since this is the area where terrestrialisation first manifests. **Table 3.3** outlines the hypothesis used to relate the degree of terrestrialisation to the EC.

Table 3.3 Hypothesised relationship between degree of terrestrialisation and EC for different sub-zones within the riparian zone

EC	Marginal zone	Lower zone	Upper zone	Note
A	0	0	0–5	This hypothesis is based on the phenomenon that terrestrial species occur naturally in the riparian zone, but are reduced in cover and abundance by increased flooding disturbance. Data of terrestrial:riparian plant ratios (on the Sabie River) showed a distinct reduction in terrestrial individuals with increasing exposure to flooding disturbance.
A/B	0	0	5–10	
B	0	0	10–15	
B/C	0	1–5	15–20	
C	0	5–10	20–30	
C/D	0	10–15	30–40	
D	1–5	15–20	40–50	
D/E	5–10	20–30	50–60	
E	10–15	30–40	60–70	
E/F	15–20	40–50	70–80	
F	> 20	> 50	> 80	

Indigenous riparian woody species cover

The hypothesis of expected aerial cover of indigenous riparian woody vegetation is applicable to sites/reaches where the climax community of the macro-channel bank and alluvial bars is dominated by woody riparian obligates (**Table 3.4**). In the absence of unnatural disturbance, the proportion (% cover) will tend to increase to values as high as 70 or 100% of suitable habitat.

This hypothesis is for Lowveld Bushveld rivers (generalised) and is based on a dynamic whereby riparian vegetation in the lower and upper zones will always tend towards increased woody cover with diminishing non-woody cover (including reeds), this being "reset" by large flood events. "Reset" here refers to the removal of woody plants by floods, the resulting open space being available for quick colonising non-woody species (including reeds). The hypothesis assumes that if woody cover increases beyond a given value and remains high, that the flooding regime has been changed so that large floods are smaller or less frequent or both.

Table 3.4 Hypothesis relating EC to expected aerial cover of indigenous riparian woody vegetation in different sub-zones of the riparian zone

EC	Marginal zone	Lower zone	Upper zone
A	10–20	20–40	40–50
A/B	20–40		
B	40–60; 5–10	10–20; 40–60	30–40; 50–60
B/C	60–70		60–70
C	70–80; 1–5	5–10; 60–70	20–30; 70–80
C/D			80–90
D	> 80; 0	< 5; 70–80	10–20; > 90
D/E			
E		> 80	5–10
E/F			
F			< 5

Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs)

The hypothesis of expected aerial cover of indigenous non-woody vegetation is shown in **Table 3.5**.

Table 3.5 Hypotheses for expected indigenous non-woody cover in relation to EC

EC	Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs)
A	70–80
A/B	60–70
B	50–60; 80–90
B/C	40–50
C	30–40; > 90
C/D	
D	20–30
D/E	
E	10–20
E/F	
F	< 10

Phragmites (reeds) cover

In both VEGRAI and RHAM (DWA, 2009b), reeds are classified as non-woody, and although they are a grass, their importance in riparian structure and function warrants their separate assessment in terms of RQOs, EcoSpecs and TPCs. The expectations for aerial cover of reeds in relation to EC are shown in **Table 3.6**. This hypothesis for Lowveld Bushveld rivers (generalised) is a corollary to the riparian woody cover hypothesis i.e. it is based on a dynamic whereby riparian vegetation will always tend towards increased woody cover with diminishing reed cover, this being "reset" by large flood events. "Reset" here refers to the removal of woody plants by floods, the resulting open space being available for quick colonising reeds. The hypothesis assumes that reeds will colonise open alluvium (similar to the pioneer species concept) created by floods and will increase in cover until slowly replaced by woody vegetation as shading occurs. A natural flow regime will create a patch mosaic of woody versus reed areas, thus a mix is always expected (in the absence of very infrequent extreme events). An increase in reed cover beyond a specified value is seen to be a loss of riverine diversity and as such will begin to reduce the EC. Reeds would decrease with increasing proportions of bedrock, hence in bedrock anastomosing sites all values would have to be decreased before application.

Table 3.6 Hypotheses for expected *Phragmites* (reed) cover in relation to sub-zones within the riparian zone and EC

EC	Marginal zone	Lower zone	Upper zone
A	60–80	40–60	20–30
A/B	40–60	60–70	
B	30–40; > 80	30–40; 70–80	< 20; 30–40
B/C	20–30	20–30	
C	10–20	10–20; 80–90	40–50
C/D			
D	1–10	1–10; > 90	50–60
D/E	0	0	
E			60–70
E/F			
F			> 70

Moderate priority RUs

Data from the PESEIS project (DWS, 2014c) were used to develop narrative and numerical RQOs for moderate priority RUs. Where more than a single SQ was included in the RU, data from an SQ with a better EC and further downstream was used to represent the RU. The following indicators are described below and were used to describe narrative (and where data lend themselves numerical) RQOs.

Dominant vegetation cover

Different types of riparian ecosystems are characterised by different dominant riparian vegetation e.g. grass-dominated Highveld/mountainous streams, tree and shrub-dominated Lowveld/lowland rivers flowing through Bushveld, tall tree-dominated (forest) streams through forested /kloof areas, or mixed vegetation e.g. reed and tree/shrub dominated rivers which are common in the Inkomati catchment. The dominant vegetation type (riparian) is a key component of the structure and function of the riparian zone as a whole.

Presence of alien plant species

Invasion of riparian zones by alien plant species is a major concern and determinant of EC deterioration along almost all South African rivers. As such, its consideration and measurement are imperative for effective management. The consideration here makes no distinction of species but does focus on perennial aliens rather than including annuals as well. Alien invasion is expressed as the percentage aerial cover (% of total riparian zone area) of all perennial aliens within the riparian zone area.

Longitudinal riparian zone continuity

Longitudinal riparian zone continuity was an integral factor in the PESEIS project (DWS, 2014c) and since it is another important measure of riparian condition within a reach, it was additionally used to define certain riparian RQOs for each reach. Riparian zone continuity is also a characteristic of the riparian zone which lends itself to assessment from satellite imagery and hence is easier and quicker to measure, while remaining meaningful.

Riparian zone fragmentation

The ability of the riparian zone to function as such depends largely on the level of longitudinal and lateral fragmentation. Where fragmentation is high functionality is lost. As such RQOs were developed that relate to fragmentation but make specific reference to agricultural and forestry activities as these are the most common and dominant reasons for an increase in fragmentation. Since both agricultural and forestry activities were rated in the PESEIS project (DWS, 2014c) fact sheets, it is possible to monitor changes over time.

Riparian plant endemism

Based on the observed distribution of riparian species, the PESEIS project (DWS, 2014c) measured the presence of endemic riparian species. These data were used to develop RQOs that highlight the presence of these species within respective RUs.

Threatened riparian species

Based on the observed distribution of riparian species, the PESEIS project (DWS, 2014c) measured the presence of threatened riparian species (those with International Union for Conservation of Nature (IUCN) status other than Least Concern (LC) or Data Deficient (DD).

These data were used to develop RQOs that highlight the presence and protection of these species within respective RUs.

Riparian taxon richness

Based on the observed distribution of riparian species, the PESEIS project (DWS, 2014c) measured the presence of riparian species (referred to as taxa). These data were used to develop RQOs that highlight the maintenance of baseline species (riparian) richness within respective RUs.

3.2 ESTUARIES

3.2.1 Legislative context for RQOs in estuaries

Government response in mitigating deterioration of South Africa's estuaries is manifested in two pieces of key legislation, namely the National Water Act – NWA (Act 36 of 1998) and National Environmental Management: Integrated Coastal Management Act – ICM (Act 24 of 2008).

- South Africa's NWA recognises the right to water for aquatic ecosystems, only second to the right to water for basic human needs. The estuary freshwater requirements and RQOs are determined as part of the National Water Classification System provided for under this act.
- More recently, the ICM Act set out specific requirements for the development of a National Estuarine Management Protocol (NEMP) for South Africa, as well as the development of individual estuarine management plans.

South Africa's estuaries have a diversity of management requirements, often unique to individual systems, and are governed by a variety of authorities, from national to local level. Therefore, estuary management must allow for a dynamic process that facilitates integrated cross-sectorial planning and implementation including stakeholders involved in land-use planning, management of freshwater and marine resources, amongst others. Consequently, it was necessary to develop a flexible, but legally defensible NEMP providing guidance to estuarine managers at all levels to develop sound management plans to suit individual systems. South Africa's NEMP was published in May 2013. The NEMP (as set out in the ICM Act) sets out to:

- Determine a strategic vision and objectives for achieving effective integrated management of estuaries.
- Set standards for management of estuaries.
- Establish procedures or provide guidance regarding how estuaries must be managed and how the management responsibilities are to be exercised by different organs of state and other parties.
- Establish minimum requirements for estuarine management plans.
- Identify who must prepare estuarine management plans and the process to be followed in doing so.
- Specify the process for reviewing estuarine management plans to ensure that they comply with the requirements of the ICM Act.

While the specific requirement for the development and implementation of estuarine management plans is stipulated in the NEMP (in accordance with the ICM Act), there are numerous existing management initiative promulgated under other Acts that are also taking place in South Africa's estuaries. Key management initiatives to consider in individual estuarine management planning include:

- Biodiversity management plans (Biodiversity Act as articulated in the National Biodiversity Assessment (NBA) 2011 and future updates).
- Integrated Development Plans and Spatial Development Frameworks (Municipal Systems Act).
- Classification of water resources, including estuaries (NWA).
- Living resources management plans (Marine Living Resources Act).
- Biodiversity targets and incorporation of DWS water resource classification process.

In the NBA 2011 (Van Niekerk and Turpie, 2012) estuary biodiversity targets are defined in terms of achieving representation of ecosystem types, habitats and species, as well as meeting population targets that ensure their viability. The overall target was to protect a minimum of 20% of total estuarine area. Targets for ecosystem type are sometimes used as a surrogate for biodiversity for which data are lacking. In NBA 2011, estuary ecosystem type was defined on the basis of mouth state, salinity structure, freshwater type and size, to align with the estuary ecosystem types used for the assessment of threat status and protection level in the NBA (Van Niekerk and Turpie, 2012). A target of 20% was set for the total area of each type.

In the case of estuaries, protection is not only effected by localised management actions but also through ensuring adequate quantity and quality of freshwater flows into the estuary. Future flows into an estuary will be decided on the basis of its Ecological Category (A, B, C or D) determined under the National WRCS (Dollar et al., 2010). The outcome of the classification process therefore informs and supports other estuary planning initiatives, and products developed as part of this process are aligned as much as possible with other management initiatives.

3.2.2 Format of RQO components

As per the DWS methodology, estuaries are sufficiently different in terms of state, functioning and management to form individual RUs. RQOs are set for the short to medium term (5 to 10-year period) for the following components (DWAF, 2008c):

- Quantity, pattern and timing of instream flow (hydrology).
- Mouth state (hydrodynamics).
- Water quality.
- Characteristics and condition of primary producers (e.g. macrophytes).
- Characteristics and condition of biota (e.g. fish).

In the case of the Mzimvubu Estuary, ROQs for the TEC (linked to Scenario 69) were derived from the EcoSpecs and TPCs as set for the REC in the EWR study, as the TEC is similar to the REC.

Hydrological RQOs are provided as a flow regime (described by means of a flow duration table) associated with the TEC for Mzimvubu Estuary.

Water quality RQOs were set for river inflow and within the estuary based on environmental requirements and national guidelines or standards.

Habitat and biota is described as the habitat and biota associated with a TEC. The format of the RQOs is as follows:

- Overall TEC.
- PES for each component.

- Ecological objectives for components.

3.2.3 Approach followed in developing estuary RQOs

Hydrodynamics

In the case of Mzimvubu, the estuary is permanently open, and this should be maintained for the TEC.

Salinity

Salinity RQOs were derived from available measured data on the Mzimvubu Estuary, as well as knowledge on similar types systems as documented in the Estuary EWR report for the study (DWS, 2017b).

Water quality

For estuaries, unlike for rivers, there are no official, numerical water quality RQOs specified for various health categories because of the diverse and site-specific nature of many of these variables in estuaries. Therefore, water quality ROQs for the protection of the aquatic ecosystem was derived from available measured data on the Mzimvubu Estuary, as well as knowledge on similar types of systems, as documented in the Estuary EWR report (DWS, 2017b).

In terms of RQOs for recreational use (water quality), the recommended targets proposed for South Africa's coastal marine waters were applied as summarised in **Table 3.7** (Department of Environmental Affairs (DEA), 2012).

Table 3.7 RQOs for recreational use in Mzimvubu Estuary specified as risk-based ranges for intestinal enterococci and *E. coli* (microbiological indicator organisms) (DEA, 2012)

Category	Estimated risk per exposure	Enterococci	*E. coli*
		(Count per 100 ml)	(Count per 100 ml)
Excellent	2.9% gastrointestinal (GI) illness risk	≤ 100 (95 percentile)	≤ 250 (95 percentile)
Good	5% GI illness risk	≤ 200 (95percentile)	≤ 500 (95 percentile)
Sufficient or Fair (minimum requirement)	8.5% GI illness risk	≤ 185 (90 percentile)	≤ 500 (90 percentile)
Poor (unacceptable)	> 8.5% GI illness risk	> 185 (90 percentile)	> 500 (90 percentile)

In South Africa, the minimum requirement for recreational use is the "Sufficient or Fair" category, thus also representative of the **RQOs for estuaries used for used contract recreation.** For estuaries where the Blue Flag status has been awarded, or for estuaries immediately adjacent to beaches awarded Blue Flag status, the ROQ for recreation in the "Excellent" category was awarded.

Macrophytes, invertebrates, fish and birds

For estuaries there are official numerical RQOs for biotic components specified for various health categories because of the diverse and site-specific nature of estuarine biotic characteristics. For this reason, the biotic RQOs for the Mzimvubu Estuary were based on available measured data on

the estuary, as well as knowledge on similar types of systems, as documented in the Estuary EWR Report (DWS, 2017b).

4 MZIMVUBU (T31): IUA T31 RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. There are no surface water developments planned in the IUA. The land-use activities include intensive commercial irrigation farming, dryland cultivation as well as subsistence farming. There are a large number of minor instream and off-channel farm dams located in some parts of the IUA. The IUA is predominantly rural with commercial farming activities (including irrigation) and scattered rural and informal settlements in the lower portion of the IUA.

The upper reaches are mostly inaccessible due to the steep slopes of the mountainous area, resulting in limited use and hence fewer impacts on these river reaches. Primary land use and impacts are associated with limited farming (agriculture), grazing, erosion and alien vegetation encroachment. The predominant ecological state is slightly to moderately modified from natural conditions (B/C). The middle and lower reaches include formal farming activities (agriculture including dryland and irrigated fields as well as livestock farming practices) with a mostly C Ecological Category. The upper mountainous reaches of quaternary catchments T31H and T31J occurring to the south-east of the town of Matatiele have steep slopes and mountainous characteristics and hence few impacts on the uppermost river reaches in this zone. Lower reaches of this zone fall within more occupied rural areas where increased dryland agriculture and grazing result in notable erosion. The predominant ecological state of the upper reaches is slightly modified from natural conditions (B) while the lower reaches are moderately to largely modified (C/D).

IUA T31 is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T31 – Upper Mzimvubu

PRIORITY RATINGS

RU	Main river	Priority	PES	REC	TEC
T31-1	Mzimvubu	2	B/C	B/C	B/C
T31-2	Krom	2	B	B	B
T31-3	Mzimvubu	3	B	B	B
T31-4	Nyongo	2	C	C	C
T31-5	Mzimvubu	2	B	B	B
T31-6	Riet	2	C	C	C
T31-7	Tswereka	2	B	B	B
T31-8	Tswereka	3	B/C	B/C	B/C
T31-9	unnamed	2	C	C	C
T31-10	Tswereka	3	D	D	D
T31-11	unnamed	2	B/C	B/C	B/C
T31-12	Mzimvubu	3 (WQ)	C	C	C
T31-13	Mzimvubu	3	B/C	B/C	B/C
T31-14	Mvenyane	2	B	B	B
T31-15	Mvenyane	2	B/C	B/C	B/C
T31-16	Mkemane	2	B	B	B
T31-17	unnamed	2	C	B/C	B/C
T31-18	Mkemane	2	C/D	B/C	B/C
T31-19	Mzimvubu	3	B/C	B/C	B/C

The RQOs are provided below for the catchment configuration as illustrated above.

4.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T31

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 4.1** and the full EWR rule is provided as part of the electronic data for the project. Flows are in MCM/a.

Table 4.1 Flow RQOs for IUA T31: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[2]	Low flows	Low flows (%nMAR)	Total flows	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T31-1	B/C	B/C	32.73	31.25	4.72	14.43	7.67	23.4	0.04	0.03	0.754	0.302
T31-2	B	B	31.33	29.95	4.66	14.87	7.41	23.6	0.06	0.01	0.712	0.296
T31-3	B	B	87.01	83.51	15.23	17.50	24.09	27.7	0.334	0.192	2.388	0.87
T31-4	C	C	8.92	8.83	1.10	12.38	1.92	21.5	0.052	0.029	0.165	0.083
T31-5	B	B	104.92	100.32	18.50	17.63	28.87	27.5	0.33	0.09	2.864	1.057
T31-6	C	C	13.98	11.93	1.76	12.57	2.72	19.4	0.05	0.04	0.239	0.124
T31-7	B	B	12.78	12.71	2.32	18.18	3.7	29	0.115	0.05	0.331	0.131
T31-8	B/C	B/C	29.55	27.73	4.55	15.41	7.42	25.1	0.23	0.112	0.641	0.286
T31-9	C	C	4	3.97	0.51	12.64	0.87	21.8	0.026	0.015	0.07	0.035
T31-11	B/C	B/C	3.71	3.42	0.52	14.02	0.89	24.1	0.031	0.014	0.069	0.027
T31-12	C	C	190.45	178.26	27.44	14.41	50.19	26.4	1.04	0.446	4.325	1.792
T31-13	B/C	B/C	217.82	204.88	36.49	16.75	63.2	29	1.234	0.47	5.852	2.087

RU	PES	TEC (EWR)	nMAR[1]	pMAR[2]	Low flows	Low flows (%nMAR)	Total flows	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T31-14	B	B	23.98	21.44	3.90	16.27	6.61	27.6	0.195	0.082	0.574	0.191
T31-15	B/C	B/C	40.83	37.95	5.62	13.77	9.85	24.1	0.287	0.135	0.813	0.301
T31-16	B	B	13.61	13.48	2.21	16.26	3.77	27.7	0.111	0.047	0.324	0.105
T31-17	C	B/C	1.3	1.3	0.15	11.27	0.28	21.7	0.008	0.004	0.021	0.011
T31-18	C/D	B/C	64.81	61.8	6.35	9.80	12.03	18.6	0.339	0.203	0.893	0.424
T31-19	B/C	B/C	335.66	316.55	55.01	16.39	96.49	28.7	2.114	0.746	8.821	3.028

[1] nMAR: natural Mean Annual Runoff

[2] pMAR: present Mean Annual Runoff

4.2 RU T31-1: MZIMVUBU RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.2**.

Table 4.2 RU T31-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	The upper portion of the RU should be dominated by grassland.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain large (not become serious or critical) or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain small, or improve	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of small. There shall be no expansion of agricultural activities into the riparian zone and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.3 RU T31-2: KROM RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.3**.

Table 4.3 RU T31-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	Extensive areas within the RU contain floodplain wetlands and oxbows and should remain dominated by grassland.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain small or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain small, or improve	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of small. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (*Anguilla mossambica* (AMOS) and *Barbus/Enteromius anoplus* (BANO)) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Thirty to 40 taxa are listed as potentially occurring in the SQ in T31-2. The expected taxa that may be suitable RQO indicators are listed in **Table 4.4** below. There are less high-scoring taxa than one would anticipate. They include Baetidae (2spp), Heptageniidae, Leptophlebiidae, Tricorythidae, Elmidae, and Athericidae. Their velocity, habitat and water quality preferences appear in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain a PES of B, and thus conditions which will support both sensitive indicators (particularly Heptageniid mayflies), as well as the lower scoring more resilient indicator taxa.		
Water quality	Prevent any further non-natural alterations to the sediment regime and water quality. Minimise or mitigate those alterations which may have a negative effect on water quality.	No data to support numeric RQO. Maintain very good water quality (as indicated by the suite of expected invertebrates according to the MIRAI model). See DWAF (2008b) for guidelines on an A/B-B category (or very good) water quality state.
Flow	Maintain flows which mimic the natural discharge pattern (ensure appropriate hydrological variability and seasonality), and which provide areas of moderate and high velocity flow	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) to support Heptageniidae.

Indicators	Narrative RQO	Numerical RQO
	during the relevant months.	
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 30% clear of silt and algae; with areas of mobile, unembedded cobbles. Marginal vegetation should be partly inundated.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC[1], MV[2], and GSM[3]).	10–15 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season.

1 Stones-in-Current 2 Marginal Vegetation Gravel-Sand-Mud

Table 4.4 RU T31-2: Macroinvertabrate indicator taxa for at various confidence levels

SQ no	SQ	River	Perlidae	Baetidae > 2 spp	Ephemeridae	HEptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1479	T31B-04745	Krom		3				3			3	3	3	3		3						32
1480	T31B-04868	Krom				3		3			3	3	3	3		3			3			39
1481	T31B-04873							3			3	3	3	3		3	3		3		3	36

4.4 T31-3: MZIMVUBU RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC. *Note that this is a water quality priority protection area as a drinking water quality point in winter when springs run low or dry.*

4.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.5**.

Table 4.5 RU T31-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
	into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	

4.5 RU T31-4: NYONGO RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.5.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Run-off from rural settlements.
Water quality issue: Nutrients, turbidity.

Narrative and numerical details are provided in **Table 4.6**.

Table 4.6 RU T31-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).

4.5.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.7**.

Table 4.7 RU T31-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	Some areas within the RU are natural grassland and should remain dominated by grassland.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.6 RU T31-5: MZIMVUBU RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.6.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.8**.

Table 4.8 RU T31-5: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	Some areas within the RU contain wetlands, oxbows and natural grassland and should remain dominated by grassland.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species:		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species:		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 43 taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the SQs in T31-5 (all at high or moderate confidences). The macroinvertebrate community as a whole is highly sensitive and requires optimal water quality, habitat and velocity conditions. The selected RQO indicator taxa are Baetidae > 2spp, Leptophlebiidae, Heptageniidae, Prosopistomatidae, Teloganodidae, Tricorythidae, Elmidae, Psepheniidae and Athericidae (**Table 4.9**). The most sensitive indicator is the Prosopistomatid mayfly which scores 15. The confidence in the occurrence of the taxa in different SQs is tabulated below and their individual velocity, habitat and water quality preferences are presented in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain conditions which will maintain the PES of B and support both the sensitive indicators and the diversity of indicators.		
Water quality	Minimise non-natural alterations to the	No data to support numeric RQO.

Indicators	Narrative RQO	Numerical RQO
	sediment regime and water quality.	Maintain very good water quality (with a PES of B).
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s). Areas of lower flow are also required to fulfil the preferences of Leptophlebiidae and Corbiculid and Sphaerid snails which should occur here.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 30% clear of silt and algae. There should be areas of mobile, unembedded cobbles, and inundated marginal vegetation.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred hydraulic habitats of the indicator taxa (SIC, MV, GSM, but particularly coarse substrates in moderate to very fast flow areas).	10–15 cm depth over the top of the critical habitat (coarse substrates such as cobbles). Marginal grasses and sedges, if present, should be inundated or at least have areas of overhanging vegetation, particularly during wet season, and areas both in and out of flow are preferable.

Table 4.9 T31-5: Macroinvertabrate indicator taxa for at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1486	T31D-04926	Mzimvubu	5	5		5		5	5	5	5	5	5	5	5	5	5	5	5			46
1490	T31D-05076	Mzimvubu		3				3			3	3	3	3		3	3		3	3		37

4.7 RU T31-6: RIET RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.7.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.10.**

Table 4.10 RU T31-6: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	Some areas within the RU contain natural grassland and should remain dominated by grassland.	N/A

Indicators	Narrative RQO	Numerical RQO
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 46 taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the SQs in T31-6 (at moderate confidences) (**Table 4.11**). The expected taxa which may serve as indicators are listed in the table below. Their velocity, habitat and water quality preferences are presented in **Section 3.5**, **Table 3.1.** The most sensitive indicator taxon is the Prosopistomatid mayfly (scores 15) which is expected at a low confidence. The next most sensitive taxa with preferences for optimal flow, water quality and habitat conditions is the Heptageniid mayfly (scores 13). The RQOs are set to maintain conditions which will maintain the PES of C and support both the sensitive indicators and the diversity of indicators.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to >0.6 m/s). Areas of lower flow are also required to support taxa such as Hydrophilidae and Gomphidae.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 30% clear of silt and algae; with areas of mobile, unembedded cobbles.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, GSM).	1 –15 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 4.11 T31-6: Macroinvertabrate indicator taxa for at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	N0 Taxa
T31D-04936	Riet	0	3		1		3			3	3	3	3		3	3		3			41
T31D-05030	Riet		3				3			3	3	3	3		3	3	3	3			43
T31D-05060		3	3		3		3	1		3	3	3	3		3	1	3	3			46

4.8 RU T31-7: TSWEREKA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.8.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.12**.

Table 4.12 RU T31-7: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation cover	Some areas within the RU contain small pockets of natural forest and should remain dominated by forest	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.

Indicators	Narrative RQO	Numerical RQO
Secondary indicator species: BANO	overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 52 taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the sub-quaternary in T31-7 (at low and moderate confidences) (**Table 4.13**). Those which may serve as indicator taxa are presented in the table below. Their velocity, habitat and water quality preferences are presented in **Section 3.5**, **Table 3.1**. The most sensitive indicator taxa are perlid stoneflies, and prosopistomatid, telagonodid, heptageniid, baetid (> 2spp) and leptophlebiid mayflies (all at low confidence). The RQOs are set to maintain conditions which will maintain the PES of B and support both this highly sensitive suite of indicators as well as the more resilient taxa.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate and very high velocity flow (0.3 to > 0.6 m/s) to support the FDIs. Areas of lower flow are also required to support taxa such as Leptophlebiidae, Gomphidae, and Corbiculidae.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would occur under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 50% clear of silt and algae; with areas of mobile, unembedded cobbles.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, GSM).	15cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 4.13 T31-7: Macroinvertabrate indicator taxa for at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T31E-04836	Tswereka	1	3		3		3	1	1	3	3	3	3	1	3	3	3	3	1		52

4.9 RU T31-8: TSWEREKA RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

4.9.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.14**.

Table 4.14 RU T31-8: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate**, or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.10 RU T31-9: UNNAMED (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.10.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Irrigation activities.
Water quality issue: Nutrients.

Narrative and numerical details are provided in **Table 4.15**.

Table 4.15 RU T31-9: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

4.10.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.16**.

Table 4.16 RU T31-9: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or decrease.	Presence of alien plant species
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate**, or improve.	Riparian zone continuity

Indicators	Narrative RQO	Numerical RQO
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Riparian zone fragmentation
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 40 taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the SQs in T31-9. Those which may serve as RQO indicator taxa are shown in **Table 4.17**. This is an unusually poor 'expected' fauna, with the highest scoring being Leptophlebiidae (9), then coenagriids, aeshnids and gomphids. The velocity, habitat and water quality preferences of the taxa are presented in **Section 3.5**, **Table 3.1**. The RQOs are set to provide conditions which will maintain the PES of C and support the suite of indicators.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain moderate water quality.
Flow	Maintain baseflows and floods which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate velocity flow, particularly during the wet season.	Diverse flow habitat, with areas of moderate velocity flow (0.3 to 0.6 m/s) Areas of lower flow are also required. Flows should inundate marginal vegetation if present at least during wet season.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 20% clear of silt and algae. Areas of mobile cobbles. Clean gravel and sand areas. Marginal vegetation if present, in order to supply habitat for Hydrophilid beetles and other taxa.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, GSM).	10–15 cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season.

Table 4.17 T31-9: Macroinvertabrate indicator taxa for at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T31E-05055							1				1	1	1		1	1					40

4.11 RU T31-10: TSWEREKA RIVER (HIGH PRIORITY – 3)

4.11.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Diary rrigation runoff.
Water quality issue: Nutrients.

Narrative and numerical details are provided in **Table 4.18**.

Table 4.18 RU T31-10: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).

4.11.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.19**.

Table 4.19 RU T31-10: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical), or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
	zone.	
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 39 taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the SQs of T31-10 (at moderate to low confidences). But for heptageniid mayflies which score 13, the community comprises generally lower-scoring, more resilient taxa, as indicated below in **Table 4.20**. This is likely due to the many dams and the extent of commercial farming and irrigation in the catchment. The selected RQO indicator taxa among these are listed in **Table 4.20**. Leptophlebiidae and Tricorythidae (moderate confidence). Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain the PES of D.		
Water quality	Minimise further non-natural alterations to the sediment regime and water quality. Retain and treat irrigation return flows where possible, or disincentivise these.	No data to support numeric RQO. Maintain moderate water quality.
Flow	Maintain flows which ensure areas of moderate and high velocity flow during wet months. Propose taht releases are made where appropriate from the in-channel and off-channel dams.	Maintain flows which provide adequate width and depth, and areas of low, moderate and high velocity hydraulic habitat.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions. Aim to improve habitat conditions through flow management (e.g dam releases).	Coarse substrates (cobbles, boulders): surfaces should be at least 20% clear of silt and algae; and at least partly mobile. Marginal vegetation should be inundated (to a depth which activates the habitat) or overhanging during the wet season and high flow periods.
Depth	Manage the catchment to ensure that the river width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, GSM).	10 cm depth over the top of the critical habitat (SIC) for indicator mayfly taxa. Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 4.20 Indicator taxa for T31-10 at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1494	T31E-05013	Tswereka				1		3			3	3	3	3		3	3					39

4.12 RU T31-11: UNNAMED (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.12.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.21**.

Table 4.21 RU T31-11: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.13 RU T31-12: MZIMVUBU RIVER (MODERATE PRIORITY – 3(WQ))

No improvement is required to achieve the TEC.

4.13.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Pivot irrigation, erosion and sedimentation.
Water quality issue: Nutrients, turbidity.

Narrative and numerical details are provided in **Table 4.22**.

Table 4.22 RU T31-12: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO4-P (Aquatic ecosystems: driver).
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

4.13.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.23**.

Table 4.23 RU T31-12: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.14 RU T31-13: MZIMVUBU RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

4.14.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Pivot irrigation, erosion and sedimentation.
Water quality issue: Nutrients, turbidity.

Narrative and numerical details are provided in **Table 4.24**.

Table 4.24 RU T31-13: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO4-P (Aquatic ecosystems: driver).
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

4.14.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.25** below.

Table 4.25 RU T31-13: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.15 RU T31-14: MVENYANE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.15.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.26**.

Table 4.26 RU T31-14: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.16 RU T31-15: MVENYANE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.16.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.27**.

Table 4.27 RU T31-15: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.17 RU T31-16: MKEMANE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

4.17.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.28**.

Table 4.28 RU T31-16: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

4.18 RU T31-17: UNNAMED TRIBUTARY (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C to a B/C EC. To achieve this, the following is required:

- Erosion control and improved agricultural practices.
- Alien vegetation removal.

4.18.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A

Users: Extensive erosion from agricultural practises.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 4.29**.

Table 4.29 RU T31-17: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Tolerable limits.	A large change from natural with erosion being a known cause of unnaturally large increases in sediment loads and turbidity. Habitat often silted but clears (Aquatic ecosystems: driver).

4.18.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in the table below.

Table 4.30 RU T31-17: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.

4.19 RU T31-18: MKEMANE RIVER (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C/D to a B/C EC. To achieve this, the following is required:

- Water quality improvement required in terms of sedimentation, i.e. erosion control.

4.19.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Extensive erosion.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 4.31**.

Table 4.31 RU T31-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Tolerable limits.	A large change from natural with erosion being a known cause of unnaturally large increases in sediment loads and turbidity. Habitat often silted but clears (Aquatic ecosystems: driver).

4.19.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.32**.

Table 4.32 RU T31-18: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.

4.20 RU T31-19: MZIMVUBU RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

4.20.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 4.33**.

Table 4.33 RU T31-19: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
	not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	

5 MZINTLAVA (T32): IUA T32_A RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. There are no major surface water developments planned in the IUA. Some development includes the projected increase in water supply and return flows associated with Kokstad's future growth. The land use activities include intensive commercial farming (irrigation and dryland cultivation). A large number of minor instream and off-channel farm dams are located in the IUA. The IUA is predominantly rural with commercial farming activities (including irrigation), with the towns of Franklin Town and the larger Kokstad also located in the IUA.

IUA T32_a is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying Table.

IUA T32_a – Mzintlava

PRIORITY RATINGS

RU	Main river	Priority	PES	REC	TEC
T32-1	Mzintlava	2	C	B/C	B/C
T32-2	Mzintlava	2	C	C	C
T32-3	Mzintlava	3	C	B/C	B/C
T32-4	Mill Stream	2	C	B/C	B/C
T32-5	aManzamnyama	3	B/C	B/C	B/C
T32-6	Mzintlava	4 (WQ)	B	B	B
T32-7	unnamed	3	B/C	B/C	B/C
T32-8	Droewig	2	C	C	C
T32-9	Mzintlava	3 (WQ)	D	D	D

5.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T32_A

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 5.1** and the full EWR rule is provided as part of the electronic data for the project.

Table 5.1 Flow RQOs for IUA T32_a: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T32-1	C	B/C	9.46	8.78	1.31	13.84	2.27	24	0.01	0.006	0.178	0.077
T32-2	C	C	37.6	31.93	4.24	11.28	6.61	17.6	0	0	0.569	0.288
T32-3	C	B/C	11.08	10.74	1.53	13.83	2.66	24	0.072	0.034	0.212	0.091
T32-4	C	B/C	4.26	4.12	0.60	14.14	1.04	24.3	0.029	0.014	0.082	0.036
T32-5	B/C	B/C	13.86	13.14	1.96	14.14	3.35	24.2	0.095	0.045	0.267	0.116
T32-6	B	B	86.17	75.38	14.18	16.46	22.54	26.2	0.328	0.126	1.958	0.756
T32-7	B/C	B/C	8.53	8.18	1.21	14.13	2.06	24.2	0.058	0.028	0.164	0.071
T32-8	C	C	18.43	16.63	2.22	12.06	3.75	20.3	0.08	0.06	0.287	0.147
T32-9	D	D	98.14	88.08	7.76	7.90	15.86	16.2	0.402	0.289	1.028	0.698

[1] MCM/a

5.2 RU T32-1: MZINTLAVA RIVER (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C to a B/C EC. To achieve this, the following is required:

- Improvement of flow in terms of controling and management of dams.

An EWR for the B/C has been supplied as the flow RQO.

5.2.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Irrigation, forestry.
Water quality issue: Nutrients, toxics

Note that this RU is a water quality priority protection area due to the presence of the Franklin Vlei RAMSAR site.

Narrative and numerical details are provided in **Table 5.2**.

Table 5.2 RU T32-1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.

5.2.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.3**.

Table 5.3 RU T32-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, *A. marmorata* (AMAR) and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Forty seven taxa are listed in the PESEIS database (DWS, 2014c) as potentially occurring in the SQ in T32-1. The selected RQO indicator taxa among these are listed in **Section 3.5**, **Table 3.1** with their velocity, habitat and water quality preferences. All indicator taxa are predicted to occur, at low (1) to moderate (3) confidences (**Table 5.4)**. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. Perlid stoneflies, prosopistomatid, heptageniid and tricorythid mayflies are all sensitive taxa scoring 12 or more, and many are unlikely to persist under PES C conditions. If conditions are improved to the TEC of B/C (e.g. by implementation of Reserve flows from upstream dams in order to improve depth, water quality and habitat condition), these taxa would be more likely to occur. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s). Areas of lower flow are also required to support taxa such as Hydrophilidae and Gomphidae.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders): surfaces at least 30% clear of silt and algae; with areas of mobile, unembedded cobbles.
Depth	Maintain conditions which support a width and depth which emulates that	10–15 cm depth over the top of the critical habitat (SIC). Marginal grasses,

Indicators	Narrative RQO	Numerical RQO
	of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, GSM).	if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 5.4 Indicator taxa for T32-1 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T32A-04965	Mzintlava	1	3		1		3	1		3	3	3	3		3	3	1	3		1	47

5.3 RU T32-2: MZINTLAVA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

5.3.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Sawmill, run-off from settelements.
Water quality issue: Nutrients, pH, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 5.5**.

Table 5.5 RU T32-2: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that pH stays within an Acceptable range.	5th and 95th percentiles must not fall outside of the following ranges respectively: 5.9-6.5 and 8.0-8.8		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

5.3.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.6**.

Table 5.6 RU T32-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 53 taxa potentially occur in the SQ in T32-2 (PESEIS database; DWS (2014)). The following indicator taxa are expected, with high confidence (5) as they have historically been collected: Perlid stoneflies, prosopistomatid, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans and elmid, hydrophilid and psephenid beetle larvae (**Table 5.7)**. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The first three of these taxa score ≥ 12 and if they occur will be present in small numbers under PES C conditions. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s). Areas of lower flow are also required to support taxa such as Hydrophilidae and Gomphidae.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders); with areas of mobile, unembedded cobbles.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates	Up to 10cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated,

Indicators	Narrative RQO	Numerical RQO
	the preferred habitats of the indicator taxa (SIC, MV)	particularly during wet season, and areas both in and out of flow are preferable.

Table 5.7 Indicator taxa for T32-2 at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1513	T32A-04907	Mzintlanga	1	3		1		3			3	3	3	3		3	3	1	3	1	1	40
1515	T32B-05103	Mzintlava	5	5		5		5	5		5	5	5	5		5	3	5	5		5	53

5.4 RU T32-3: MZINTLAVA (HIGH PRIORITY – 3)

The TEC requires improvement of the PES from a C to a B/C EC. To achieve this, the following is required:

- Improvement of flow by the control of, amongst others, pivot irrigation to supply the EWR.

An EWR for the B/C has been supplied as the flow RQO.

5.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.8**.

Table 5.8 RU T32-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.

Indicators	Narrative RQO	Numerical RQO
Primary indicator species: AMOS/AMAR	present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 50 macroinvertebrate families potentially occur in the SQs of T32-3 (PESEIS database; DWS (2014)). The indicator taxa highlighted in the table below are expected to occur with moderate confidence (3): Perlid stoneflies, baetid, prosopistomatid, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans and psephenid beetle larvae (**Table 5.9)**. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The first three of these taxa score > 12 and are unlikely to occur under PES C conditions, however may be found if the TEC of a B/C were to be attained. This would require an improvement in water quality, habitat condition, and flow. This is possible as the EWR flows are provided for a B/C condition. The RQOs are set to maintain the PES of C and improve instream conditions.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 5.9 Indicator taxa for T32-3 at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	NoTaxa
1517	T32B-05184	Mzintlava	3	3		3		3	3		3	5	5	3		3	3	3	3			50

5.5 RU T32-4: MILLSTREAM RIVER (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C to a B/C EC. To achieve this, a combination of flow and non-flow impacts must be addressed.

5.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.10**.

Table 5.10 RU T32-4: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

5.6 RU T32-5: HIGH PRIORITY – 3

No improvement is required to achieve the TEC.

5.6.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.11**.

Table 5.11 RU T32-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

5.7 RU T32-6: MZINTLAVA RIVER (VERY HIGH PRIORITY – 4 (WQ))

No improvement is required to achieve the TEC.

5.7.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Pivot irrigation, erosion, impacts from extensive settlements and urban areas.
Water quality issue: Turbidity, nutrients, toxics, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 5.12**.

Table 5.12 RU T32-6: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A small change from natural with some modifications to the catchment, resulting in largely natural modifications in turbidity levels. Minor and temporary silting of habitats.		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

5.7.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.13**.

Table 5.13 RU T32-6: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.

5.8 RU T32-7: UNNAMED (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

5.8.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.14**.

Table 5.14 RU T32-7: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

5.9 RU T32-8: DROEWIG RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

5.9.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Pivot irrigation.
Water quality issue: Nutrients, toxics.

Narrative and numerical details are provided in **Table 5.15**.

Table 5.15 RU T32-8: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO4-P (Aquatic ecosystems: driver).
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.

5.9.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.16**.

Table 5.16 RU T32-8: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR, BANOand *Monodactylus falciformes* (*MFAL*)) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate	Maintain indigenous species richness (AMOS, AMAR, BANO, and MFAL) and current habitat diversity.
Primary indicator species:		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should

Indicators	Narrative RQO	Numerical RQO
	marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	be mitigated.
Secondary indicator species:		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 35 macroinvertebrate families potentially occur in the relevant sub-quaternary of T32-8 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 5.17** below are expected to occur with low (1) to moderate confidence (3): perlid stoneflies, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans and elmid and hydrophilid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The most sensitive of these are heptageniid mayflies which are likely to occur only in low numbers under PES C conditions. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain moderately good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage Heptageniidae. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae).
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 5.17 Indicator taxa for T32-8 at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1523	T32D-05172	Droewig				1		3			3	5	3	1		5	3		1			35

5.10 RU T32-9: MZINTLAVA RIVER (HIGH PRIORITY – 3 (WQ))

No improvement is required to achieve the TEC.

5.10.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Kokstad WWTW, urban impacts, irrigation.
Water quality issue: Nutrients, salts, turbidity, toxics, *E.coli*/faecal coliforms

Narrative and numerical details are provided in **Table 5.18**.

Table 5.18 RU T32-9: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

5.10.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 5.19**.

Table 5.19 RU T32-9: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or decrease.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 32 macroinvertebrate families potentially occur in the relevant sub-quaternary of T32-9 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 5.20** below are expected to occur, with low confidence of 1 (which means little is known about this sub-quaternary): leptophlebiid and tricorythid mayflies, aeshnid and coenagriid dragonfly larvae, elmid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. All are relatively low-scoring and reflective of the current C condition. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of high and moderate velocity flow (0.3 to >0.6 m/s) to support the flow-dependent taxa (e.g. Tricorythidae, Elmidae). Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Coenagriidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 5.20 T32-9: Macroinvertabrate indicator taxa for at various confidence levels

SQ No	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1524	T32D-05352	Mzintlava						1			1	1	1	1		1						32

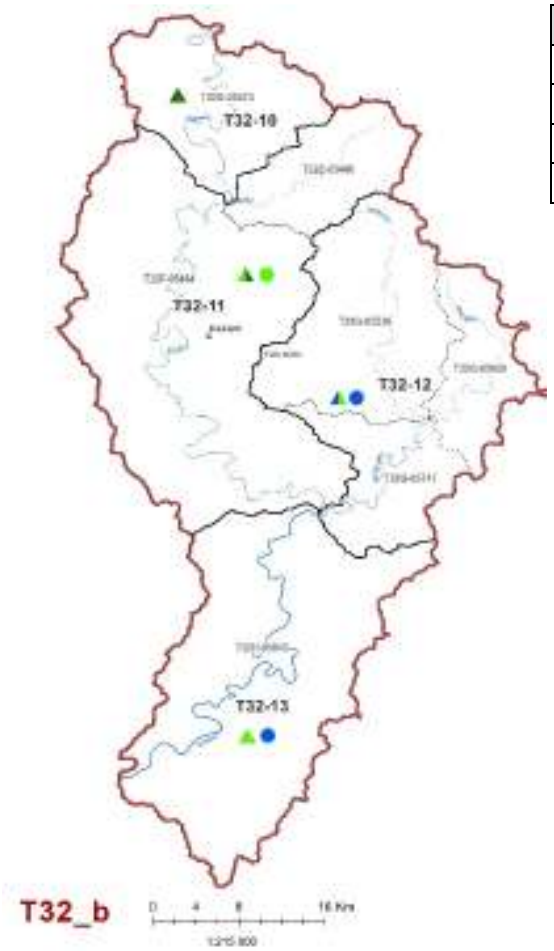
6 MZINTLAVA (T32): IUA T32_B RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. There are no surface water developments planned in the IUA. The land-use activities include intensive commercial farming (irrigation and dryland cultivation) with a large number of minor instream and off-channel farms dams. The upper portion (T32D) of the IUA is characterised by intense commercial farming activities (including irrigation). The lower portion of the IUA is predominantly rural with a large number of scattered rural and informal settlements and high levels of erosion and sedimentation are prominent as a result of poor land-use practices.

IUA T32_b is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T32_b – Mzintlava



PRIORITY RATINGS

RU	Main river	Priority	PES	REC	TEC
T32-10	Mzintlava	3 (WQ)	D	D	D
T32-11	Mzintlava	4 (WQ)	C/D	C	C
T32-12	Mzintlavana	3	B/C	B	B
T32-13	Mzintlava	3	C	B	B

6.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T32_B

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 6.1** and the full EWR rule is provided as part of the electronic data for the project.

Table 6.1 Flow RQOs for IUA T32_b: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T32-10	D	D	134.49	120.44	10.87	8.08	21.34	15.9	0.304	0.186	1.418	0.962
T32-11	C/D	C	223.24	205.32	27.11	12.15	52.72	23.6	1.141	0.622	3.799	1.857
T32-12	B/C	B	57.16	55.41	7.05	12.32	13.11	22.9	0.351	0.159	0.864	0.362
T32-13	C	B	348.86	326.94	44.81	12.84	86.05	24.7	1.881	0.929	6.185	2.8

[1] MCM/a

6.2 RU T32-10: MZINTLAVA RIVER (HIGH PRIORITY – 3 (WQ))

No improvement is required to achieve the TEC.

6.2.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Urban impacts, irrigation return flows from pivots.
Water quality issue: Nutrients, toxics, salts, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 6.2**.

Table 6.2 RU T32-10: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that electrical conductivity (salt) levels are within Acceptable limits.	95th percentile of the data must be less than or equal to 55 mS/m (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

6.2.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 6.3**.

Table 6.3 RU T32-10: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **serious** (not become critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **serious** (not become critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

6.3 RU T32-11: MZINTLAVA RIVER (VERY HIGH PRIORITY – 4 (WQ))

The TEC requires improvement of the PES from a C/D to a C EC. To achieve this, the following is required:

- Erosion control.
- Improved agricultural practices.
- Alien vegetation removal.
- Improvement in water quality discharges from Mount Ayliff WWTW.

6.3.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Mount Ayliff high risk WWTW, extensive erosion, widespread rural settlements, dryland cultivation, nsizwa (nickel) Mine (status unknown, but presumably not currently in production).
Water quality issue: Nutrients (Total Inorganic Nitrogen (TIN) and phosphate), turbidity, salts, toxics, *E.coli/*faceal coliforms.

Narrative and numerical details are provided in **Table 6.4**.

Table 6.4 RU T32-9: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that electrical conductivity (salt) levels are within Ideal limits.	95th percentile of the data must be less than or equal to 30 mS/m (Aquatic ecosystems: driver).
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
	50th percentile of the data must be less than 1.0 mg/L TIN-N (Aquatic ecosystems: driver).

Narrative RQO	Numerical RQO		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996a) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

6.3.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 6.5**.

Table 6.5 RU T32-11: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.

6.4 RU T32-12: MZINTLAVA RIVER (HIGH PRIORITY – 3)

The TEC requires improvement of the PES from a B/C to a B EC. To achieve this, the following is required:

- Erosion control.
- Alien vegetation removal.

6.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 6.6**.

Table 6.6 RU T32-12: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone	Modification of riparian zone continuity	Insufficient quantitative data exist to

Indicators	Narrative RQO	Numerical RQO
continuity	should remain **moderate** or improve.	develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.

6.5 RU T32-13: MZINTLAVA RIVER (HIGH PRIORITY – 3)

The TEC requires improvement of the PES from a C to a B EC. To achieve this, the following is required:

- Improve riparian continuity by improving riparian buffer zone (floodplain agriculture).

6.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 6.7**.

Table 6.7 RU T32-13: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone. Buffer zones through urban areas should not be encroached.	Insufficient quantitative data exist to develop numerical RQOs.
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.

7 KINIRA (T33): IUA T33_A RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area, while smaller dams include the Mountain Dam and Belfort Dam which supply water to Matatiele and the Maluti Scheme respectively. There are no surface water developments planned in the IUA. Some development incudes the projected increase in water supply and return flows associated with Matatiele and the surrounding area's future growth. The lower portion of the IUA is predominantly rural with a large number of scattered rural and informal settlements. High levels of erosion and sedimentation are prominent due to poor land-use practices.

IUA T32_a is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T33_a – Kinira

PRIORITY RATINGS

RU	Main river	Priority	PES	REC	TEC
T33-1	Mafube	2	B	B	B
T33-2	Kinira	3	B/C	B/C	B/C
T33-3	Kinira	3 (WQ)	C	C	C
T33-4	Jordan	2	B	B	B
T33-5	Seeta	3	B/C	B/C	B/C
T33-6	Mosenene	2	C	C	C

7.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T33_A

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 7.1** and the full EWR rule is provided as part of the electronic data for the project. Note [1]MCM/a.

Table 7.1 Flow RQOs for IUA T33_a: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T33-1	B	B	20.45	19.6	3.27	15.97	5.62	27.5	0.148	0.062	0.515	0.174
T33-2	B/C	B/C	26.29	26.16	3.55	13.49	6.28	23.9	0.166	0.078	0.549	0.205
T33-3	C	C	97.37	94.75	10.67	10.96	19.96	20.5	0.512	0.279	1.626	0.706
T33-4	B	B	33.94	33.87	5.04	14.85	9.13	26.9	0.206	0.083	0.843	0.27
T33-5	B/C	B/C	69.76	69.37	8.74	12.53	16.27	23.3	0.37	0.17	1.439	0.516
T33-6	C	C	94.27	93.66	9.55	10.13	18.83	20	0.416	0.221	1.547	0.643

7.2 RU T33-1: MAFUBE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

7.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.2**.

Table 7.2 RU T33-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation unit	Areas of the RU contain natural forest and these should remain dominated by woody species.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

7.3 RU T33-2: KINIRA RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

7.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.3**.

Table 7.3 RU T33-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation unit	Areas of the RU contain natural forest and these should remain dominated by woody species.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There shall be no expansion of agricultural activities into the riparian zone or wetlands, and existing agriculture shall not expand or intensify towards or within the riparian zone.	Insufficient quantitative data exist to develop numerical RQOs.

7.4 RU T33-3: KINIRA RIVER (HIGH PRIORITY – 3 (WQ))

7.4.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Matatiele WWTW discharge into streams. piggery north of WWTW, sand mining, numerous settlements and crossings, erosion, dryland cultivation.
Water quality issue: Turbidity, nutrients, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 7.4**.

Table 7.4 RU T33-3: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

7.4.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.5**.

Table 7.5 RU T33-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation unit	Areas of the RU contain wetlands and these should remain dominated by non-woody species.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

7.5 RU T33-4: JORDAN RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

7.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.6**.

Table 7.6 RU T33-4: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There should be no expansion of agricultural activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.

7.6 RU T33-5: SEETA RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC. Note this RU is a water quality priority protection area as there is a drinking water collection point from the weir.

7.6.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.7**.

Table 7.7 RU T33-5: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation unit	Areas of the RU contain wetlands and these should remain dominated by non-woody species.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

7.7 RU T33-6: MOSENENE RIVE (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

7.7.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 7.8**.

Table 7.8 RU T33-6: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Dominant vegetation unit	Areas of the RU contain wetlands and these should remain dominated by non-woody species.	N/A
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large** (not become serious or critical). There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 43 macroinvertebrate families potentially occur in the SQs of T33-6 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 7.9** are expected to occur with low (1) or moderate (3) confidence: baetid, prosopistomatid, leptophlebiid and tricorythid mayflies, athericid dipterans and hydrophilid, elmid and psephenid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. Prosopistomatids are expected but at low confidence and are unlikely to occur in a PES of C. The other mayfly taxa serve as suitable indicators. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which provide areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate (0.3 to >0.6 m/s) will encourage the taxa scoring >12. Areas of lower flow are also required to support taxa with this preference (e.g.

Indicators	Narrative RQO	Numerical RQO
		Leptophlebiidae).
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse substrates (cobbles, boulders) with good mobility should be available.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 7.9 Indicator taxa for T33-6 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T33B-04939	Mabele	1	1		1		1	1		1	1	1	1	1	1	1	1	1			43
T33B-04956	Mosenene	1	3		3		3			3	3	3	3		3	3	3	3			40

8 KINIRA (T33): IUA T33_B RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. Smaller dams include the Ntenyana Dam and Forest Dam which supply water to the Kwa Bacha Scheme and Tabankulu respectively. There are no major surface water developments planned in the area. The IUA is predominantly rural with a large number of scattered rural and informal settlements and some cultivation and subsistence farming. Some of the larger towns/villages include Mount Frere and Tabankulu. High levels of erosion and sedimentation are prominent due to poor land-use practices.

IUA T33_b is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying Table.

IUA T33_b – Kinira

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
T33-7	Kinira	2	C	C	C
T33-8	Somabadi	2	C	C	C
T33-9	Kinira	2	C	C	C
T33-10	Ncome	2	C	C	C
T33-11	Cabazi	2	C	C	C
T33-12	Mnceba	2	C	C	C
T33-13	Caba	2	C	B	B
T33-14	Mzimvubu	3	B	B	B
EWR3_ Kinira	Kinira	2	C	C	C

8.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T33_B

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 8.1** and the flow RQOs for MzimEWR3 are provided in **Table 8.2.** The full EWR rule is provided as part of the electronic data for the project.

Table 8.1 Flow RQOs for IUA T33_b: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T33-7	C	C	302.96	296.36	38.07	12.56	74.52	24.6	1.437	0.705	6.575	2.367
T33-8	C	C	6.17	6.13	0.68	11.02	1.27	20.7	0.038	0.021	0.091	0.046
T33-9	C	C	368.32	360.77	47.17	12.81	91.8	24.9	1.824	0.902	7.916	2.93
T33-10	C	C	15.58	15.15	1.65	10.57	3.17	20.3	0.082	0.044	0.235	0.116
T33-11	C	C	14.01	12.06	1.48	10.53	2.82	20.1	0.07	0.038	0.213	0.105
T33-12	C	B	17.05	16.89	1.71	10.04	3.37	19.8	0.092	0.049	0.204	0.1
T33-13	C	B	9.22	8.63	0.93	10.04	1.82	19.8	0.05	0.026	0.11	0.054
T33-14	B	B	extrapolated from MzimEWR4									

[1] MCM/a

Table 8.2 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in Table 8.2 as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 8.2 Flow RQOs (EWRs in MCM/a) for MzimEWR3

MRU	River	Target EC	nMAR[1]	pMAR[1]	% of nMAR	Low flows[1]	Low flows (%)	High flows[1]	High flows (%)	Total flows[1]	Total (%)
Summary statistics											
Mzim EWR3	Kinira	C	407.12	399.3	98.08	82.87	20.3	52.57	12.9	135.44	33.4

MzimEWR3: Low flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)																	
Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	16.40	16.40	8.57	5.69	5.61	5.38	4.20	3.62	2.93	2.29	1.73	1.30	1.19	1.15	1.15	1.15	1.15
Nov	19.37	19.37	10.46	6.42	6.42	6.42	5.26	4.42	3.60	2.74	2.18	1.69	1.61	1.61	1.61	1.61	1.61
Dec	22.97	22.97	17.27	13.90	13.54	12.99	10.31	8.25	5.19	3.40	2.45	1.79	1.52	1.26	1.07	1.07	1.07
Jan	37.84	37.84	29.72	24.37	21.56	19.70	16.24	12.43	9.25	6.03	4.34	3.08	2.69	2.17	1.87	1.87	1.87
Feb	30.73	30.73	30.01	28.90	27.48	25.75	21.57	16.84	12.06	8.25	5.46	4.06	3.48	3.00	2.81	2.17	2.17
Mar	49.09	49.09	34.97	27.95	26.91	26.07	20.47	16.33	12.32	9.17	6.63	5.16	4.64	4.05	3.45	2.93	2.93
Apr	30.40	30.40	20.16	15.51	15.50	15.15	13.90	12.15	8.62	6.18	4.58	3.54	3.28	2.76	2.14	1.98	1.98
May	17.36	17.36	10.75	8.81	8.78	8.70	6.79	5.79	4.59	3.41	2.69	1.93	1.80	1.80	1.80	1.80	1.80
Jun	15.60	15.60	8.48	5.18	5.04	4.89	4.32	3.84	3.05	2.38	1.78	1.63	1.63	1.63	1.63	1.63	1.63
Jul	11.96	11.96	8.04	5.85	4.86	4.30	3.91	3.64	2.82	2.15	1.71	1.70	1.70	1.70	1.70	1.70	1.70

Aug	12.77	12.77	7.87	5.34	4.62	4.09	3.53	2.99	2.61	1.93	1.50	1.43	1.43	1.43	1.43	1.43	1.43
Sep	4.44	4.44	4.32	4.14	3.93	3.70	3.16	2.70	2.24	1.79	1.39	1.07	0.95	0.85	0.76	0.71	0.71
MzimEWR3: High flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)																	
Month	**Duration (%)**																
	0.1	**1**	**5**	**10**	**15**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**85**	**90**	**95**	**99**	**99.9**
Oct	34.30	34.30	9.56	7.62	2.69	2.59	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	37.08	37.08	18.86	7.68	2.67	2.67	2.34	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	44.46	44.46	18.06	17.73	13.15	10.41	7.07	2.82	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	89.12	89.12	62.24	27.09	21.54	17.24	9.90	7.18	4.66	3.34	2.40	0.11	0.08	0.00	0.00	0.00	0.00
Feb	66.20	66.20	58.93	35.39	32.90	21.31	14.92	10.65	7.68	4.72	2.50	2.11	1.56	0.09	0.00	0.00	0.00
Mar	89.12	89.12	40.44	34.12	21.36	19.66	7.43	8.03	7.61	2.30	2.46	0.37	0.10	0.00	0.00	0.00	0.00
Apr	14.18	14.18	12.08	7.68	3.16	2.50	2.19	1.57	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	35.98	35.98	4.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	40.26	40.26	2.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	10.36	10.36	2.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	17.82	17.82	3.99	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	89.12	89.12	7.68	2.72	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] MCM/a

8.2 RU T33-7: KINIRA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

8.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.3**.

Table 8.3 RU T33-7: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also

Indicators	Narrative RQO	Numerical RQO
	rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 39 macroinvertebrate families potentially occur in the SQs of T33-7 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 8.4** below are expected to occur with either low (1) or moderate (3) confidence: perlid stoneflies, baetid, prosopistomatid, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans and elmid, hydrophilid and psephenid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The first three of these taxa score > 13 and may not occur under PES C conditions. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain moderate to good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage any taxa scoring > 12. Areas of lower flow are also required to support other indicator taxa with this preference.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Areas of mobile coarse substrates (cobbles, boulders) should be available.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	There should be 5–10 cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, and areas both in and out of flow are preferable.

Table 8.4 Indicator taxa for T33-7 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T33C-05131	Morulane	1	3		3		3			3	3	3	3		3	3	3	3			38
T33D-05063	Kinira	1	1		1		1	1		1	1	1	1		1		1	1			36
T33D-05106	Pabatlong	3			1		3			3	3	1	3		3	1	3	1			39
T33D-05150	Kinira	1	1		1		1	1		1	1	1	1		1		1	1			37

8.3 RU T33-8: SOMABADI RIVER (MODERATE PRIORITY– 2)

No improvement is required to achieve the TEC.

8.3.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Erosion and sedimentation.
Water quality issue: Turbdity.

Narrative and numerical details are provided in **Table 8.5**.

Table 8.5 RU T33-8: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

8.3.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.6**.

Table 8.6 RU T33-8: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.4 RU T33-9: KINIRA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

8.4.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Erosion and sedimentation.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 8.7**.

Table 8.7 RU T33-9: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

8.4.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.8**.

Table 8.8 RU T33-9: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.5 RU T33-10: NCOME RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

8.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.9**.

Table 8.9 RU T33-10: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species	Maintain indigenous species richness

Indicators	Narrative RQO	Numerical RQO
	richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	(AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 34 macroinvertebrate families potentially occur in the relevant sub-quaternary of T33-10 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 8.10** below are expected to occur with low (1) or moderate confidence (3): perlid stoneflies, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans, and elmid and psephenid beetle larvae. Their habitat, flow velocity and water quality preferences are tabulated in **Section 3.5**, **Table 3.1**. Any taxa scoring over 12 are only likely to be present in small numbers at the PES of C. The RQOs are set to maintain the PES of C		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of low to very high velocity flow (0.1 to > 0.6 m/s) should be present to support taxa with this preference.
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Areas of coarse substrates (cobbles, boulders) with > 30% mobility should be maintained. These should be > 40% clear of fines and algae on their upper surfaces.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 8.10 Indicator taxa for T33-10 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T33F-05439	Ncome	1			1		3			3	1	3	3		3		1	1			34

8.6 RU T33-11: CABAZI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

8.6.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Erosion and sedimentation.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 8.11**.

Table 8.11 RU T33-11: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).

8.6.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.12**.

Table 8.12 RU T33-11: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.7 RU T33-12: MNCEBA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

8.7.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.13**.

Table 8.13 RU T33-12: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.8 RU T33-13: CABA RIVER (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C to a B EC. To achieve this, the following is required:

- Improvement of WWTW discharge quality.
- Erosion prevention.
- Riparian buffer protection.

8.8.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: WWTW, extensive settlements.
Water quality issue: Nutrients, *E.coli*/faecal coliforms.

These RQOs are added as a precautionary measure as there appear to be WWTWs in this RU, but little evidence of discharge from some (e.g. Ntabankulu Correctional Centre oxidation ponds) into water resources.

Narrative and numerical details are provided in **Table 8.14**.

Table 8.14 RU T33-13: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 - 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

8.8.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.15**.

Table 8.15 RU T33-13: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.9 RU T33-14: MZIMVUBU RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC. Flow RQOs are extrapolated from MzimEWR4.

8.9.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Access roads, sand-mining.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 8.16**.

Table 8.16 RU T33-14: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A small change from natural with some modifications to the catchment, resulting in largely natural modifications in turbidity levels. Minor and temporary silting of habitats.

8.9.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 8.17**.

Table 8.17 RU T33-14: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

8.10 MRU EWR3_KINIRA: MZIMEWR3 KINIRA RIVER (MODERATE PRIORITY – 2)

The TEC for the different components for which RQOs must be specified are provided below:

Component	PES, REC, TEC
Physico-chemical	B/C
Geomorphology	C/D
Fish	C
Macroinvertebrates	C
Instream	C
Riparian vegetation	C/D
EcoStatus	C

8.10.1 Geomorphology

Key concerns related to geomorphology at MzimEWR3 were:

- Widespread deposition of fines on channel bed. Extent of fines needs to be reduced to stop the channel moving into a D EC.
- Widespread sand deposits over boulder bars – need to monitor direction of change in relation to flow changes.
- Insufficient time at site for establishing baseline criteria for monitoring; degraded floodbench morphology on transect line adds to uncertainty about desired directional change of features.

EcoSpecs and TPCs are presented in **Table 8.18**, with the surveyed transect shown diagrammatically in **Figure 8.1**.

Table 8.18 MzimEWR3: Geomorphology EcoSpecs and TPCs (PES C/D)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Particle size distribution of rapid	D50 (50th percentile) and D16 (particle size of which 16% is smaller; i.e. representing fine particles) of mobile bed sediment should not decrease below that measured at present: Note no measurement was undertaken during the site visit due to time constraints. Baseline survey needed.	D50 and D16 reduced by 20%.
Embeddedness	% embedded on rapid or riffle units should range between 10% to 30% fines among boulder, cobble or coarse gravel.	Embeddedness exceeds 30% at more than 25% of the area.

Geomorphology metrics	EcoSpecs	TPC
Channel cross-section		
Width of rapid at transect	Width between lower flood benches should be stable at 20 m on transect line (see **Figure 8.1** below).	Width reduced to less than 18 m or greater than 22 m.
Lower flood bench		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding.
Sediment deposits	Fine sediment (silt and very fine sand) deposits present but not excessive.	No recent fine sediment deposits or excessive deposits.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand) but not excessive.	No recent sediment deposits linked to the last wet season or excessive deposits.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

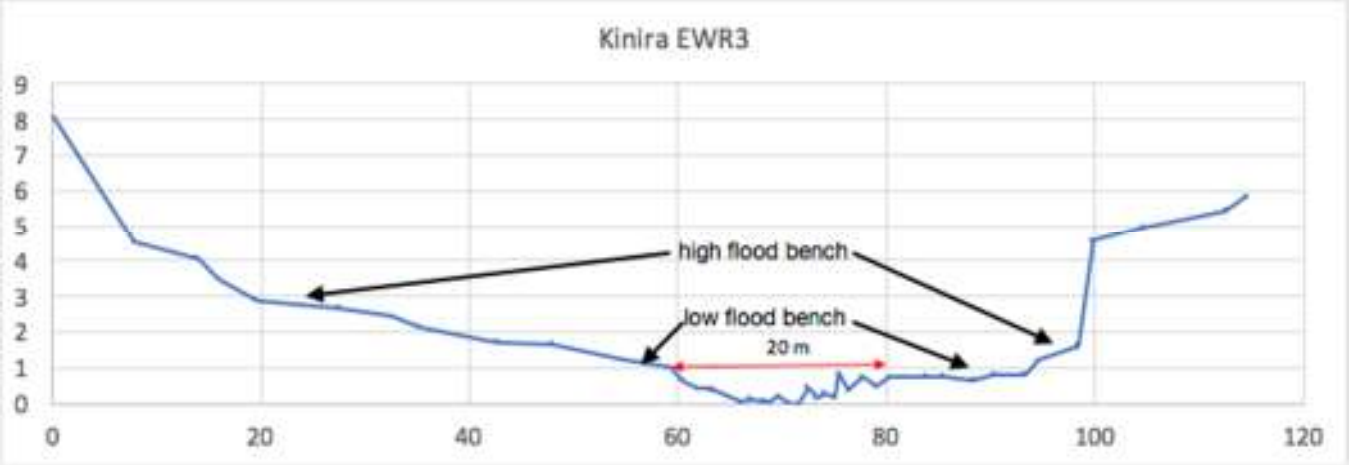


Figure 8.1 Surveyed transect line at MzimEWR3 showing current width of lowflow channel between low flood benches

8.10.2 Water quality (EcoSpecs)

Extensive erosion is evident in this part of the catchment, with land use being predominantly dryland farming and extensive rural settlements. Land degradation is extensive, with some impact on salt and nutrient levels from land use. EcoSpecs and TPCs are shown in **Table 8.19**.

Table 8.19 MzimEWR3: Water quality EcoSpecs and TPCs (PES B/C)

Water quality metrics	EcoSpecs	TPC
Inorganic salts(*)		
$MgSO_4$	The 95th percentile of the data must be ≤ 16 mg/L.	The 95th percentile of the data is 13–16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤ 20 mg/L.	The 95th percentile of the data is 16–20 mg/L.

Water quality metrics	EcoSpecs	TPC
$MgCl_2$	The 95th percentile of the data must be ≤ 15 mg/L.	The 95th percentile of the data is 12–15 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤ 21 mg/L.	The 95th percentile of the data is 17–21 mg/L.
NaCl	The 95th percentile of the data must be ≤ 45 mg/L.	The 95th percentile of the data is 36–45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤ 351 mg/L.	The 95th percentile of the data is 280–351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤ 42.5 mS/m.	The 95th percentile of the data is 33–42.5 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 8.0 to 8.8	The 5th percentile of the data is < 6.7 and > 7.8, and the 95th percentile is < 8.2 and > 8.6
Temperature	Natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥ 8.0 mg/L.	The 5th percentile of the data is < 8.2 mg/L.
Turbidity	Serious change from natural: Erosion and urban runoff processes are known causes of unnaturally large increases in sediment loads and turbidity. Increases are present most of the time with a serious reduction in habitat.	More frequent silting of habitats and increased turbidity levels over the monthly average of available data. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤ 0.25 mg/L	The 50th percentile of the data is 0.2–0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤ 0.015 mg/L.	The 50th percentile of the data is 0.012–0.015 mg/L
Response variables		
Chl-*a* phytoplankton (#)	The 50th percentile of the data must be ≤ 15 mg/L	The 50th percentile of the data is 12–15 µg/L
Chl-*a* periphyton (#)	The 50th percentile of the data must be ≤ 21 mg/m^2	The 50th percentile of the data is 17–21 mg/m^2
Toxics		
Ammonia (NH_3-N)	The 95th percentile of the data must be ≤ 0.03 mg/L	The 95th percentile of the data is 0.024–0.03 mg/L
Toxics	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008b), or within the Acute Effects Value (AEV) as stated in DWAF (1996a) for those variables not in DWAF (2008).	An impact is expected if the 95th percentile of the data exceeds the A category range in DWAF (2008), or the Target Water Quality Range (TWQR) as stated in DWAF (1996).

(*) Organic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available. Organic salt boundaries are provided for an A category but may require adjustment as data become available.
(#) Low confidence. EcoSpec and TPC. Boundaries may need adjusting as data becomes available.

8.10.3 Riparian vegetation

EcoSpecs and TPCs for riparian vegetation are shown in **Table 8.20**.

Table 8.20 MzimEWR3: Riparian vegetation EcoSpecs and TPCs (PES C/D)

Assessed metric	EcoSpec	TPC
Marginal zone		
Alien species invasion	Maintain an absence of perennial alien plant species.	An occurrence of perennial alien plant species.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species.	An occurrence of terrestrial woody species in the sub-zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species below 20%.	An increase in woody species cover above 30%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Upper zone		
Alien species invasion	Maintain cover (% aerial) of perennial alien plant species below 20%.	An increase in perennial alien plant species cover > 30%.
Terrestrial woody species aerial cover	Maintain cover (% aerial) of terrestrial woody species at 20% or lower.	An increase in terrestrial woody species cover above 30%.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species above 5% and below 40%.	An absence of indigenous riparian woody species, or an increase above 50%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 30%.	A decrease in non-woody cover (% aerial) below 20%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 59% for the riparian zone.	A decrease in PES score below 57.4% for the riparian zone.
Species richness	Maintain the presence of at least 14 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 10.
Dominant vegetation type	The dominant vegetation type shall remain non-woody in the riparian zone.	Reduced proportion of non-woody cover below 10% in the marginal or lower zones; reduced proportion of non-woody cover below 30% in the upper zone.

8.10.4 Fish

Table 8.21 outlines the spatial FROC (Frequency of Occurrence) of fish for the EWR site and indicates the FROC under reference and PES (baseline conditions. EcoSpecs and TPCs based on the Fish Response Assessment Index (FRAI; Kleynhans, 2007) data are provided in **Table 8.22** for the PES.

Table 8.21 MzimEWR3: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC	
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC
Indigenous species				
AMOS	*Anguilla mossambica**	4	2.5	< 2.5 in reach (present at < 25% of suitable sites sampled).
BANO	*Barbus/Enteromius anoplus*	3	1	< 1 (present at < 10% of suitable sites sampled).

* Sampled at EWR site during baseline survey (September 2016).

Table 8.22 MzimEWR3: Fish EcoSpecs and TPCs (PES C)

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present ecological status of fish is in a C (62.6%).	Decrease of PES into a lower EC than PES (< C).	Any deterioration in habitat that results in decrease in FROC of species.
Species richness	All indigenous species	Both expected indigenous fish species estimated to still be present in the reach under PES (Presence of AMOS confirmed during September 2016 survey).	Loss of any indigenous species. Presence of less than one indigenous species at EWR site using similar sampling methods and conducted during similar conditions (season, flow).	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water.	AMOS	Range of size classes present in relatively low abundance at site (September 2016 survey: 3 specimens ranging 15–50 cm, Catch Per Unit Effort (CPUE): 0.05 individuals/minute (ind/min))	AMOS absent during any survey OR present at FROC of <2.5 in reach (present at < 25% of suitable sub-sites sampled). Absence of range of life stages (juveniles to adults) during various surveys.	Reduced suitability (abundance and quality) of flowing (FS, Fast-Intermediate (FI, FD / riffle-rapid-run) habitats (i.e. decreased flows, increased zero flows, altered seasonality).
Fast Deep (FD) habitats				Reduced suitability (abundance and quality) of FD habitats (i.e. decreased flows, increased zero flows)
Fast Shallow (FS) habitats				Reduced suitability (abundance and quality) of FS habitats (i.e. decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Water quality intolerance	BANO	BANO expected to still be present in low abundance in reach. None sampled during September 2016 EWR survey at site. The primary impacts on BANO is associated with the loss of vegetation as cover and food source (due to overgrazing, trampling, erosion, alien plant encroachment, increased turbidity	BANO absent during more than 2 consecutive survey OR present at FROC of <1 (present at <10% suitable sites). Absence of range of life stages (juveniles to adults) during various surveys.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation				Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).

Metric	Indicator	EcoSpecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation		reducing aquatic vegetation growth) and especially the presence of aggressive predatory alien species (*Micropterus salmoides* (MSAL)).		Significant change in instream (aquatic) vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes)
Water column				Reduction in suitability of water column (i.e. increased sedimentation of pools, reduced flows).
Slow Deep (SD) habitats				Significant change in SD habitat suitability (i.e. increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
Slow-Shallow (SS) habitats				Significant change in SS habitat suitability (i.e. increased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	*Micropterus salmoides*, *Oncorhynchus mykiss* (OMYK), *Cyprinus carpio* (CCAR) known or expected to be present in the SQ reach (September 2016 EWR survey confirmed presence of MSAL and CCAR).	Presence of any additional alien/introduced species or increase in abundance (CPUE > 0.4 ind/min) and distribution of existing species.	N/A
Migratory success[1]		The presence of the catadromous Shortfin eel (AMOS) was confirmed at site, while the potamodromous Chubbyhead barb (BANO) is also expected to still be present.	Loss or decreased FROC (<2.5 in reach: present at < 25% of suitable sub-sites sampled) of especially the catadromous eel (AMOS).	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

[1]Migratory guilds
Catadromous – Fishes which spend most of their lives in freshwater and migrate to the sea (or saline reaches of estuaries) to breed as adults (e.g. eels) (Catchment scale migrations).
Potamodromous: Truly migratory species whose entire life cycle is completed within freshwater and that undertake migrations within freshwater zones (between SQ reaches) of rivers for a variety of reasons, such as for spawning, feeding, dispersion after spawning, colonisation after droughts, for over-wintering, etc.

8.10.5 Macroinvertebrates

Available SASS5 data collected at or near MzimEWR3 are summarised in **Table 8.23**. Data from River Health Programme sites were also used, e.g. T3KINI_GWEIR.

Table 8.23 MzimEWR3: Available SASS5 data

MRU	MRU Kinira			
Type	**Sample site**	**Sites used in development of reference**		
Site	**MzimEWR3**	**PES/EIS for T33G-05395**	**T3_MZIM_N2ROA (T33H-05680)**	**T3KINI_GWEIR (T33E-05213)**
Reference	**This study**	**PESEIS project (DWS, 2014c)**		
Date	20.09.2016	Various	Various	Various
Flow (m^3/s)				
Biotope suitability	IHAS = 88%	No data	No data	No data
SASS5 score or guideline	153	> 190	112	147
No. of taxa	22	> 25	14	21
Average score per taxon (ASPT)	7	6–7	8	7
PES percentage	77.2% C			
PES: MIRAI (Category A–F)	C			
Additional high-scoring taxa expected under reference conditions		Baetidae > 2spp Prosopistomatidae Tricorythidae Hydropsychidae 2spp Athericidae	Prosopistomatidae, Tricorythidae Hydropsychidae > 2spp Athericidae	Hydropsychidae > 2spp Atheridcidae

Indicator taxa

The following taxa were selected as monitoring indicators for MzimEWR3: Perlidae, Baetidae (2spp), Heptageniidae, Oligoneuridae, and Teloganodidae. Their flow velocity preferences and habitat preferences are indicated in **Table 8.24** (extracted from MIRAI spreadsheet). Scores of 4 and over indicate a high preference. EcoSpecs and TPCs are shown in **Table 8.25**.

Table 8.24 Taxon preferences for physical and hydraulic habitat and water quality extracted from MIRAI (Thirion, 2007)

Taxon	Taxon preferences for physical and hydraulic habitat and water quality									
	Flow velocity (m/s)				Habitat					WQ
	< 0.1	0.1–0.3	0.3–0.6	>0.6	BR	COBB	VEG	GSM	WATER	
Perlidae	1	1	1	5	1	4	1	0	0	High
Baetidae 2spp	2	2	2	2	2	2	2	2	1	Low
Heptageniidae	1	1	3	2	1	4	1	0	0	High
Leptophlebiidae	3	2	2	1	1	3	2	0	0	Moderate
Oligoneuridae	0	0	1	5	2	3	1	1	1	High
Telagonodidae	0	0	2	4	1	4	1	0	0	High
Note: Preference increases with increasing score										

Table 8.25 MzimEWR3: Macroinvertebrate EcoSpecs and TPCs for C PES

Parameter	Baseline (PES)	EcoSpec	TPC
Community composition and balance	Diverse community but with low abundances of highest scoring taxa. No dominant taxa.	Diverse community but with low abundances of highest scoring taxa. No dominant taxa.	Low abundances (< 5 per sample) of taxa scoring > 9, and /or numerical dominance of one or more taxa (excepting Baetidae).
SASS score range	130–160	130–160	< 120
ASPT score range	6–7+	6–7+	< 5.5
MIRAI score range (Using same reference condition)	77.2%	70–77%	< 63%

9 THINA (T34): IUA T34_A RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. The IUA is predominantly rural with the upper reaches being largely natural and the middle to lower reaches having scattered rural and informal settlements and some cultivation and subsistence farming. Erosion and sedimentation are prominent due to poor land-use practices.

IUA T34_a is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T34_a – Thina

PRIORITY RATINGS

RU	Main river	Priority	PES	REC	TEC
T34-1	Phinari	2	B	B	B
T34-2	Thina	2	B	B	B
T34-3	Thina	2	B/C	B/C	B/C
T34-4	Phirie-ntso	2	B	B	B

9.1 HYDROLOGICAL (FLOW) RQOS FOR IUA T34_A

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 9.1** and the full EWR rule is provided as part of the electronic data for the project. Note [1]MCM/a.

Table 9.1 Flow RQOs (EWRs in MCM/a) for IUA T34_a: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T34-1	B	B	33.59	33.45	4.88	14.52	8.92	26.6	0.199	0.082	0.797	0.294
T34-2	B	B	32.91	32.64	4.69	14.24	8.68	26.4	0.172	0.07	0.796	0.292
T34-3	B/C	B/C	41.14	40.89	4.94	12.00	9.42	22.9	0.187	0.085	0.83	0.343
T34-4	B	B	68.08	67.39	9.72	14.27	17.98	26.4	0.363	0.149	1.641	0.603

9.2 RU T34-1: PHINARI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

9.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 9.2**.

Table 9.2 RU T34-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

9.3 RU T34-2: THINA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

9.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 9.3**.

Table 9.3 RU T34-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to

Indicators	Narrative RQO	Numerical RQO
	management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 53 macroinvertebrate families potentially occur in the SQs of T34-2 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 9.4** below are expected to occur at high confidence: heptageniid, leptophlebiid and tricorythid mayflies and elmid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. At lower confidences, Prosopistomatidae and Oligoneuridae are expected to occur, which is possible with a PES of B. The latter taxa are highly sensitive, flow dependent invertebrates and require optimal flow, habitat and water quality conditions. The RQOs are set to maintain the PES of B.		
Water quality	Mitigate against any non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality (B category).
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high to very high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) to support flow dependent indicator taxa scoring >12. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Areas of coarse mobile substrates (cobbles, boulders) should be available. Less than 20% embeddedness and less than 20% silt or algal cover over the rock surface.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	10–15 cm depth over the top of the critical habitat (SIC). Marginal vegetation species, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 9.4 Indicator taxa for T34-2 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T34A-05354	Zindawa	3	3		3	1	3	1		3	3	3	3		3	1	1	3			52
T34A-05362	Vuvu	3	3		3	1	3	1	1	3	3	3	3		3	1	1	3			53
T34A-05394	Vuvu	3	3		3		3	1		3	3	3	3	3		3	3	3			50
T34A-05404	Thina	3	3		3		3			3	3	3	3	3		3	3	3			51
T34A-05415	Thina	5	5		5	1	5			5	3	3	3		5		1	3			48

9.4 RU T34-3: THINA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

9.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 9.5**.

Table 9.5 RU T34-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator		Ensure the habitat requirements

Indicators	Narrative RQO	Numerical RQO
species: BANO	regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	(especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
41 macroinvertebrate families potentially occur in the relevant sub-quaternary of T34-3 (PESEIS database; DWS (2014). The indicator taxa highlighted in **Table 9.6** below are expected to occur with moderate (3) confidence: perlid stoneflies, baetid, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans and elmid beetle larvae. Their habitat preferences are presented in **Section 3.5**, **Table 3.1**. The first three of these taxa score > 12 and are likely to occur under B/C conditions. Heptageniids are likely to be scarce. RQOs are set to maintain the PES of B/C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 9.6 Indicator taxa for T34-3 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T34A-05408	Khohlong	3	3		3		3			3	3	3	3		3		1	3			41

9.5 RU T34-4: PHIRI-EN-NTSO RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

9.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 9.7** below.

Table 9.7 RU T34-4: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

10 THINA (T34): IUA T34_B RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. There are no major surface water developments planned in the IUA. Some development includes projected increase in water use and return flows associated with Mount Fletcher's growth. The IUA is predominantly rural with a large number of scattered rural and informal settlements and some cultivation and subsistence farming. High levels of erosion and sedimentation are prominent due to poor land-use practices.

IUA T34_b is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T34_b – Thina

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
T34-5	Thina	2	C	B/C	B/C
T34-6	Tokwana	3 (WQ)	C	C	C
T34-7	Luzi	2	B	B	B
T34-8	Luzi	2	B/C	B/C	B/C
T34-9	Nxaxa	2	B	B	B
T34-10	Tsilithwa	2	B	B	B
T34-11	Ngcothi	3	B	B	B
T34-12	Ngcibira	2	C	C	C
MRU Thina_ B	Thina	3	C	C	C
MRU Thina_ C	Thina	3	C	C	C

10.1 HYDROLOGICAL (FLOW) RQOS FOR IUA T34_B

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 10.1** and the flow RQOs for MzimEWR2 are provided in **Table 10.2.** The full EWR rule is provided as part of the electronic data for the project.

Table 10.1 Flow RQOs for IUA T34_b: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T34-5	C	B/C	123.48	120.06	12.14	9.83	24.3	19.7	0.503	0.267	1.977	0.959
T34-6	C	C	20.35	20.21	2.13	10.47	4.1	20.2	0.094	0.051	0.333	0.164
T34-7	B	B	45.2	44.38	6.52	14.43	11.98	26.5	0.247	0.101	1.096	0.405
T34-8	B/C	B/C	84.7	83.32	10.56	12.47	19.65	23.2	0.427	0.197	1.723	0.721
T34-9	B	B	27.13	22.55	4.27	15.76	7.38	27.2	0.197	0.082	0.588	0.224
T34-10	B	B	20.07	18.96	3.15	15.70	5.47	27.2	0.143	0.06	0.435	0.166
T34-11	B	B	11.86	11.3	1.86	15.69	3.23	27.2	0.084	0.035	0.257	0.097
T34-12	C	C	18.25	17.13	1.97	10.79	3.7	20.3	0.094	0.051	0.266	0.132

[1] MCM/a

Table 10.2 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 10.2** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

Table 10.2 Flow RQOs for MzimEWR2

MRU	River	Target EC	nMAR[1]	pMAR[1]	% of nMAR	Low flows[1]	Low flows (%)	High flows[1]	High flows (%)	Total flows[1]	Total (%)
Summary statistics											
Thina_C MzimEWR2	Thina	C	404.51	393.23	97.21	89.24	22.1	32.41	8	121.65	30.1

MzimEWR2: LOW flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	34.10	34.10	28.94	25.96	25.94	25.32	22.77	20.51	17.87	15.44	12.81	10.90	10.03	9.33	8.93	8.72	8.72
Nov	37.13	37.13	37.13	34.98	34.75	33.72	28.50	25.08	22.35	18.39	14.97	13.17	11.92	11.65	11.65	11.65	11.65
Dec	47.66	47.66	47.66	47.66	47.66	47.65	44.00	35.60	27.60	22.67	18.53	14.75	12.73	11.29	9.71	9.45	9.45
Jan	62.11	62.11	62.11	57.65	57.31	55.38	51.20	43.39	36.58	29.67	24.10	18.74	16.15	13.95	12.55	11.70	11.70
Feb	70.94	70.94	70.94	70.94	70.94	62.72	53.48	46.52	40.18	32.53	27.75	21.21	18.91	16.69	15.94	14.62	14.62
Mar	79.59	79.59	78.95	77.83	76.26	74.10	67.53	57.32	48.84	39.72	33.43	27.85	25.44	23.17	21.08	19.67	19.67
Apr	57.14	57.14	57.14	57.14	57.14	56.69	52.85	44.76	39.83	33.41	27.79	22.70	20.01	17.74	15.49	15.30	15.30

May	41.77	41.77	41.77	40.16	38.15	35.61	35.17	30.89	28.28	22.93	18.47	15.28	14.03	13.42	13.41	13.41	13.41
Jun	32.39	32.39	31.46	26.37	26.29	26.04	25.52	21.69	19.05	15.41	12.79	11.36	11.35	11.34	11.34	11.34	11.34
Jul	28.61	28.61	27.96	23.87	23.76	23.59	22.97	19.85	17.09	14.15	12.13	10.68	9.74	9.18	8.94	8.56	8.56
Aug	21.52	21.52	21.38	21.15	20.82	20.36	19.03	17.33	15.36	13.24	11.23	9.49	8.79	8.36	8.00	7.77	7.77
Sep	43.71	43.71	27.40	19.94	19.70	19.69	17.39	15.92	14.98	11.60	9.69	8.38	8.38	8.37	8.37	8.37	8.37

MzimEWR2: HIGH flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	146.76	146.76	85.54	30.40	30.26	21.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	333.43	333.43	132.67	95.66	42.97	30.37	29.59	0.87	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	298.80	298.80	132.67	105.01	75.67	42.98	40.92	27.62	19.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	451.00	451.00	239.86	161.13	75.27	58.19	34.32	34.97	28.55	20.87	4.44	0.65	0.59	0.00	0.00	0.00	0.00
Feb	434.11	434.11	311.52	189.93	136.44	116.26	62.03	36.18	30.41	28.34	21.16	1.87	1.15	0.30	0.00	0.00	0.00
Mar	513.10	513.10	360.97	211.04	125.31	75.74	66.91	38.38	32.28	31.54	30.13	2.79	1.11	0.63	0.00	0.00	0.00
Apr	358.04	358.04	42.97	42.97	30.41	30.41	29.66	21.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	277.53	277.53	39.20	1.44	0.64	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	129.12	129.12	60.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	129.12	129.12	30.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	30.41	30.41	26.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	98.10	98.10	29.56	18.92	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[1] MCM/a

10.2 RU T34-5: THINA RIVER (MODERATE PRIORITY – 2)

The TEC requires improvement of the PES from a C to a B/C EC. To achieve this, the following is required:

- Supply the EWR from the dam.
- Improve the WWTW discharge quality. Note that discharge from Cacudi WWTW could not be confirmed.

10.2.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Settlements, erosion, assumed discharge from Cacudi WWTW.
Water quality issue: Turbidity, *E.coli*/faecal coliforms, nutrients.

Narrative and numerical details are provided in **Table 10.3**.

Table 10.3 RU T34-5: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).

	Low	Medium	High
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

10.2.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.4**.

Table 10.4 RU T34-5: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 44 macroinvertebrate families potentially occur in the SQs of T34-5 (PESEIS database; DWS (2014). The indicator taxa in **Table 10.5** below are expected to occur with high confidence (5): perlid stoneflies, prosopistomatid, heptageniid, leptophlebiid and tricorythid mayflies, Athericid dipterans and Elmid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The first three taxa score 12-15/15 for sensitivity. They will be absent or present in low numbers in the PES C condition, but may be present if the TEC of a B/C is attained. This would require an improvement in water quality, habitat condition, and flow. This is possible if the EWR flows are provided and the WWTW effluent quality is improved as per the Objectives. The RQOs are set to maintain the PES of C and to improve instream conditions.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain and improve water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of lower flow are also required to support taxa with

Indicators	Narrative RQO	Numerical RQO
		this preference (e.g. Leptophlebiidae).
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 10.5 Indicator taxa for T34-5 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	NoTaxa
T34D-05412	Thina	5	5		5		5	3		5	1	5	5		5			5			44

10.3 RU T34-6: TOKWANA RIVER (HIGH PRIORITY – 3(WQ))

No improvement is required to achieve the TEC.

10.3.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Mount Fletcher WWTW in high risk, urban impacts, crossings.
Water quality issue: Nutrients, turbidity, toxics, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 10.6**.

Table 10.6 RU T34-6: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996c) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

10.3.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.7**.

Table 10.7 RU T34-6: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 43 macroinvertebrate families potentially occur in the SQs of T34-6 (PESEIS database; DWS (2014). The indicator taxa in **Table 10.8** below are expected occur with a low (1) to moderate (3) confidence: baetid, ephemerid, heptageniid, leptophlebiid and tricorythid mayflies, aeshnid and gomphid odonates, and elmid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. Ephemerid mayflies are unlikely to occur at a PES of C, and heptageniids are likely to occur in low numbers. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)

Indicators	Narrative RQO	Numerical RQO
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 10.8 Indicator taxa for T34-6 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T34D-05433	Tokwana		3		3		3			3	3	3	3		3	3	3	3			39
T34D-05462	Khalatsu	1	3		3	1	3			3	3	3	3		3		3	3			43

10.4 RU T34-7: LUZI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

10.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.9**.

Table 10.9 RU T34-7: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

10.5 RU T34-8: LUZI RIVER (MODERATE PRIORITY – 2)

10.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.10**.

Table 10.10 RU T34-8: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

10.6 RU T34-9: NXAXA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

10.6.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.11**.

Table 10.11 RU T34-9: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

10.7 RU T34-10: TSILITHWA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

10.7.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.12**.

Table 10.12 RU T34-10: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone	Modification of riparian zone continuity	Insufficient quantitative data exist to

Indicators	Narrative RQO	Numerical RQO
continuity	should remain **moderate** or improve.	develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 38 macroinvertebrate families potentially occur in the SQs of T34-10 (PESEIS database; DWS (2014). The indicator taxa highlighted in **Table 10.13** below are expected to occur with moderate confidence (3): perlid stoneflies, baetid, heptageniid, leptophlebiid and tricorythid mayflies, athericid dipterans, coenagriid and aeshnid odonates, and elmid, hydrophilid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain the PES of B.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of slower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC, SOC, GSM should be present. Cobbles should be at least 75% mobile and 25% clear of fines and algae.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Ten to 15 cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 10.13 Indicator taxa for T34-10 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	NoTaxa
T34H-05714	Qhanqu						1			1	1	3	3		1	1		1			31
T34H-05769	Tsilithwa	1	1		1		1			1	1	1	1		1	1		1			36
T34H-05791	Tsilithwa	1	3		1		3			3	3	3	3		3	3	1	1			38

10.8 RU T34-11: NGCOTHI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

10.8.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.14**.

Table 10.14 RU T34-11: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

10.9 RU T34-12: NGCIBIRA RIVER (MODERATE – 2)

No improvement is required to achieve the TEC.

10.9.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Dryland cultivation, settlements, crossings and erosion.
Water quality issue: Turbidity, nutrients, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 10.15**.

Table 10.15 RU T34-12: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that turbidity or clarity levels stay within Acceptable limits.	A moderate change from natural with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

10.9.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 10.16**.

Table 10.16 RU T34-12: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** (not become serious or critical) or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 35 macroinvertebrate families potentially occur in the SQs of T34-12 (PESEIS database; DWS (2014). The indicator taxa highlighted in **Table 10.17** below below are expected to occur, with low (1) to moderate (3) confidence: perlid stoneflies, baetid > 2spp, heptageniid, leptophlebiid and tricorythid		

Indicators	Narrative RQO	Numerical RQO
mayflies, athericid dipterans and elmid, hydrophilid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The first three of these taxa score > 12 and are likely to occur only in small number under PES C conditions. The RQOs are set to maintain the PES of C and improve instream conditions.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the sensitive flow-dependent invertebrates. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC (coarse mobile substrates such as cobbles, boulders) should not be more than 60% embedded or covered with silts/algae. SOC and GSM should be present.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, SOC).	Up to 10 cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 10.17 Indicator taxa for T34-12 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T34H-05699	Mvuzi						1			1	1	1	1		1	1		1			31
T34H-05809	Mvumvu		1				1			1	1	3	3		1	1		1			33
T34H-05738	Ngcibira	1	1		1		1			1	1	1	1		1	1	1	1			35

10.10 MRU THINA_B AND C: MZIMEWR2 THINA RIVER (HIGH PRIORITY – 3)

The TEC for the different componenets for which RQOs must be specified are provided below:

Component	PES, REC, TEC
Physico-chemical	B
Geomorphology	C
Fish	B/C
Macroinvertebrates	C
Instream	C
Riparian vegetation	C/D
EcoStatus	C

10.10.1 Geomorphology

Key aspects relating to geomorphology include:

- Keeping riffles free of fine sediment.
- Preventing further loss of flood benches.
- Promoting extension of degraded floodbench on right bank.
- Promoting development of an intact lower flood bench on right bank to support marginal zone vegetation.

Geomorphology EcoSpecs and TPCs are shown in **Table 10.18**.

Table 10.18 MzimEWR2: Geomorphology EcoSpecs and TPCs (PES C)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Particle size distribution of riffle areas	D50 and D16 of mobile bed sediment should not decrease below that measured at present: 45 mm and 18 mm respectively.	D50 reduced by 20% (36 mm and 14 mm)
Embeddedness	% embedded on rapid should range between 10% to 30% fines among cobble or coarse gravel.	Embeddedness exceeds 30% at more than 25% of the area of cobble and coarse gravel.
Channel cross-section		
Width of rapid at transect	Width across low flow channel should not be less than 25 m on transect line (marginal zone on right bank may have been lost previously by erosion).	Width reduced to less than 20 m.
Lower flood bench		
Present-absent	Lower flood bench /marginal zone should be present on right bank.	Further loss of lower flood bench.
Sediment deposits	Evidence of fine sediment (silt and very fine sand) deposits at right bank channel edge.	No recent fine sediment deposits.
Upper flood bench		
Present-absent	Upper flood bench should be present on both banks; extension of upper flood bench over boulder bar on left bank.	Upper flood bench actively eroding either bank.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand).	No recent sediment deposits linked to the last wet season.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type

10.10.2 Water quality (EcoSpecs)

Water quality EcoSpecs and TPCs are shown in **Table 10.19**. Few water quality issues are seen in this part of the catchment, where land-use is primarily dryland farming and rural settlements. Sedimentation from erosion and high turbidities are evident.

Table 10.19 MzimEWR2: Water quality EcoSpecs and TPCs (PES B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts(*)		
$MgSO_4$	The 95th percentile of the data must be ≤ 16 mg/L.	The 95th percentile of the data is 13–16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤ 20 mg/L.	The 95th percentile of the data is 16–20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤ 15 mg/L.	The 95th percentile of the data is 12–15 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤ 21 mg/L.	The 95th percentile of the data is 17–21 mg/L.
NaCl	The 95th percentile of the data must be ≤ 45 mg/L.	The 95th percentile of the data is 36–45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤ 351 mg/L.	The 95th percentile of the data is 280–351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤ 30 mS/m.	The 95th percentile of the data is 24–30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 8.0 to 8.8	The 5th percentile of the data is < 6.7 and > 7.8, and the 95th percentile is < 8.2 and > 8.6
Temperature	Natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥ 8.0 mg/L.	The 5th percentile of the data is < 8.2 mg/L.
Turbidity	Moderate – Large change from natural: Erosion and urban runoff processes are known causes of unnaturally large increases in sediment loads and turbidity. Increases are not permanent with clearing of habitats at times.	Frequent silting of habitats. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤ 0.25 mg/L	The 50th percentile of the data is 0.2–0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤ 0.015 mg/L.	The 50th percentile of the data is 0.012–0.015 mg/L
Response variables		
Chl-*a* phytoplankton (#)	The 50th percentile of the data must be ≤ 15 mg/L	The 50th percentile of the data is 12–15 µg/L
Chl-*a* periphyton (#)	The 50th percentile of the data must be ≤ 21 mg/m^2	The 50th percentile of the data is 17–21 mg/m^2
Toxics		
Toxics	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008b), or within the Acute Effects Value (AEV) as stated in DWAF (1996a) for those variables not in DWAF (2008b).	An impact is expected if the 95th percentile of the data exceeds the A category range in DWAF (2008b), or the Target Water Quality Range (TWQR) as stated in DWAF (1996a).

(*) Organic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
(#) Low confidence. EcoSpec and TPC. Boundaries may need adjusting as data becomes available.

10.10.3 Riparian vegetation

Riparian vegetation EcoSpecs and TPCs are shown in **Table 10.20**.

Table 10.20 MzimEWR2: Riparian vegetation EcoSpecs and TPCs (PES C/D)

Assessed metric	EcoSpec	TPC
Marginal zone		
Alien species invasion	Maintain an absence of perennial alien plant species.	An occurrence of perennial alien plant species.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species.	An occurrence of terrestrial woody species in the sub-zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species below 20%.	An increase in woody species cover above 30%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain reed cover below 25%.	An increase in reed cover above 30%.
Upper zone		
Alien species invasion	Maintain cover (% aerial) of perennial alien plant species below 10%.	An increase in perennial alien plant species cover > 20%.
Terrestrial woody species aerial cover	Maintain cover (% aerial) of terrestrial woody species at 10% or lower.	An increase in terrestrial woody species cover above 20%.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species above 5% and below 40%.	An absence of indigenous riparian woody species, or an increase above 50%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain reed cover below 10%.	An increase in reed cover above 20%
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 59% for the riparian zone.	A decrease in PES score below 57.4% for the riparian zone.
Species richness	Maintain the presence of at least 24 indigenous plant species within the riparian zone, including at least 1 aquatic species.	A decrease in the number of indigenous plant species within the riparian zone below 20.
Dominant vegetation type	The dominant vegetation type shall remain non-woody in the marginal and upper zones, and woody on the Macro Channel Bank (MCB).	Reduced proportion of non-woody cover below 10% in the marginal or upper zones; reduced proportion of woody cover below 40% on the MCB.

10.10.4 Fish

Table 10.21 outlines the spatial FROC of the EWR site and indicates the FROC under reference and PES (baseline) conditions. EcoSpecs and TPCs based on the FRAI (Kleynhans, 2007) data are provided in **Table 10.22**.

Table 10.21 MzimEWR2: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: B/C EC	
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC
Indigenous species				
AMOS	*Anguilla mossambica**	2	1	< 1 (present at < 10% of suitable sites sampled).
BANO	*Barbus/Enteromius anoplus*	4	3.5	< 3.5 in reach (present at < 25% of suitable sites sampled).

* Sampled at EWR site during baseline survey (September 2016).

Table 10.22 MzimEWR2: Fish EcoSpecs and TPCs (PES: B/C)

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present ecological status of fish is in a B/C (78.4%).	Decrease of PES into a lower EC than PES (< B/C).	Any deterioration in habitat that results in decrease in FROC of species.
Species richness	All indigenous species	Both expected indigenous fish species estimated to still be present in the reach under PES (Presence of BANO confirmed during September 2016 EWR survey).	Loss of any indigenous species. Presence of less than 1 indigenous species at EWR site using similar sampling methods and conducted during similar conditions (season, flow).	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water.	AMOS	AMOS expected to still be present in low abundance in reach. None sampled during September 2016 EWR survey at site. It is estimated that the AMOS population have been impacted by reduced substrate quality (sedimentation causing loss of habitat for food sources), reduced pool depth (due to sedimentation), increased turbidity reduces visibility for feeding).	AMOS absent during more than 2 consecutive survey OR present at FROC of < 1 (present at < 10% suitable sites). Absence of range of life stages (juveniles to adults) during various surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e. decreased flows, increased zero flows, and altered seasonality).
FD habitats				Reduced suitability (abundance and quality) of FD habitats (i.e. decreased flows, increased zero flows).
FS habitats				Reduced suitability (abundance and quality) of FS habitats (i.e. decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Water quality intolerance	BANO	Range of size classes present in relatively high abundance at site (September 2016 survey: 50 individuals ranging 5 - 9cm tail length, CPUE: 0.9 ind/min)	BANO absent during any survey OR present at FROC of < 3.5 in reach (present at < 40% of suitable sites sampled). Absence of range of life stages (juveniles to adults) during various surveys.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation				Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes).
Water column				Reduction in suitability of water column (i.e. increased sedimentation of pools, reduced flows).
SD habitats				Significant change in SD habitat suitability (i.e. increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
SS habitats				Significant change in SS habitat suitability (i.e. increased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	Based on available data for the region, it is expected that three alien species may be present (MSAL, CCAR and possibly also OMYK). None sampled during September 2016 EWR survey.	Presence of any additional alien/introduced species.	N/A
Migratory success	AMOS and BANO	The presence of the potamodromous Chubbyhead barb (BANO) was confirmed at site, while the catadromous Shortfin eel (AMOS) is also expected to still be present.	Loss or decreased FROC BANO and continued absence of the catadromous eel (AMOS).	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

10.10.5 Macroinvertebrates

Available SASS5 data collected at or near MzimEWR2 are summarised in **Table 10.23**.

Table 10.23 MzimEWR2: Available SASS5 data

MRU	MRU Mzimvubu			
Type	**Sample site**	**Sites used in development of reference**		
Site	**MzimEWR2**	**T34K 05835 (PES EIS Data)**	**T3TINA-N2ROA T34K-05835**	**T3 THIN-R316R T34A-05415**
Reference	**This study**	**PESEIS project (DWS, 2014c)**		
Date	20.09.2016	Various	20.09.2016	Various
Flow (m^3/s)		No data		No data
Biotope suitability	IHAS = 86%	No data	IHAS = 86%	No data
SASS5 Score or guideline	145	Final Reference Guideline Range: 160–190	145	Final Reference Guideline Range: 160–190
No of Taxa	22	Final Reference Guideline Range: 25–40	22	Final Reference Guideline Range: 25–40
ASPT	6.6	Final Reference Guideline Range: 6.0–7.2	6.6	Final Reference Guideline Range: 6.0–7.2
PES Percentage	76.5%	NA	76.5%	NA
PES: MIRAI (Category A–F)	C	NA	C	NA
Additional high-scoring taxa expected under reference conditions		Philopotamidae Psepheniidae Chlorocyphidae Athericidae		Philopotamidae Psepheniidae Chlorocyphidae Athericidae

Indicator taxa

The following taxa were selected as monitoring indicators for MzimEWR2: Perlidae, Baetidae (2spp), Heptageniidae, Leptophlebiidae, Teloganodidae, and Psepehenidae. Their flow velocity, habitat and water quality preferences are indicated in **Table 10.24** (extracted from MIRAI spreadsheet). Preference increases with score, with 4 or greater indicating a high preference. EcoSpecs and TPCs are shown in **Table 10.25**.

Table 10.24 Sampled and reference taxon preferences for flow velocities, physical habitat and water quality extracted from MIRAI (Thirion, 2007)

Taxon	Indicator and reference taxa: Preferences for physical and hydraulic habitat and water quality											
	Mzim EWR2	REF	Flow Velocity (m/s)				Habitat					WQ
	SASS SCORE		< 0.1	0.1–0.3	0.3–0.6	> 0.6	BR	COBB	VEG	GSM	WATER	
Perlidae	12	12	1	1	1	5	1	4	1	0	0	High
Baetidae >2spp	12	12	2	2	2	2	2	2	2	2	1	High
Heptageniidae	13	13	1	1	3	2	1	4	1	0	0	High
Leptophlebiidae	9	9	3	2	2	1	1	3	2	0	0	Moderate
Telagonodidae	12	12	0	0	2	4	1	4	1	0	0	High
Psephenidae	10	10	0	1	3	4	1	4	1	0	0	Moderate
Prosopistomatida		15	1	1	2	3	1	4	1	0	0	High
Trichorythidae		9	0	1	1	4	1	4	1	0	0	Moderate
Chlorocyphidae		10	2	3	1	0	1	4	1	0	0	Moderate
Athericidae		10	0	1	2	2	1	4	1	1	0	Moderate

Table 10.25 EcoSpecs and TPCs

Parameter	Baseline (PES)	EcoSpec	TPC
Community structure and balance (based on standard SASS5 sample)	Diverse community sampled, with 6 of the 22 taxa scoring in the 9–13 range, and occurring in A to B abundances (1–100). No indication of dominant taxa or other community structure imbalances (e.g. distortion in age distribution).	Sample should indicate a diverse community, sample with at least 4 indicator or expected taxa collected, at least 2 of which should score ≥ 12. High scoring taxa should occur in abundances of A to B (not as individuals). No indication of dominance. Diverse age structure.	Three or less indicator or expected taxa scoring ≥ 9, and one or more of these are present in sample as individuals only. Many of the lower-scoring taxa absent. There may be some indication of community imbalance (e.g. dominance of one or more taxa; age structure of the sample is biased either towards juveniles or adults).
SASS score range	160–190	160–190	< 130
No. of taxa	22	20 +	< 15
No. taxa scoring ≥ 9	6	5	≤ 4
ASPT score range	6.2–6.6	6.2–7	< 5.5
MIRAI score range (Using same reference condition as for this study)	77.6%	≥ 70%	< 60%

11 TSITSA (T35): IUA T35_A RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. Some smaller dams include Nquandu Dam and Maclear Dam which supply water to the Sidwadeni Scheme and Maclear (including former townships), respectively. There are a number of small farm dams located in the IUA, particularly in T35D. Lalini Dam is a major surface water development planned on the Tsitsa River (T35E) to supply water to regional settlements, proposed irrigation developments and for hydropower generation. Other development includes increased abstractions and return flows associated with the Maclear's growth. The IUA is largely rural with commercial farming operations, forestry plantations as well as many scattered rural and informal settlements and some cultivation and subsistence farming. High levels of erosion and sedimentation are prominent as a result of poor land-use practices.

IUA T35_a is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T35_a – Tsitsa

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
T35-1	Tsitsa	3	B	B	B
T35-2	Pot	3	B	B	B
T35-3	Klein Mooi	2	B	B	B
T35-4	Mooi	3 (WQ)	C	C	C
T35-5	Gqukunqa	2	B	B	B
MRU Tsitsa _B	Tsitsa	3	C	C	C

11.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T35_A

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 11.1** and the full EWR rule is provided as part of the electronic data for the project.

Table 11.1 Flow RQOs for IUA T35_a: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T35-1	B	B	101.14	97.6	17.50	17.30	28.25	27.9	0.756	0.331	2.547	1
T35-2	B	B	79.71	78.37	13.35	16.74	22.17	27.8	0.601	0.26	1.84	0.715
T35-3	B	B	63.69	61.52	9.76	15.33	17.16	26.9	0.282	0.122	1.619	0.615
T35-4	C	C	127.57	111.92	13.91	10.90	25.89	20.3	0.479	0.264	2.173	1.091
T35-5	B	B	46.09	43.9	7.63	16.56	12.63	27.4	0.349	0.149	1.019	0.396
MRU Tsitsa B	C	C	Extrapolated from MzimEWR1									

[1]MCM/a

11.2 RU T35-1: TSITSA RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

11.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 11.2**.

Table 11.2 RU T35-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Very low natural indigenous fish species richness with only one species (BANO) expected to be present. Flows should be adequate to ensure suitable habitats for this species. Flood regime, catchment management and water quality should be optimised. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species. Very low natural indigenous fish species richness with only one species (BANO) expected to be present. Flows should be adequate to ensure suitable habitats for	Maintain indigenous species richness (BANO) and current habitat diversity.
Indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
Species richness		Maintain indigenous species richness (BANO) and current habitat diversity.

Indicators	Narrative RQO	Numerical RQO
	this species. Flood regime, catchment management and water quality should be optimised. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	
MACROINVERTEBRATES		
Up to 48 macroinvertebrate families are expected to occur in the SQs of T35-1 (PESEIS database; DWS (2014). The indicator taxa highlighted in **Table 11.3** below are expected to occur with moderate (3) to high (5) confidence: perlid stoneflies; baetid, heptageniid, leptophlebiid and tricorythid mayflies; elmid and psephenid beetle larvae. There is a lower confidence that prosopistomatid mayflies (sensitivity score 15/15) will occur. The velocity, habitat and water quality prefernces for these taxa are listed in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain the PES of B.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain excellent water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate, high and very high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring > 12. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support diverse habitats (SIC, SOC, MV, and GSM) at the quality which would be expected under present day conditions.	Areas of coarse mobile substrates (cobbles, boulders) in slow to very fast flow should be present. MV is expected both in and out of flow. There should be patches of gravel, sand or mud (GSM).
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	Maintain ten to 15 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 11.3 Indicator taxa for T35-1 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T35A-05596	Tsitsana	5	5		5		5			5	5	3	5		5	3	5	3			43
T35A-05648	Tsitsa	1	5		5		5	1		5	5	5	5		5	5	5	5			48
T35A-05657	Hlankomo	3	3		3		3			3	3	1	3		3	1	3	1			39
T35A-05750	Tsitsa	3	5		3		5	1		5	5	3	5	5	3	5	1	3			46

11.3 RU T35-2: POT RIVER (HIGH PRIORITY – 3)

No improvement is required to achieve the TEC.

11.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 11.4**.

Table 11.4 RU T35-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of agricultural or forestry activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

11.4 RU T35-3: KLEIN-MOOI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

11.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 11.5**.

Table 11.5 RU T35-3: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

11.5 RU T35-4: MOOI RIVER (HIGH PRIORITY – 3(WQ))

No improvement is required to achieve the TEC.

11.5.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.

Model: N/A

Users: Maclear WWTW, urban impacts and a solid waste transfer site, cultivation/irrigation. A second WWTW outside Maclear has been observed on on Google Earth, which seems to discharge to a stream. An irrigation farmer in the area also reported poor water quality in the area in May 2017.

Water quality issue: Nutrients, toxics, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 11.6**.

Table 11.6 RU T35-4: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996c) and DWAF (2008b).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

11.5.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 11.7**.

Table 11.7 RU T35-4: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural or forestry activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Very low natural indigenous fish species richness with only one species (BANO) expected to be present. Flows should be adequate to ensure suitable habitats for this species. Flood regime, catchment management and water quality should be optimised. Adequate	Maintain indigenous species richness (BANO) and current habitat diversity.
Indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.

Indicators	Narrative RQO	Numerical RQO
Species richness	marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species. Very low natural indigenous fish species richness with only one species (BANO) expected to be present. Flows should be adequate to ensure suitable habitats for this species. Flood regime, catchment management and water quality should be optimised. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (BANO) and current habitat diversity.
MACROINVERTEBRATES		
Up to 52 macroinvertebrate families are expected to occur in the relevant SQs of T35-4 (PESEIS database; DWS (2014). The indicator taxa highlighted in **Table 11.8** below are expected to occur with moderate (3) to high (5) confidence: perlid stoneflies; baetid, heptageniid, prosopistomatid, leptophlebiid and tricorythid mayflies; elmid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1.** Prosopistomatids are unlikely to occur at a PES of C. The RQOs are set to maintain the PES of C.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain moderate to good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate, high and very high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to high velocity flow (0.3 to 0.6 m/s) will encourage the taxa scoring 12 and higher. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae.)
Habitat	Maintain conditions which support diverse habitats (SIC, SOC, MV, and GSM) at a moderate quality.	Areas of coarse mobile substrates (cobbles, boulders) in slow to very fast flow should be present to support the Flow Dependent Invertebrates. MV is expected both in and out of flow. There should be patches of gravel, sand or mud (GSM).
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV)	Maintain 5–10 cm depth over the top of the critical habitat (SIC). Marginal grasses, if present, should be inundated.

Table 11.8 Indicator taxa for T35-4 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	Nr Taxa
T35C-05874	Mooi	5	5		5		5	5		5	5	5	5	5	5	5	5	5			52
T35F-05973	Kuntombizi ninzi		5		3		5			5	5	5	5		5	5	5	5		5	42

11.6 RU T35-5: GQUKUNQA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

11.6.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Nessie Knight Hospital WWTW, settlements.
Water quality issue: Nutrients, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 11.9**.

Table 11.9 RU T34-6: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.025 mg/L PO_4-P (Aquatic ecosystems: driver).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

12 TSITSA (T35): IUA T35_B RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. A smaller dam includes Ugie Dam which supplies water to the town of Ugie. There are a number of small farm dams located in the IUA, particularly in T35G. There are no major surface water developments planned in the area. Other development includes increased abstractions and return flows associated with the growth of Ugie town. The IUA is largely rural with commercial farming operations, including irrigation and forestry plantations as well as some scattered rural villages in the lower part of the IUA.

IUA T35_b is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T35_b – Tsitsa

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
T35-6	Inxu	4	B	B	B
T35-7	Gqaqala	4	B	B	B
T35-8	Kuntombizininzi	4	B	B	B
MRU Inxu EWR 1	Inxu	3 (WQ)	B/C	B/C	B/C
MRU Gat IFR1	Gatberg	4	B/C	B	B

12.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T35_B

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 12.1** and the full EWR rule is provided as part of the electronic data for the project.

Table 12.1 Flow RQOs for IUA T35_b: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T35-6	B	B	37.64	33.71	6.30	16.74	10.38	27.6	0.288	0.124	0.87	0.339
T35-7	B	B	26.15	24.02	4.55	17.39	7.31	28	0.257	0.11	0.563	0.222
T35-8	B	B	14.29	9.68	2.39	16.74	3.75	26.3	0.06	0.03	0.33	0.129
MRU Inxu (EWR1)	C	C	44.4	39.4	6.35	14.31	7.93	17.87	0.345	0.171	0.812	0.369
MRU Gat (IFR1)	B	B	10.9	8.1	1.90	17.39	3.06	28.10	0.105	0.046	0.235	0.092

[1]MCM/a

12.2 RU T35-6: INXU RIVER (VERY HIGH PRIORITY – 4)

No improvement is required to achieve the TEC.

12.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 12.2**.

Table 12.2 RU T35-6: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of forestry activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

12.3 RU T35-7: GQAQALA RIVER (VERY HIGH PRIORITY – 4)

No improvement is required to achieve the TEC.

12.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 12.3**.

Table 12.3 RU T35-7: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 41 macroinvertebrate families are expected to occur in the relevant SQs of T34-7 (PESEIS database; DWS (2014)). There is a moderate (3) confidence that the following indicator taxa will occur (**Table 12.4**): perlid stoneflies, baetid, prosopistomatid, heptageniid, leptophlebiid and tricorythid mayflies, aeshnid and gomphid odonates, elmid and hydrophilid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. These are all likely to occur at a PES of B. The RQOs are set to maintain the PES of B.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of slow, moderate and very high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) to support FDIs. Areas of low flow (< 0.1–0.3 are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC, MV and GSM should be available. SIC areas should not be more than 30% embedded, and should have more than than 30% covered by silt or algae.

Indicators	Narrative RQO	Numerical RQO
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Ten to 15 cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 12.4 Indicator taxa for T35-7 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T35G-06135	Gqaqala	3	3		3		3	3		3	3	3	3	3	3	3		3			41
T35G-06169	Gqaqala						3				3	3	3		3	3		3			35
T35G-06179							3				3	3	3		3	3		3			35

12.4 RU T35-8: KUNTOMBIZININZI RIVER (VERY HIGH PRIORITY – 4)

No improvement is required to achieve the TEC.

12.4.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 12.5**.

Table 12.5 RU T35-8: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of forestry activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS	Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate	Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth

Indicators	Narrative RQO	Numerical RQO
	rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 42 macroinvertebrate families potentially occur in the SQs of T35-8 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 12.6** below are expected to occur with moderate (3) to high (5) confidence: perlid stoneflies; baetid (> 2spp), heptageniid, leptophlebiid and tricorythid mayflies; athericid dipterans, and elmid, hydrophilid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The first three of these taxa are sensitive, scoring ≥ 12 out of 15. The RQOs are set to maintain the PES of B. As the priority of this node is very high, the conditions have been set accordingly.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate to very high velocity flow during summer months in particular.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) will encourage the taxa scoring 12 or higher. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC, SOC and GSM should be present and in good condition. SIC should comprise clean, mobile cobbles with < 10% silt or algal cover.
Depth	Maintain depth conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, and GSM).	Ten to 15cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 12.6 Indicator taxa for T35-8 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T35F-05973	Kuntombizi ninzi		5		3		5			5	5	5	5		5	5	5	5		5	42

12.5 MRU INXU EWR 1: INXU RIVER (HIGH PRIORITY – 3(WQ))

No improvement is required to achieve the TEC.

12.5.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Ugie (appears to be low risk) WWTW, urban impacts, downstream irrigation and cultivation.
Water quality issue: Nutients, toxics, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 12.7**.

Table 12.7 MRU INXU EWR 1: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Acceptable limits.	50th percentile of the data must be less than 0.075 mg/L PO_4-P[1] (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996c) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

[1]This value is based on the Reserve water quality assessment for the development of Ugie Dam study (Scherman Colloty & Associates, 2011) and data from T3H014 DWS gauging weir. Note that the A category had to be re-calibrated for the site.
* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

12.5.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 12.8**.

Table 12.8 MRU Inxu EWR 1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.

12.6 MRU GAT IFR1: GATBERG RIVER (VERY HIGH PRIORITY – 4)

No improvement is required to achieve the TEC.

12.6.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 12.9**.

Table 12.9 MRU Gat IFR 1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only two species (AMOS and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, and BANO) and current habitat diversity.
Primary indicator species: AMOS		Maintain suitable flows to sustain semi-rheophilic AMOS (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 42 macroinvertebrate families potentially occur in the SQs of MRU GAT IFR1 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 12.10** below and expected to occur with low (1) to moderate (3) confidence are: Perlid stoneflies and Baetid (> 2spp) mayflies; and with moderate to high (5) confidence are: heptageniid, leptophlebiid and tricorythid mayflies; aeshnid and gomphid odonates, hydropsychid caddisflies, athericid dipterans, and elmid, hydrophilid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. Perlids, heptageniids and leptophlebiids are sensitive, scoring ≥12 out of 15. The RQOs are set to maintain the PES of B/C and to improve instream conditions to achieve the TEC of B. As the priority of this node is very high, the conditions have been set accordingly.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain very good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate to very high velocity flow during summer months in particular.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) to encourage the taxa scoring 12 or higher. Areas of lower flow are also required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC, SOC and GSM should be present and in good condition. SIC should comprise clean, mobile cobbles with < 10% silt or algal cover.

Indicators	Narrative RQO	Numerical RQO
Depth	Maintain depth conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, and GSM).	Ten to 15cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and areas both in and out of flow are preferable.

Table 12.10 Indicator taxa for MRU Gat (IFR1) at various confidence levels

SQ Nr	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1629	T35G-06069	Gatberg				5		5	5		5	5	5	5	5	5	5		5		1	46
1630	T35G-06074	Gatberg	3	3		3		3			3	3	3	3	3	1	3	3	3			41
1631	T35G-06099	Gatberg	1			1		1			1	5	1	5	5	1	5		1			38
1632	T35G-06100											1	3	3								24
1633	T35G-06108	Inxu	1	1		1		1	1		1	1	1	1		1	1	1	1			36
1634	T35G-06118	Gatberg						5			5	5	5	5	5	3	5		5			42
1635	T35G-06133			3				3				3	3	3		3	3					30

13 TSITSA (T35): IUA T35_C RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. There are a number of small farm dams located throughout the IUA. The proposed Lalini Dam on the Tsitsa River (T35L), to be used in conjunction with the proposed upstream Ntabelanga Dam for hydropower generation, is a major surface water development planned in the IUA. The IUA is largely rural with scattered rural villages and informal settlements supplied by rural water supply schemes. High levels of erosion and sedimentation are prominent as a result of poor land-use practices.

IUA T35_c is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T35_c – Tsitsa

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
MRU Inxu	Inxu	3	Extrapolated from MzimEWR4		
T35-9	KuNgindi	2	B/C	B/C	B/C
T35-10	Qwakele	2	C	B/C	B/C
T35-11	Ncolosi	2	C/D	C	C
T35-12	Culunca	2	C	B/C	B/C
T35-13	Tyira	2	C/D	C/D	C/D
T35-14	Xokonxa	4 (WQ)	C	C	C
T35-15	Ngcolora	2	C	C	C
T35-16	Ruze	2	B	B	B

13.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T35_C

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 13.1** and the full EWR rule is provided as part of the electronic data for the project.

Table 13.1 Flow RQOs for IUA T35_c: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T35-9	B/C	B/C	35.07	34.43	5.05	14.39	8.42	24	0.254	0.122	0.628	0.277
T35-10	C	B/C	19.87	19.72	2.33	11.73	4.1	20.7	0.12	0.067	0.288	0.147
T35-11	C/D	C	29.76	29.18	3.09	10.38	5.55	18.6	0.156	0.095	0.393	0.222
T35-12	C	B/C	18.12	17.58	2.10	11.61	3.74	20.6	0.112	0.062	0.254	0.129
T35-13	C/D	C/D	14.72	14.25	1.50	10.20	2.74	18.6	0.082	0.049	0.181	0.102

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T35-14	C	C	36.24	33.38	4.21	11.61	7.47	20.6	0.225	0.124	0.507	0.26
T35-15	C	C	10.19	10.07	0.92	8.98	1.93	18.9	0.05	0.025	0.108	0.032
T35-16	B	B	13.52	13.52	2.00	14.77	3.56	26.3	0.096	0.039	0.246	0.092

[1]MCM/a

13.2 RU T35-9: KUNGINDI (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.2**.

Table 13.2 T35-9: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

13.3 RU T35-10: GWAKELE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.3**.

Table 13.3 RU T35-10: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

13.4 RU T35-11: NCOLOSI RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.4.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Erosion and sedimentation.
Water quality issue: Turbidity.

Narrative and numerical details are provided in **Table 13.4**.

Table 13.4 RU T35-11: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO
Ensure that turbidity or clarity levels stay within Tolerable limits.	A large change from natural with erosion being a known cause of unnaturally large increases in sediment loads and turbidity. Habitat often silted but clears (Aquatic ecosystems: driver).

13.4.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.5**.

Table 13.5 RU T35-11: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** or improve.	Insufficient quantitative data exist to develop numerical RQOs.

Indicators	Narrative RQO	Numerical RQO
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

13.5 RU T35-12: CULUNCA RIVER (MODERATE PRIORITY – 2)

13.5.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.6**.

Table 13.6 RU T35-12: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 36 macroinvertebrate families potentially occur in the SQs of T35-12 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 13.7** below are expected to occur with low (1) confidence: perlid stoneflies; baetid (> 2spp), heptageniid, leptophlebiid and tricorythid mayflies, coenagriid and gomphid odonates, athericid dipterans and elmid, hydrophilid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The first three of these taxa score ≥ 12 and may be absent or occur in low numbers under PES C conditions, however are likely to be present if the TEC of a B/C is attained. This would require		

Indicators	Narrative RQO	Numerical RQO
an improvement in water quality, habitat condition, and flow. The RQOs are set to maintain the PES of C and to improve instream conditions to achieve the TEC of a B/C.		
Water quality	Minimise and mitigate against non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality and aim to improve this to very good quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to very high velocity flow (0.3 to > 0.6 m/s) to encourage the taxa scoring ≥ 12. Areas of slower flow are required to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	At least SIC, SOC and GSM should be present. SIC should comprise cobbles with > 50% mobility and <40% silt or algal cover.
Depth	Maintain conditions which support a width and depth which activates the preferred habitats of the indicator taxa (SIC, SOC, and MV)	Up to 10cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated, particularly during wet season, and MV areas both in and out of flow are preferable.

Table 13.7 Indicator taxa for T35-12 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	NoTaxa
T35K-05897	Culunca	1	1		1		1			1	1		1		1	1	1	1			36

13.6 RU T35-13: TYIRA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.6.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Settlements, erosion and sedimentation.
Water quality issue: Turbidity, nutrients, *E.coli*/faecal coliforms.

Narrative and numerical details are provided in **Table 13.8**.

Table 13.8 RU T35-13: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996c) and DWAF (2008b).		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

13.6.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.9**.

Table 13.9 RU T35-13: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further introduction of alien fish species.	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover) are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 36 macroinvertebrate families potentially occur in the sub-quaternary of T35-13 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 13.10** below are expected to occur with low (1) confidence: perlid stoneflies, baetid, heptageniid, leptophlebiid and tricorythid mayflies,		

Indicators	Narrative RQO	Numerical RQO
coenagriid and gomphid odonates, athericid dipterans and elmid, hydrophilid and psephenid beetle larvae. It is unlikely that taxa scoring ≥ 12 will occur at a PES of C/D however, and if they do, they will be in low numbers. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The RQOs are set to maintain the more resilient indicators and the PES of C/D.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain fair water quality.
Flow	Maintain flows which ensure areas of moderate and high velocity flow during the relevant months.	Maintain diverse flow habitat, with separate areas of slow, moderate and high velocity flow (0.1–0.6 m/s).
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	SIC, SOC and GSM should occur. Cobbles should have > 30% mobility and have <60% silt /algal cover.
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV, and GSM)	Five centimetres depth over the top of the critical habitat (SIC). At least the rootzone of marginal vegetation plants should be inundated, particularly during wet season.

Table 13.10 Indicator taxa for T35-13 at various confidence levels

SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
T35K-05897	Culunca	1	1		1		1			1	1		1		1	1	1	1			36

13.7 RU T35-14: XOKONXA RIVER (VERY HIGH PRIORITY – 4(WQ)

13.7.1 Water quality RQOs

Source: No detailed water quality assessment conducted. PESEIS data (DWS, 2014c) and literature sources (e.g. DWS, 2014a; DWAF, 1996a–e) were used.
Model: N/A
Users: Tsolo WWTW (critical risk), urban impacts (including Tsolo Agricultural College, St Lucy's and Dr Maliza Mphehle Memorial hospitals), crossings, dryland cultivation. There appears to be a number of WWTWs impacting on this stretch of river.
Water quality issue: Nutrients, turbidity, toxics, *E.coli/*faecal coliforms.

Narrative and numerical details are provided in **Table 13.11**.

Table 13.11 RU T35-14: Narrative and numerical water quality RQOs

Narrative RQO	Numerical RQO		
Ensure that nutrient levels are within Tolerable limits.	50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver).		
Ensure that turbidity or clarity levels stay within Tolerable limits.	A large change from natural with erosion being a known cause of unnaturally large increases in sediment loads and turbidity. Habitat often silted but clears (Aquatic ecosystems: driver).		
Ensure that toxics are within Ideal limits or A categories.	95th percentile of the data must be within the TWQR for toxics. Numerical limits can be found in DWAF (1996c) and DWAF (2008b).		
Ensure water quality state maintains biotic requirements as specified by RQOs for biota.	See specified biota requirements.		
Meet faecal coliform and *E. coli* targets for recreational / other (full or partial contact) use*	Potential health risks in terms of counts / 100 ml (SA NMMP guidelines).		
	Low	**Medium**	**High**
	< 600	600 – 2 000	> 2 000

* Guidelines are provided in the absence of data or knowledge of recreational activities in the area.

13.7.2 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.12**.

Table 13.12 RU T35-14: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural or forestry activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.
FISH		
Species richness	Low natural indigenous fish species richness with only three species (AMOS, AMAR and BANO) expected to be present. Flows should be adequate to ensure suitable habitats for primary (flow dependent) indicator species (juvenile AMOS and AMAR). Flood regime, catchment management and water quality should also be optimised to maintain adequate rocky substrate quality. Adequate marginal and aquatic vegetation as cover for BANO should be provided (limit overgrazing, altered flood regimes). Do not allow an increase in migration barriers to fish or further	Maintain indigenous species richness (AMOS, AMAR, and BANO) and current habitat diversity.
Primary indicator species: AMOS/AMAR		Maintain suitable flows to sustain semi-rheophilic AMOS and AMAR (especially juveniles). Floods and catchment management should be adequate to prevent deterioration in rocky substrate condition. Adequate depth should also be available to facilitate migration (especially wet season) and migration barriers should be mitigated.
Secondary indicator species: BANO		Ensure the habitat requirements (especially adequate vegetative cover)

Indicators	Narrative RQO	Numerical RQO
	introduction of alien fish species.	are maintained for BANO. Do not allow further introduction or spreading of predatory alien fish species.
MACROINVERTEBRATES		
Up to 32 macroinvertebrate families potentially occur in the sub-quaternary relevant to node T35-14 (PESEIS database; DWS (2014)). The indicator taxa highlighted in **Table 13.12** below are expected to occur with low (1) to moderate (3) confidence: baetid > 2spp, heptageniid, leptophlebiid mayflies, aeshnid and gomphid odonates, athericid dipterans and elmid and psephenid beetle larvae. The velocity, habitat and water quality preferences for these taxa are listed in **Section 3.5**, **Table 3.1**. The first two of these taxa score ≥ 12 and will likely only occur in small numbers under PES C conditions. The RQOs are set to maintain the PES of C.		
Water quality	Minimise non-natural alterations to the sediment regime and water quality.	No data to support numeric RQO. Maintain good water quality.
Flow	Maintain flows which mimic the natural hydrological variability and seasonality, and which ensure areas of moderate and high velocity flow during the relevant months.	Diverse flow habitat, with areas of moderate to high velocity flow (0.3 to 0.6 m/s) to encourage the taxa scoring ≥ 12, and areas of slower flow to support taxa with this preference (e.g. Leptophlebiidae, Gomphidae.)
Habitat	Maintain conditions which support the habitat type, diversity and quality which would be expected under present day conditions.	Coarse mobile substrates (cobbles, boulders) should be available
Depth	Maintain conditions which support a width and depth which emulates that of present day, and which activates the preferred habitats of the indicator taxa (SIC, MV).	Up to 10cm depth over the top of the critical habitat (SIC). Marginal vegetation, if present, should be inundated (at least the root zone), particularly during wet season, and areas both in and out of flow are preferable.

Table 13.13 Indicator taxa for T35-14 at various confidence levels

SQ Nr	SQ	RiverName	Perlidae	Baetidae > 2 spp	Ephemeridae	Heptageniidae	Oligoneuridae	Leptophlebiidae	Prosopistomatidae	Teloganodidae	Tricorythidae	Coenagrionidae	Aeshnidae	Gomphidae	Hydropsychidae > 2 spp	Elmidae/dryopidae	Hydrophilidae	Psephenidae	Athericidae	Corbiculidae	Sphaeriidae	No Taxa
1652	T35K-06167	Xokon-xa		3		3		3				1	3	3		1	1		3			32

13.8 RU T35-15: NGCOLORA RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.8.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.14**.

Table 13.14 RU T35-15: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **large** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **large**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

13.9 RU T35-16: RUZE RIVER (MODERATE PRIORITY – 2)

No improvement is required to achieve the TEC.

13.9.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 13.15**.

Table 13.15 RU T35-16: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **small** or improve	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of agricultural activities into the riparian zone or wetlands. Riparian zones through urban areas should not be additionally encroached.	Insufficient quantitative data exist to develop numerical RQOs.

14 TSITSA (T35): IUA T35_D RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. Lalini Dam is a major surface water development planned on the Tsitsa River (T35E) to supply water to regional settlements, proposed irrigation developments and for hydropower generation which will largely impact on the operational aspects of the IUA. The IUA is largely rural with scattered rural villages and informal settlements. High levels of erosion and sedimentation are prominent as a result of poor land-use practices.

IUA T35_d is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying table.

IUA T35_d – Tsitsa

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
MRU Tsitsa_Ca (MzimEWR 1)	Tsitsa	4	C	C	C
MRU Tsitsa_Cb (EWR1 Lalini)	Tsitsa	4	C	C	C
MRU Tsitsa D	Tsitsa	4	Represented by MzimEWR1		

Note that RQOs are not provided for MRU Tsitsa_Cb (EWR1 Lalini) as this is a hypothetical site situated downstream of the proposed Lalini Dam in the Tsitsa River (T35L). The site information from MzimEWR1 was used for this site as the study team did not survey the site. The hydrology and EWR results from the upstream MzimEWR1 were therefore extrapolated to a point below Lalini Dam to include the inflows downstream of MzimEWR1. This node is referred to as EWR1 Lalini. RQOs are provided for MzimEWR1 to satisfy IUA T35_d objectives.

14.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T34_D

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughes and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

Table 14.1 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in **Table 14.1** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.

- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

The following must be noted for the EWR sites impacted by dams of the MWP, i.e. MzimEWR1 (Tsitsa River) and MzimEWR4 (Lower Mzimvubu River). The TEC is a C for both sites. The EWRs associated with the C is provided as two scenarios:

Scenario 1 – MWP does not go ahead and dams are not built:

- Use EWR rule (flow duration table) for MzimEWR1.

Scenario 2 – MWP is implemented and Ntabelanga and Lalini dams are built:

- Scenario 69 flow duration table: It must be noted that Sc 69 includes all flow requirements for downstream users including the EWRs. Due to the nature of of the operation of a system for hydropower, exceedance of the required flows at unacceptable levels may arise, with an associated impact on seasonality. Flows should therefore not exceed the monthly flow distribution according to Sc 69 during the dry season. The wet season is limited to either Sc 69 or the natural flows. If the operating rule changes to flows less than Sc 69, it should at least provide the EWR with an acceptable seasonal distribution.

It must be noted that the TEC will not be achieved if any pulsed releases that cause unseasonal daily fluctuations form part of the operation of the MWP. During this study and the associated MWP studies, it was indicated that pulsed releases do not form part of the planned operating rule.

In summary therefore, information for MzimEWR1 (Tstitsa River) and MzimEWR4 (Lower Mzimvubu River) are presented as both EWR flows (no dam development) and flows related to Sc 69, i.e. flows required to be released from Ntabelanga and Lalini dams to meet downstream ecological requirements. Note that the Sc 69 flows therefore represent the total flows, which include releases, spills and tributary inflows (if relevant) that flow past the EWR site. These flows are the bottem flow duration table in **Table 14.1**. Note that the summary statistics are only relevant for the EWR rules (flow assurance rules) and not for the Sc 69 assurance table.

Table 14.1 Flow RQOs for MzimEWR1

MRU	River	Target EC	nMAR (MCM)	pMAR (MCM)	% of nMAR	Low flows (MCM)	Low flows (%)	High flows (MCM)	High flows (%)	Total flows (MCM)	Total (%)
Summary statistics											
MRU Tsitsa_Ca	Tsitsa	C	438.04	413.16	94.32	87.43	20	48.25	11	135.68	31

MzimEWR1: LOW flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)																	
Month	**Duration (%)**																
	0.1	**1**	**5**	**10**	**15**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**85**	**90**	**95**	**99**	**99.9**
Oct	8.70	8.70	8.01	7.16	7.15	7.12	5.83	5.09	4.01	3.12	2.64	2.24	2.12	2.02	1.89	1.65	1.65
Nov	11.31	11.31	11.31	11.31	11.31	11.08	9.01	7.58	5.67	3.99	3.37	2.89	2.65	2.38	2.11	2.00	2.00
Dec	15.20	15.20	15.20	15.20	15.20	15.16	13.26	10.96	7.96	5.61	4.33	3.49	3.10	2.60	1.97	1.22	1.22

Jan	18.57	18.57	18.57	18.57	18.57	18.35	15.44	13.09	10.11	7.58	5.50	4.18	3.60	3.03	2.32	1.74	1.74
Feb	19.53	19.53	19.53	19.53	19.53	19.03	16.27	14.47	11.34	8.35	5.73	4.19	3.65	3.15	2.71	2.31	2.31
Mar	23.57	23.57	23.30	22.84	22.21	21.39	19.42	16.98	14.22	10.57	7.09	4.75	4.01	3.37	2.84	2.61	2.61
Apr	17.94	17.94	17.94	17.94	17.94	17.49	15.29	13.70	11.40	8.10	5.75	4.36	3.76	3.22	2.65	2.12	2.12
May	13.37	13.37	12.41	11.14	11.12	11.10	9.66	8.39	6.70	4.83	3.56	2.91	2.69	2.46	2.21	2.09	2.09
Jun	8.75	8.75	8.14	7.74	7.72	7.45	5.87	4.98	3.54	2.69	2.44	2.22	2.05	1.96	1.87	1.74	1.74
Jul	7.66	7.66	7.07	6.57	6.55	6.48	4.78	4.33	3.41	2.60	2.32	2.12	2.00	1.92	1.79	1.56	1.56
Aug	6.33	6.33	6.09	5.75	5.47	5.16	4.51	3.84	3.00	2.39	2.09	1.89	1.82	1.76	1.71	1.69	1.69
Sep	8.54	8.54	6.51	5.72	5.70	5.32	4.20	3.97	3.15	2.18	1.83	1.74	1.52	1.30	1.18	1.18	1.18

MzimEWR1: HIGH flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	19.60	19.60	7.42	3.58	3.48	2.74	2.37	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	41.63	41.63	26.22	19.09	14.41	5.71	3.72	3.04	2.52	1.62	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Dec	60.02	60.02	26.22	20.85	19.60	18.49	7.92	4.73	3.17	2.65	2.36	0.05	0.00	0.00	0.00	0.00	0.00
Jan	63.74	63.74	28.48	19.60	12.76	7.71	6.63	5.83	2.92	3.33	2.63	2.33	0.65	0.08	0.00	0.00	0.00
Feb	57.35	57.35	48.53	23.58	19.60	17.18	14.19	9.49	4.96	2.75	2.43	2.05	0.81	0.11	0.00	0.00	0.00
Mar	74.63	74.63	36.90	25.28	20.08	17.66	8.90	5.91	5.17	4.06	3.16	2.67	1.66	0.44	0.14	0.00	0.00
Apr	26.22	26.22	7.60	4.14	3.48	3.05	3.48	2.74	1.91	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	19.60	19.60	2.05	2.22	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	16.22	16.22	2.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	35.01	35.01	3.11	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	7.85	7.85	3.33	2.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	30.67	30.67	3.35	2.23	2.20	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MzimEWR1: Sc69 Total (simulated flows in MCM)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	101.07	99.63	31.60	28.26	26.76	25.58	23.56	19.39	9.56	7.16	5.52	3.48	2.71	2.47	2.09	1.72	1.65
Nov	141.56	119.37	88.58	49.88	44.78	44.29	43.15	41.48	33.18	28.48	22.47	16.05	11.26	8.71	3.46	2.25	2.16
Dec	125.62	120.23	106.06	87.84	81.01	60.13	49.21	46.05	44.92	42.88	35.90	25.62	17.62	15.18	11.40	2.06	1.75
Jan	211.23	167.54	122.86	106.79	94.60	72.14	54.61	46.90	45.18	41.72	34.06	27.61	24.54	17.74	11.86	2.39	2.39
Feb	217.00	203.08	154.36	142.30	121.38	90.21	50.17	42.37	37.12	34.12	22.54	18.71	16.22	14.55	12.44	6.32	3.03
Mar	288.77	238.72	169.78	125.59	93.52	81.18	62.38	44.97	41.87	37.96	26.28	19.42	17.72	15.01	12.73	6.36	5.12
Apr	168.58	137.55	88.92	63.94	51.77	47.39	44.90	42.29	36.02	27.17	19.36	15.66	14.00	7.16	5.34	2.64	2.23
May	97.22	69.23	40.03	26.01	22.76	19.28	16.47	13.50	11.05	8.08	5.88	3.44	3.20	2.64	2.21	2.09	2.09
Jun	66.35	65.99	17.97	13.53	12.73	12.38	11.69	8.79	6.99	5.27	3.61	2.40	2.29	2.21	1.95	1.83	1.77
Jul	110.24	54.80	27.88	12.96	12.47	12.24	11.88	9.80	6.15	4.64	3.71	2.59	2.37	2.00	1.85	1.66	1.56
Aug	58.22	54.11	25.77	13.54	12.93	12.68	12.13	11.76	7.34	5.07	4.00	2.52	2.06	1.97	1.74	1.69	1.69
Sep	77.19	46.26	17.85	11.13	10.61	10.25	9.44	8.17	5.71	4.08	3.32	1.94	1.83	1.67	1.18	1.18	1.18

14.2 MRU TSITSA_C AND D: MZIMEWR1 TSITSA RIVER (VERY HIGH PRIORITY – 4)

The TEC for the different componenets for which RQOs must be specified are provided below:

Component	PES, REC, TEC
Physico-chemical	B
Geomorphology	C
Fish	C
Macroinvertebrates	C
Instream	C
Riparian vegetation	C/D
EcoStatus	C

14.2.1 Geomorphology

Geomorphology EcoSpecs and TPCs are shown in **Table 14.2**.

Table 14.2 MzimEWR1: Geomorphology EcoSpecs and TPCs (PES C)

Geomorphology metrics	EcoSpecs	TPC
Bed condition		
Particle size distribution of rapid	D50 of bed sediment should not decrease below that measured at present: 0.240 – 0.280 m.	D50 reduced by 20% (0.196 m).
Embeddedness	% embedded on rapid should range between 10% to 30% fines among boulder, cobble or coarse gravel.	Embeddedness exceeds 30% at more than 25% of the transect.
Channel cross-section		
Width of rapid at transect	Width between lower flood benches should not be less than 25 m on transect line (lower flood bench on left bank thought to have been lost previously by erosion).	Width reduced to less than 25 m.
Width of channel in pool	Increased extent of sandbar should not reduce the low flow channel width in the pool (present width 15 m).	Width of sandbar increased to 22m and low flow channel reduced to 13 m.
Lower flood bench		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding.
Sediment deposits	Evidence of fine sediment (silt and very fine sand) deposits.	No recent fine sediment deposits.
Upper flood bench		
Present-absent	Upper flood bench should be present on left bank.	Upper flood bench actively eroding.
Sediment deposits	Evidence of fine sediment deposits (silt to medium sand).	No recent sediment deposits linked to the last wet season.
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

14.2.2 Water quality (EcoSpecs)

Water quality EcoSpecs and TPCs are shown in **Table 14.3**. Few water quality issues are seen in this part of the catchment, where land-use is primarily dryland farming, rural settlements and limited irrigation along the rivers. Water quality impacts are seen around towns such as Qumbu (WWTW), downstream Tsolo (T35K) and upstream Ugie and Maclear, and the WWTW at Nessie Knight Hospital, but little evidence of these issues are prevalent at the site. Main water quality issues are erosion and elevated turbidities, and limited nutrient elevation. Due to the paucity of toxics data, assessments should revert to instream biota as indicators of water quality.

Table 14.3 MzimEWR1: Water quality EcoSpecs and TPCs (PES B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts(*)		
$MgSO_4$	The 95th percentile of the data must be ≤ 16 mg/L.	The 95th percentile of the data is 13–16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤ 20 mg/L.	The 95th percentile of the data is 16–20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤ 15 mg/L.	The 95th percentile of the data is 12–15 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤ 21 mg/L.	The 95th percentile of the data is 17–21 mg/L.
NaCl	The 95th percentile of the data must be ≤ 45 mg/L.	The 95th percentile of the data is 36–45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤ 351 mg/L.	The 95th percentile of the data is 280–351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤ 30 mS/m.	The 95th percentile of the data is 24–30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 8.0 to 8.8	The 5th percentile of the data is < 6.7 and > 7.8, and the 95th percentile is < 8.2 and > 8.6
Temperature	Natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥ 8.0 mg/L.	The 5th percentile of the data is < 8.2 mg/L.
Turbidity	Moderate – Large change from natural: Erosion and urban runoff processes are known causes of unnaturally large increases in sediment loads and turbidity. Increases are not permanent with clearing of habitats at times.	Frequent silting of habitats. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤ 0.25 mg/L	The 50th percentile of the data is 0.2–0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤ 0.015 mg/L.	The 50th percentile of the data is 0.012–0.015 mg/L
Response variables		
Chl-*a* phytoplankton (#)	The 50th percentile of the data must be ≤ 15 mg/L	The 50th percentile of the data is 12–15 µg/L

Water quality metrics	EcoSpecs	TPC
Chl-*a* periphyton (#)	The 50th percentile of the data must be ≤ 21 mg/m^2	The 50th percentile of the data is 17–21 mg/m^2
Toxics		
Toxics	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008b), or within the Acute Effects Value (AEV) as stated in DWAF (1996a) for those variables not in DWAF (2008b).	An impact is expected if the 95th percentile of the data exceeds the A category range in DWAF (2008b), or the Target Water Quality Range (TWQR) as stated in DWAF (1996a).

(*) Organic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
(#) Low confidence. EcoSpec and TPC. Boundaries may need adjusting as data becomes available.

14.2.3 Riparian vegetation

EcoSpecs and TPCs for riparian vegetation are shown in **Table 14.4**.

Table 14.4 MzimEWR1: Riparian vegetation EcoSpecs and TPCs (PES C/D)

Assessed metric	EcoSpec	TPC
Marginal zone		
Alien species invasion	Maintain an absence of perennial alien plant species.	An occurrence of perennial alien plant species.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species.	An occurrence of terrestrial woody species in the sub-zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species below 20%.	An increase in woody species cover above 30%
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Upper zone		
Alien species invasion	Maintain cover (% aerial) of perennial alien plant species below 40%.	An increase in perennial alien plant species cover > 40%.
Terrestrial woody species aerial cover	Maintain cover (% aerial) of terrestrial woody species at 10% or lower.	An increase in terrestrial woody species cover above 20%.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species above 5% and below 40%.	An absence of indigenous riparian woody species, or an increase above 50%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain an absence of reed cover	A presence of reeds.
MCB		
Alien species invasion	Maintain cover (% aerial) of perennial alien plant species below 60%.	An increase in perennial alien plant species cover >60%.
Terrestrial woody species aerial cover	Maintain cover (% aerial) of terrestrial woody species at 20% or lower.	An increase in terrestrial woody species cover above 30%.
Indigenous riparian woody	Maintain cover (% aerial) of	An absence of indigenous riparian

Assessed metric	EcoSpec	TPC
species cover (% aerial)	indigenous riparian woody species above 5% and below 40%.	woody species, or an increase above 50%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 10%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 59% for the riparian zone.	A decrease in PES score below 57.4% for the riparian zone.
Species richness	Maintain the presence of at least 19 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 15.
Dominant vegetation type	The dominant vegetation type shall remain non-woody in the marginal zone, and woody on the MCB.	Reduced proportion of non-woody cover below 10% in the marginal zone; reduced proportion of woody cover below 50% on the MCB.

14.2.4 Fish

Table 14.5 outlines the spatial FROC of the EWR site and indicates the FROC under reference and PES (baseline) conditions. EcoSpecs and TPCs based on the FRAI (Kleynhans, 2007) data are provided in **Table 14.6** for the PES.

Table 14.5 MzimEWR1: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC	
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC
Indigenous species				
AMOS	*Anguilla mossambica**	5	4	<4 (present at <50% of suitable sites sampled).
BANO	*Barbus/Enteromius anoplus*	3	1	<1 in reach (present at <10% of suitable sites sampled).

* Sampled at EWR site during baseline survey (September 2016).

Table 14.6 MZEWR1: Fish EcoSpecs and TPCs (PES: C)

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present ecological status of fish is in a C (68.2%).	Decrease of PES into a lower EC than PES (< C).	Any deterioration in habitat that results in decrease in FROC of species.
Species richness	All indigenous species	Both expected indigenous fish species estimated to still be present in the reach under PES (presence of AMOS confirmed during September 2016 survey).	Loss of any indigenous species. Presence of less than 1 indigenous species at EWR site using similar sampling methods and conducted during similar conditions (season, flow).	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water.	AMOS	Range of size classes present in moderate abundance at site (September 2016 survey: 6 specimens ranging 5–70 cm, CPUE: 0.11 ind/min).	AMOS absent during any survey OR present at FROC of < 4 in reach (present at <50% of suitable sites sampled). Absence of range of life stages (juveniles to adults) during various surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e. decreased flows, increased zero flows, and altered seasonality).
FD habitats				Reduced suitability (abundance and quality) of FD habitats (i.e. decreased flows, increased zero flows)
FS habitats				Reduced suitability (abundance and quality) of FS habitats (i.e. decreased flows, increased zero flows).
Substrate				Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates, Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Water quality intolerance	BANO	BANO expected to still be present in low abundance in reach. None sampled during September 2016 EWR survey at site. The primary impacts on BANO is associated with the loss of vegetation as cover and food source (due to overgrazing, trampling, erosion, alien plant encroachment) and the presence of	BANO absent during more than 2 consecutive survey OR present at FROC of < 1 (present at < 10% suitable sites). Absence of range of life stages (juveniles to adults) during various surveys.	Decreased water quality (especially flow related water quality variables such as oxygen).
Overhanging vegetation				Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
Instream vegetation		aggressive predatory alien species (MSAL and OMYK).		Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes)
Water column				Reduction in suitability of water column (i.e. increased sedimentation of pools, reduced flows).
SD habitats				Significant change in SD habitat suitability (i.e. increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
SS habitats				Significant change in SS habitat suitability (i.e. increased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	MSAL, OMYK, CCAR known or expected to be present in the SQ reach (September 2016 EWR survey confirmed presence of MSAL).	Presence of any additional alien/introduced species or increase in abundance (CPUE > 0.04 ind/min) and distribution of existing species.	N/A
Migratory success	Migratory species.	The presence of the catadromous Shortfin eel (AMOS) was confirmed at site, while the potamodromous Chubbyhead barb (BANO) is also expected to still be present.	Loss or decreased FROC (<4 in reach: present at <50% of suitable sites sampled) of especially the catadromous eel (AMOS).	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

14.2.5 Macroinvertebrates

Available SASS5 data collected at or near MzimEWR1 are summarised in **Table 14.7**.

Table 14.7 MzimEWR1: Available SASS5 data

MRU	MRU Mzimvubu			
Type	**Sample site**	**Sites used in development of reference**		
Site	**MzimEWR1**	**T35E-5976**	**T3TSITS_LALEN T35L-5976**	**T3TSIT-NGRFL T35A-05750**
Reference	**This study**	**PESEIS project (DWS, 2014c)**		
Date	19.09.2016	Various		
Flow (m^3/s)		No data		
Biotope suitability	IHAS = 62%	No data		
SASS5 score or guideline	134	Final Reference Guideline Range: 200–250		
No. of taxa	19	Final Reference Guideline Range: 30–40		
ASPT	7.1	Final Reference Guideline Range: 6.5–7.2		
PES percentage	72.9%			
PES: MIRAI (Category A - F)	C			
Additional high-scoring taxa expected under reference conditions		Philopotamidae Athericidae	Tricorythidae Chlorocyphidae	Calopterygidae Chlorocyphidae Hydropsychidae >2spp

Indicator taxa

The following taxa were selected as monitoring indicators for MzimEWR1: Perlidae, Baetidae (2spp), Heptageniidae, Leptophlebiidae, Prosopistomatidae, and Telagonodidae. Their flow velocity, habitat and water quality are indicated in **Table 14.8** (extracted from MIRAI spreadsheet). Preference increases with score, with 4 or greater indicating a high preference. EcoSpecs and TPCs are shown in **Table 14.9**.

Table 14.8 Sampled and reference taxon preferences for flow velocities, physical habitat and water quality extracted from MIRAI (Thirion, 2007)

Taxon	Indicator and reference taxa: Preferences for physical and hydraulic habitat and water quality											
	Mzim EWR1	REF	Flow velocity (m/s)				Habitat					WQ
	SASS SCORE		<0.1	0.1 - 0.3	0.3 - 0.6	>0.6	BR	COBB	VEG	GSM	WATER	
Perlidae	12	12	1	1	1	5	1	4	1	0	0	High
Baetidae >2spp	12	12	2	2	2	2	2	2	2	2	1	High
Heptageniidae	13	13	1	1	3	2	1	4	1	0	0	High
Leptophlebiidae	9	9	3	2	2	1	1	3	2	0	0	Moderate
Prosopistomatidae	15	15	1	1	2	3	1	4	1	0	0	High
Telagonodidae	12	12	0	0	2	4	1	4	1	0	0	High

Taxon	Indicator and reference taxa: Preferences for physical and hydraulic habitat and water quality											
	Mzim EWR1	REF	Flow velocity (m/s)				Habitat					WQ
	SASS SCORE		<0.1	0.1 - 0.3	0.3 - 0.6	>0.6	BR	COBB	VEG	GSM	WATER	
Trichorythidae		9	0	1	1	4	1	4	1	0	0	Moderate
Calopterygidae		10	1	3	1	0	0	1	3	1	0	Moderate
Chlorocyphidae		10	2	3	1	0	1	4	1	0	0	Moderate
Hydropsychidae > 2spp		12	0	1	2	4	2	3	1	0	0	High
Philopotamidae		10	0	1	2	3	1	4	1	1	0	Moderate
Athericidae		10	0	1	2	2	1	4	1	1	0	Moderate

Table 14.9 MZEWR1: Macroinvertebrate EcoSpecs and TPCs (PES: C)

Note: TPCs do not apply during drought conditions.

Parameter	Baseline (PES)	EcoSpec	TPC
Community structure and balance (based on standard SASS5 sample)	Diverse community sampled, with 5 of the 19 taxa scoring in the 12–15 range, and occurring in A to B abundances (1–100). Diverse age structure and no indication of dominant taxa or other community structure imbalances.	Sample should indicate a diverse community, with at least 4 reference or expected taxa, at least two of which should score ≥ 12. All high-scoring taxa should occur in abundances of A to B (not as individuals). A balanced community with no indication of dominance, and a diverse age structure.	Three or less reference or expected taxa (scoring ≥ 9), and one or more of these present as individuals only. Many of the lower-scoring taxa are absent. There is some indication of community imbalance (e.g. dominance of one or more taxa; age structure of the sample is biased either towards juveniles or adults).
SASS score range	160–180	150–220	< 130
No. of taxa	26	> 22	< 18
No. taxa scoring ≥ 12	5	4	3 or less
ASPT score range	6.2–6.6	6.2–7	5.5 or less
MIRAI score range (Using same reference condition as for this study)	77.6%	≥70%	60% or less

15 MZIMVUBU (T36): IUA T36_A RESOURCE QUALITY OBJECTIVES

The IUA overview and description is provided below.

The storage regulation in this IUA is low with no major dams located in the area. A smaller dam, the Majola Dam, supplies water for irrigation. The proposed upstream Ntabelanga and Lalini dams on the Tsitsa River to be developed for supplying water to regional settlements, proposed irrigation schemes and hydropower generation, is a major upstream surface water development that will significantly impact on the water resources in the IUA. The IUA is largely rural with scattered rural villages and settlements with some cultivation. High sediment loads occur in the river as a result of upstream erosion and sedimentation.

IUA T36_a is depicted below and the associated priority rating of the biophysical nodes are provided in the accompanying Table.

IUA T36_a – Mzimvubu

PRIORITY RATINGS

RU and MRU	Main river	Priority	PES	REC	TEC
T36-1	Mzintshana	2	B	B	B
T36-2	Mkata	3	B	B	B
MRU Mzim (Mzim EWR4)	Mzimvubu	4	C	C	C

15.1 HYDROLOGICAL (FLOW) RQOs FOR IUA T36_A

Source: Reports from the study; DWS (2017a), DWS (2017c).
Model: Desktop Reserve Model (DRM) Hughe s and Hannart (2003), Water Resource Yield Model (WRYM) (DWAF, 2008d).

A summary of the flow RQOs for the desktop biophysical nodes are provided in **Table 15.1** and the flow RQOs for MzimEWR4 are provided in **Table 15.2.** The full EWR rule is provided as part of the electronic data for the project.

Table 15.2 provides the hydrological RQOs for rivers expressed in terms of an assigned volume at the EWR sites. The volume assigned for low (base) flows and for high (flood) flows are also provided. The distribution of this volume across the months must be variable according to a natural (unless specified differently) variability. The variability is dependent on the intra-annual (seasonal) and inter-annual patterns of natural flow conditions. Details are provided in Table **15.2** as follows:

- Low (base flows): These flows are provided as a monthly volume in the form of a flow assurance table which provides discharges which must be equalled or exceeded with different percentage frequencies.
- High (flood) flows: These flows are a set of flood events defined by a peak discharge in cubic meters per second, an event duration in hours and the frequency of the event. The frequency with which these flood events are expected to occur, as well as the size of each event, is also dependent on the natural variability and this is reflected in the high flow assurance table that defines the volume requirements with different percentage frequencies of exceedance.

The following must be noted for the EWR sites impacted by dams of the MWP, i.e. MzimEWR1 (Tsitsa River) and MzimEWR4 (Lower Mzimvubu River). The TEC is a C for both sites. The EWRs associated with the C is provided as two scenarios:

Scenario 1 – MWP does not go ahead and dams are not built:
- Use EWR rule (flow duration table) for MzimEWR4.

Scenario 2 – MWP is implemented and Ntabelanga and Lalini dams are built:
- Scenario 69 flow duration table: It must be noted that Sc 69 includes all flow requirements for downstream users including the EWRs. Due to the nature of of the operation of a system for hydropower, exceedance of the required flows at unacceptable levels may arise, with an associated impact on seasonality. Flows should therefore not exceed the monthly flow distribution according to Sc 69 during the dry season. The wet season is limited to either Sc 69 or the natural flows. If the operating rule changes to flows less than Sc 69, it should at least provide the EWR with an acceptable seasonal distribution.

It must be noted that the TEC will not be achieved if any pulsed releases that cause unseasonal daily fluctuations form part of the operation of the MWP. During this study and the associated MWP studies, it was indicated that pulsed releases do not form part of the planned operating rule.

In summary therefore, information for MzimEWR1 (Tstitsa River) and MzimEWR4 (Lower Mzimvubu River) are presented as both EWR flows (no dam development) and flows related to Sc 69, i.e. flows required to be released from Ntabelanga and Lalini dams to meet downstream ecological requirements. Note that the Sc 69 flows therefore represent the total flows, which include releases, spills and tributary inflows (if relevant) that flow past the EWR site. These flows are the bottem flow duration table in **Table 14.1**. Note that the summary statistics are only relevant for the EWR rules (flow assurance rules) and not for the Sc 69 assurance table.

Table 15.1 Flow RQOs for IUA T36_a: RUs with desktop biophysical nodes

RU	PES	TEC (EWR)	nMAR[1]	pMAR[1]	Low flows[1]	Low flows (%nMAR)	Total flows[1]	Total (%nMAR)	Low flows			
									Sep		Feb	
									60%	90%	60%	90%
T36-1	B	B	14.34	14.25	2.17	15.10	3.75	28.1	0.153	0.06	0.173	0.068
T36-2	B	B	9.78	9.72	1.48	15.10	2.56	26.1	0.104	0.041	0.118	0.046

[1]MCM/a

Table 15.2 Flow RQOs for MzimEWR4

MRU	River	Target EC	nMAR (MCM)	pMAR (MCM)	% of nMAR	Low flows (MCM)	Low flows (%)	High flows (MCM)	High flows (%)	Total flows (MCM)	Total (%)
Summary statistics											
Mzim	Mzumvubu	C	2655.13	2532.21	95.37	331.16	12.5	301.30	11.3	632.46	23.8

MzimEWR4: LOW flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	34.10	34.10	28.94	25.96	25.94	25.32	22.77	20.51	17.87	15.44	12.81	10.90	10.03	9.33	8.93	8.72	8.72
Nov	37.13	37.13	37.13	34.98	34.75	33.72	28.50	25.08	22.35	18.39	14.97	13.17	11.92	11.65	11.65	11.65	11.65
Dec	47.66	47.66	47.66	47.66	47.66	47.65	44.00	35.60	27.60	22.67	18.53	14.75	12.73	11.29	9.71	9.45	9.45
Jan	62.11	62.11	62.11	57.65	57.31	55.38	51.20	43.39	36.58	29.67	24.10	18.74	16.15	13.95	12.55	11.70	11.70
Feb	70.94	70.94	70.94	70.94	70.94	62.72	53.48	46.52	40.18	32.53	27.75	21.21	18.91	16.69	15.94	14.62	14.62
Mar	79.59	79.59	78.95	77.83	76.26	74.10	67.53	57.32	48.84	39.72	33.43	27.85	25.44	23.17	21.08	19.67	19.67
Apr	57.14	57.14	57.14	57.14	57.14	56.69	52.85	44.76	39.83	33.41	27.79	22.70	20.01	17.74	15.49	15.30	15.30
May	41.77	41.77	41.77	40.16	38.15	35.61	35.17	30.89	28.28	22.93	18.47	15.28	14.03	13.42	13.41	13.41	13.41
Jun	32.39	32.39	31.46	26.37	26.29	26.04	25.52	21.69	19.05	15.41	12.79	11.36	11.35	11.34	11.34	11.34	11.34
Jul	28.61	28.61	27.96	23.87	23.76	23.59	22.97	19.85	17.09	14.15	12.13	10.68	9.74	9.18	8.94	8.56	8.56
Aug	21.52	21.52	21.38	21.15	20.82	20.36	19.03	17.33	15.36	13.24	11.23	9.49	8.79	8.36	8.00	7.77	7.77
Sep	43.71	43.71	27.40	19.94	19.70	19.69	17.39	15.92	14.98	11.60	9.69	8.38	8.38	8.37	8.37	8.37	8.37

MzimEWR4: HIGH flow Assurance rules (MCM) for PES and REC: C (as a flow duration table)

Month	Duration (%)																
	0.1	1	5	10	15	20	30	40	50	60	70	80	85	90	95	99	99.9
Oct	146.76	146.76	85.54	30.40	30.26	21.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	333.43	333.43	132.67	95.66	42.97	30.37	29.59	0.87	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	298.80	298.80	132.67	105.01	75.67	42.98	40.92	27.62	19.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Jan	451.00	451.00	239.86	161.13	75.27	58.19	34.32	34.97	28.55	20.87	4.44	0.65	0.59	0.00	0.00	0.00	0.00
Feb	434.11	434.11	311.52	189.93	136.44	116.26	62.03	36.18	30.41	28.34	21.16	1.87	1.15	0.30	0.00	0.00	0.00
Mar	513.10	513.10	360.97	211.04	125.31	75.74	66.91	38.38	32.28	31.54	30.13	2.79	1.11	0.63	0.00	0.00	0.00
Apr	358.04	358.04	42.97	42.97	30.41	30.41	29.66	21.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	277.53	277.53	39.20	1.44	0.64	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	129.12	129.12	60.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	129.12	129.12	30.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	30.41	30.41	26.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	98.10	98.10	29.56	18.92	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

MzimEWR4: Sc69 Total (simulated flows in MCM)

Month	**Duration (%)**																
	0.1	**1**	**5**	**10**	**15**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**85**	**90**	**95**	**99**	**99.9**
Oct	838.51	674.36	342.37	224.51	203.78	142.82	102.53	80.95	69.87	62.60	59.67	53.18	49.86	47.93	45.19	40.84	39.48
Nov	1027.27	971.20	640.08	432.04	291.86	226.02	181.66	142.31	127.09	107.02	99.40	90.37	82.75	81.55	78.09	74.22	70.77
Dec	1068.58	957.73	784.66	666.47	495.86	433.75	350.50	192.48	147.37	118.84	107.19	93.94	89.37	82.52	73.34	70.38	68.38
Jan	1529.67	1526.50	1144.31	824.08	542.77	446.43	386.01	279.86	222.13	187.51	154.59	139.33	117.07	103.41	91.08	76.47	73.34
Feb	1606.10	1477.23	1262.06	1170.57	881.16	652.91	462.27	378.03	297.87	215.46	180.47	147.73	139.94	120.48	106.05	80.17	66.67
Mar	2520.37	1816.45	1388.55	971.53	715.65	626.96	533.41	425.10	345.40	299.83	216.03	170.54	160.38	146.82	118.53	88.62	82.29
Apr	1129.41	924.45	651.48	437.52	310.31	292.62	248.13	210.55	181.20	147.33	129.17	121.71	110.00	98.13	85.92	69.90	50.22
May	1001.74	594.15	207.69	158.42	146.16	116.94	86.95	72.87	67.70	58.06	49.66	44.94	42.12	40.60	37.41	31.30	28.14
Jun	717.31	700.49	180.66	97.77	90.54	76.04	57.79	49.38	42.86	36.88	34.14	32.00	30.32	28.47	27.50	24.79	20.05
Jul	762.88	561.71	261.93	90.28	75.26	67.43	55.53	47.25	37.79	34.58	31.80	29.33	28.00	26.92	25.56	23.13	16.96
Aug	389.82	356.54	146.42	86.66	73.10	63.24	48.71	42.32	36.93	33.26	30.32	27.87	26.59	25.67	24.23	22.02	20.15
Sep	1851.31	631.08	203.83	111.18	76.19	61.05	49.07	41.93	37.08	31.97	28.35	24.92	23.89	23.19	20.27	19.49	19.30

15.2 RU T36-1 (MZINTSHANA RIVER) (MODERATE PRIORITY – 2)

15.2.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 15.3**.

Table 15.3 RU T36-1: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **moderate**. There should be no expansion of agricultural activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.

15.3 RU T36-2: MKATA RIVER (HIGH PRIORITY – 3)

15.3.1 Habitat and biota RQOs (EcoSpecs)

Habitat and biota RQOs are provided in **Table 15.4**.

Table 15.4 RU T36-2: Narrative and numerical habitat and biota RQOs

Indicators	Narrative RQO	Numerical RQO
RIPARIAN VEGETATION		
Presence of alien plant species	The extent of perennial alien plant species within the riparian zone should remain **small** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone continuity	Modification of riparian zone continuity should remain **moderate** or improve.	Insufficient quantitative data exist to develop numerical RQOs.
Riparian zone fragmentation	Riparian zone fragmentation should not increase from its assessed modification of **small**. There should be no expansion of agricultural activities into the riparian zone or wetlands.	Insufficient quantitative data exist to develop numerical RQOs.

15.4 MRU MZIM: MZIMEWR4 MZIMVUBU RIVER (VERY HIGH PRIORITY – 4)

The TEC for the different componenets for which RQOs must be specified are provided below:

Component	PES, REC, TEC
Physico-chemical	**A/B**
Geomorphology	**C**
Fish	**C**
Macroinvertebrates	**C**
Instream	**C**
Riparian vegetation	**C/D**

EcoStatus	C

15.4.1 Geomorphology

EcoSpecs and TPCs for geomorphology are shown in **Table 15.5**.

Table 15.5 MzimEWR4: Geomorphology EcoSpecs and TPCs (PES C)

Geomorphology metrics	EcoSpecs	TPC
Bed sediments		
Particle size distribution of rapid	D50 and D16 of mobile bed sediment should not decrease below that measured at present: 30 mm and 28 mm respectively.	D50 and D16 reduced by 20% (14 and 24 mm respectively).
Embeddedness	% embedded on transect should range between 5% to 20% fines among boulder, cobble or coarse gravel. Monitoring sites should also be set up in shallow edge habitat along rapid and across macroinvertebrate sampling site upstream.	Embeddedness exceeds 20% at more than 25% of the transect and at additional monitoring sites.
Channel cross-section		
Width of rapid at transect	Width between lower flood benches should not be less than 85 m on transect line (see figure below).	Width reduced to less than 80 m.
Lower flood bench		
Present-absent	Lower flood bench should be present on both banks.	Lower flood bench actively eroding.
Sediment deposits	Evidence of fine sediment (silt and very fine sand) deposits.	No recent fine sediment deposits.
Upper flood bench		
Present-absent	No clear indicators.	
Sediment deposits	No clear indicators.	
Channel pattern		
Channel type	Channel should not change from a single thread channel with pool-rapid morphology.	Change to a different channel type.

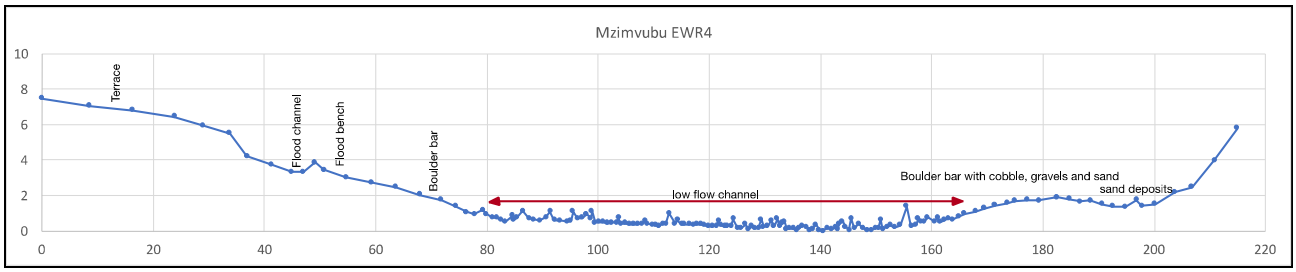


Figure 15.1 Geomorphic features identified on the cross-section transect at MzimEWR4

15.4.2 Water quality (EcoSpecs)

Water quality EcoSpecs and TPCs are shown in **Table 15.6**. Few water quality issues are seen in this part of the catchment, where the terrain is rugged with scattered rural settlements. Small agricultural plots are seen on the floodplains. Sedimentation from upstream erosion is evident but

the overall erosion status in the immediate vicinity of the site is lower than expected due to storage in the large catchment. Fine sediment deposition takes place on boulder bars but there is little instream deposition.

Table 15.6 MzimEWR4: Water quality EcoSpecs and TPCs (PES A/B)

Water quality metrics	EcoSpecs	TPC
Inorganic salts(*)		
$MgSO_4$	The 95th percentile of the data must be ≤ 16 mg/L.	The 95th percentile of the data is 13–16 mg/L.
Na_2SO_4	The 95th percentile of the data must be ≤ 20 mg/L.	The 95th percentile of the data is 16–20 mg/L.
$MgCl_2$	The 95th percentile of the data must be ≤ 15 mg/L.	The 95th percentile of the data is 12–15 mg/L.
$CaCl_2$	The 95th percentile of the data must be ≤ 21 mg/L.	The 95th percentile of the data is 17–21 mg/L.
NaCl	The 95th percentile of the data must be ≤ 45 mg/L.	The 95th percentile of the data is 36–45 mg/L.
$CaSO_4$	The 95th percentile of the data must be ≤ 351 mg/L.	The 95th percentile of the data is 280–351 mg/L.
Physical variables		
Electrical Conductivity	The 95th percentile of the data must be ≤ 30 mS/m.	The 95th percentile of the data is 24–30 mS/m.
pH	The 5th percentile of the data must range from 6.5 to 8.0, and the 95th percentile from 8.0 to 8.8	The 5th percentile of the data is < 6.7 and > 7.8, and the 95th percentile is < 8.2 and > 8.6
Temperature	Natural temperature range is expected.	Abundance and frequency of occurrence of temperature sensitive species are lower than expected for reference.
Dissolved oxygen	The 5th percentile of the data must be ≥ 8.0 mg/L.	The 5th percentile of the data is < 8.2 mg/L.
Turbidity	Moderate change from natural: Urban activities and land-use have resulted in temporary but unnaturally high sediment loads and turbidity.	More frequent silting of habitats. Check biotic response for habitat-related changes.
Nutrients		
Total Inorganic Nitrogen (TIN-N)	The 50th percentile of the data must be ≤ 0.25 mg/L	The 50th percentile of the data must be 0.2–0.25 mg/L
PO_4-P	The 50th percentile of the data must be ≤ 0.010 mg/L.	The 50th percentile of the data must be 0.008–0.010 mg/L
Response variables		
Chl-*a* phytoplankton (#)	The 50th percentile of the data must be ≤ 15 mg/L	The 50th percentile of the data must be 12–15 µg/L
Chl-*a* periphyton (#)	The 50th percentile of the data must be ≤ 21 mg/m^2	The 50th percentile of the data must be 17–21 mg/m^2
Toxics		
Toxics	The 95th percentile of the data must be within the A (or 0) category in DWAF (2008b), or within the Acute Effects Value (AEV) as stated in DWAF (1996a) for those	An impact is expected if the 95th percentile of the data exceeds the A category range in DWAF (2008b), or the Target Water Quality Range (TWQR) as stated in DWAF

Water quality metrics	EcoSpecs	TPC
	variables not in DWAF (2008).	(1996a).

(*) Organic salts only to be generated when the TPC for Electrical Conductivity is exceeded or salt pollution is expected, should a tool for generating salts be available.
(#) Low confidence. EcoSpec and TPC. Boundaries may need adjusting as data becomes available.

15.4.3 Riparian vegetation

Riparian vegetatation EcoSpecs and TPCs are shown in **Table 15.7.**

Table 15.7 MzimEWR4: Riparian vegetation EcoSpecs and TPCs (PES C/D)

Assessed metric	EcoSpec	TPC
Marginal zone		
Alien species invasion	Maintain an absence of perennial alien plant species.	An occurrence of perennial alien plant species.
Terrestrial woody species aerial cover	Maintain an absence of terrestrial woody species	An occurrence of terrestrial woody species in the sub-zone.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species below 20%.	An increase in woody species cover above 30%
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 20%.	A decrease in non-woody cover (% aerial) below 10%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Upper zone		
Alien species invasion	Maintain cover (% aerial) of perennial alien plant species below 30%.	An increase in perennial alien plant species cover > 30%.
Terrestrial woody species aerial cover	Maintain cover (% aerial) of terrestrial woody species at 10% or lower.	An increase in terrestrial woody species cover above 30%.
Indigenous riparian woody species cover (% aerial)	Maintain cover (% aerial) of indigenous riparian woody species above 5% and below 40%.	An absence of indigenous riparian woody species, or an increase above 50%.
Non-woody indigenous cover (grasses, sedges and dicotyledonous forbs) (% aerial)	Maintain non-woody cover (% aerial) above 30%.	A decrease in non-woody cover (% aerial) below 20%.
Reed cover (% aerial)	Maintain an absence of reed cover.	A presence of reeds.
Riparian zone		
PES	Maintain PES score (using VEGRAI level 4 for assessment) of at least 59% for the riparian zone.	A decrease in PES score below 57.4% for the riparian zone.
Species richness	Maintain the presence of at least 27 indigenous plant species within the riparian zone.	A decrease in the number of indigenous plant species within the riparian zone below 25.
Dominant vegetation type	The dominant vegetation type shall remain non-woody in the riparian zone.	Reduced proportion of non-woody cover below 10% in the marginal or lower zones; reduced proportion of non-woody cover below 30% in the upper zone.

15.4.4 Fish

Table 15.8 outlines the spatial FROC of the EWR site and indicates the FROC under reference and PES (baseline) conditions. EcoSpecs and TPCs based on the FRAI (Kleynhans, 2007) data are provided **Table 15.9** for the PES.

Table 15.8 MzimEWR4: Spatial FROC under reference, PES conditions and TPCs for baseline (PES) conditions

Species (Abbr.)	Scientific names: Reference species (Introduced species excl.)	Reference (A)	PES: C EC	
		Reference FROC	EC: Observed and habitat derived FROC	FROC TPC
Indigenous species				
AAEN	*Awaous aeneofuscus*	2	1	< 1 (present at <10% of suitable sites sampled).
ABIC	*Anguilla bicolor bicolor*	2	1	< 1 (present at <10% of suitable sites sampled).
ALAB	*Anguilla bengalensis labiata*	2	1	< 1 (present at <10% of suitable sites sampled).
AMAR	*Anguilla marmorata*	4	3.5	< 3.5 in reach (present at <40% of suitable sites sampled)
AMOS	*Anguilla mossambica*	4	3.5	< 3.5 in reach (present at <40% of suitable sites sampled)
BANO	*Barbus/Enteromius anoplus*	2	1	< 1 (present at <10% of suitable sites sampled).
GCAL	*Glossogobius callidus*	3	2.5	< 2.5 in reach (present at < 20% of suitable sites sampled)
GGIU	*Glossogobius giuris*	3	2.5	< 2.5 in reach (present at < 20% of suitable sites sampled)
OMOS	*Oreochromis mossambicus*	2	1	< 1 (present at <10% of suitable sites sampled).

* Sampled at EWR site during baseline survey (September 2016).

Table 15.9 EWR 4: Fish EcoSpecs and TPCs (PES: C)

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
Ecological status	PES	Present ecological status of fish is in a C (76.1%).	Decrease of PES into a lower EC than PES (< C).	Any deterioration in habitat that results in decrease in FROC of species.
Species richness	All indigenous species	All nine of the expected indigenous fish species estimated to still be present in the reach under PES. Three indigenous fish species were sampled, namely the AMAR, AMOS and *Glossogobius callidus* (GCAL).	Loss of any indigenous species. Presence of less than 3 indigenous species at EWR site using similar sampling methods and conducted during similar conditions (season, flow).	Loss in diversity, abundance and condition of velocity-depth categories and cover features that lead to a loss of species.
Requirement for flowing water.	ALAB/AMOS/ AMAR	Two eel species (AMOS and AMAR) present in relatively low abundance at site (September 2016 survey: AMAR 2 specimens ranging 33–60 cm, CPUE: 0.03 ind/min; AMOS 1 individual, 40 cm, CPUE: 0.01 ind/min).	AMOS OR AMAR absent during any survey OR present at FROC of < 3.5 in reach (present at < 40% of suitable sub-sites sampled). Absence of range of life stages (juveniles to adults) during various surveys.	Reduced suitability (abundance and quality) of flowing habitats (i.e. decreased flows, increased zero flows, and altered seasonality).
SD habitats				Significant change in SD habitat suitability (i.e. increased or decreased flows, altered seasonality, increased sedimentation of slow habitats).
FD habitats				Reduced suitability (abundance and quality) of FD habitats (i.e. decreased flows, increased zero flows)
FS habitats				Reduced suitability (abundance and quality) of FS habitats (i.e. decreased flows, increased zero flows).
Undercut banks				Significant change in undercut bank and rootwads habitats (e.g. bank erosion, reduced flows).
Substrate	*Awaous aeneofuscus* (AAEN)	Expected to still be present in reach (none sampled during EWR survey in September 2016).	AAEN absent during 3 consecutive surveys. Absence of range of life stages (juveniles to adults) during various surveys.	Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates. Increased sedimentation of riffle/rapid substrates, excessive algal growth on substrates.
Water quality intolerance				Decreased water quality (especially flow related water quality variables

Metric	Indicator	Ecospecs/RQOs	TPC (Biotic)	TPC (Habitat)
				such as oxygen).
Overhanging vegetation	BANO	Expected to still be present in reach (none sampled during EWR survey in September 2016).	BANO absent during 3 consecutive surveys. Absence of range of life stages (juveniles to adults) during various surveys.	Significant change in overhanging vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, vegetation removal, alien vegetation encroachment).
Instream vegetation				Significant change in instream vegetation habitats (overgrazing, flow modification, use of herbicides, agriculture, alien macrophytes)
Water column	OMOS	Expected to still be present in reach (none sampled during EWR survey in September 2016).	OMOS absent during 3 consecutive surveys. Absence of range of life stages (juveniles to adults) during various surveys.	Reduction in suitability of water column (i.e. increased sedimentation of pools, reduced flows).
SS habitats	GCAL	Range of size classes present in relatively low abundance at site (September 2016 survey: 5 specimens ranging 6–15cm tail length, CPUE: 0.08 ind/min)	GCAL absent during 2 consecutive surveys OR present at FROC of < 2.5 in reach. Absence of range of life stages (juveniles to adults) during various surveys.	Significant change in SS habitat suitability (i.e. increased flows, altered seasonality, increased sedimentation of slow habitats).
Alien fish species	Presence of any alien/introduced spp.	Based on other available data for the region, it is also expected that some alien species may be present (CCAR, MSAL, LMAC).	Presence of any additional alien/introduced species or increase in abundance and distribution of existing species.	N/A
Migratory success	Migratory species	The presence of the catadromous AMOS and AMAR while various potamodromous are also expected to still be present.	Loss or decreased FROC of catadromous (eels) or potamodromous species (such as BANO).	Alteration of longitudinal habitat through the creation of migration barriers (dams, weirs, zero flows, poor water quality causing chemical barriers).

15.4.5 Macroinvertebrates

Available SASS5 data collected at or near MzimEWR4 are summarised in **Table 15.10**.

Table 15.10 MzimEWR 4: Available invertebrate information

MRU	MRU Mzimvubu			
Type	**Sample site**	**Sites used in development of reference**		
Site	**MzimEWR4**	**T36A-06354**	**T3MZIM-NTSHA: T32F-05464**	**T3MZIN-FLAGS T32H-05842**
Reference	**This study**	**PESEIS project (DWS, 2014c)**		
Date	21.09.2016	Various		
Flow (m^3/s)		No data		
Biotope suitability	IHAS = 85%	No data		
SASS5 score or guideline	160	Final Reference Guideline Range: 200–240		
No. of taxa	26	Final Reference Guideline Range: 30–40		
ASPT	6.2	Final Reference Guideline Range: 6.5–7		
PES percentage	77.6%			
PES: MIRAI (Category A–F)	B/C			
Additional high-scoring taxa expected under reference conditions		Prosopistomatidae Hydropsychidae > 2spp,	Ephemeridae Tricorythidae Hydropsychidae > 2spp, Athericidae	Prosopistomatidae Tricorythidae Notonemouridae Athericidae

Indicator taxa

The following taxa, all scoring in the range 9–13 (in a sensitivity range 0–15), were selected as monitoring indicators for MzimEWR4: Palaeomonidae, Perlidae, Baetidae (> 2spp), Heptageniidae, Leptophlebiidae, Teloganodidae, Psephenidae. Their flow velocity, habitat and water quality are indicated in **Table 15.11** (extracted from MIRAI spreadsheet). Preference increases with score, with 4 or greater indicating a high preference. EcoSpecs and TPCs are shown in **Table 15.12**.

Table 15.11 Sampled and reference taxon preferences for flow velocities, physical habitat and water quality extracted from MIRAI (Thirion, 2007)

Taxon	Indicator and reference taxa: Preferences for physical and hydraulic habitat and water quality											
	Mzim EWR4	REF	Flow velocity (m/s)				Habitat					WQ
	SASS SCORE		< 0.1	0.1–0.3	0.3–0.6	>0.6	BR	COBB	VEG	GSM	WATER	
Paleomonidae	10	10	0	2	2	3	0	3	0	0	0	Moderate
Notonemouridae		14	1	1	2	4	1	4	1	0	0	High
Perlidae	12	12	1	1	1	5	1	4	1	0	0	High
Baetidae > 2spp	12	12	2	2	2	2	2	2	2	2	1	High
Ephemeridae		15	2	2	3	2	0	1	0	4	0	High
Heptageniidae	13	13	1	1	3	2	1	4	1	0	0	High
Leptophlebiidae	9	9	3	2	2	1	1	3	2	0	0	Moderate

Taxon	Indicator and reference taxa: Preferences for physical and hydraulic habitat and water quality											
	Mzim EWR4	REF	Flow velocity (m/s)				Habitat					WQ
	SASS SCORE		< 0.1	0.1–0.3	0.3–0.6	>0.6	BR	COBB	VEG	GSM	WATER	
Prosopistomatidae		15	1	1	2	3	1	4	1	0	0	High
Telagonodidae	12	12	0	0	2	4	1	4	1	0	0	High
Trichorythidae		9	0	1	1	4	1	4	1	0	0	Moderate
Psephenidae	10	10	0	1	3	4	1	4	1	0	0	Moderate
Athericidae		10	0	1	2	2	1	4	1	1	0	Moderate

Table 15.12 MzimEWR4: Macroinvertebrate EcoSpecs and TPCs

Parameter	Baseline (PES)	EcoSpec	TPC
Community structure and balance (based on standard SASS5 sample)	Diverse community sampled, with 6 of the 26 taxa scoring 10+, and occurring in A to B abundances (1–100). Diverse age structure and no indication of dominant taxa or other imbalances.	Sample should indicate a diverse community, sample with at least 5 indicators or expected taxa, scoring 10+, and occurring in abundances of A to B (not as individuals). Diverse age structure and no indication of dominance or other community structure imbalances.	Four or less reference or indicator taxa, scoring ≥ 10, and two or more of these are present in sample as individuals only. Many of the lower-scoring taxa are absent. There may also be indications of community imbalance (e.g. dominance of one or more taxa; age structure of the sample is biased either towards juveniles or adults).
SASS score range	160–180	150–220	< 130
No. of taxa	26	> 22	< 18
No. taxa scoring ≥ 10	6	5+	4 or less
ASPT score range	6.2–6.6	6.2–7	5.5 or less
MIRAI score range (Using same reference condition as for this study)	77.6%	≥ 70%	60% or less

16 MZIMVUBU ESTUARY (T36): IUA T36_B RESOURCE QUALITY OBJECTIVES

The official Estuarine Functional Zone (EFZ) boundary of the Mzimvubu Estuary as per the national requirement is indicated in **Figure 16.1**, defined by:

Downstream boundary:	31°37'52” S, 29°32'59” E (Estuary mouth)
Upstream boundary:	31°29'7.15" S, 29°22'59.66" E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank.

Figure 16.1 Geographical boundaries of the Mzimvubu Estuary based on the official EFZ (green and blue shaded areas) (lower part in green reflects area of focus for EWR study)

As per the DWS methodology, estuaries are sufficiently different in terms of state, functioning and management to form individual RUs. RQOs are set for the short-to medium term (5 to 10-year period) for the the following components:

- Quantity, pattern and timing of instream flow (hydrology)
- Mouth state (hydrodynamics)
- Water quality
- Characteristics and condition of primary producers (e.g. macrophytes)
- Characteristics and condition of biota (e.g. fish)

In the case of the Mzimvubu Estuary, RQOs for the TEC (linked to Scenario 69) were derived from the EcoSpecs and Threshold of Potential Concerns (TPCs) as set for the REC in the EWR study, as the TEC is similar to the REC. In terms of RQOs for recreational use (water quality), the recommended targets proposed for South Africa’s coastal marine waters were applied as summarised below (DEA, 2012).

RQOs for recreational use in Mzimvubu Estuary specified as risk-based ranges for intestinal enterococci and *Escherichia coli* (*E. coli*; microbiological indicator organisms) (DEA, 2012)

Category	Estimated risk per exposure	Enterococci (Count per 100 ml)	*E. coli* (Count per 100 ml)
Excellent	2.9% gastrointestinal (GI) illness risk	≤ 100 (95 percentile)	≤ 250 (95 percentile)
Good	5% GI illness risk	≤ 200 (95percentile)	≤ 500 (95 percentile)
Sufficient or Fair (minimum requirement)	8.5% GI illness risk	≤ 185 (90 percentile)	≤ 500 (90 percentile)
Poor (unacceptable)	>8.5% GI illness risk	> 185 (90 percentile)	> 500 (90 percentile)

In South Africa, the minimum requirement for recreational use is the "Sufficient or Fair" category, thus also representative of the **RQOs for estuaries used for contact recreation**. For estuaries where the Blue Flag status has been awarded, or for estuaries immediately adjacent to beaches awarded Blue Flag status, the RQOs for recreation in the "Excellent" category was awarded.

The RQOs for the Mzimvubu Estuary, to maintain the TEC (similar to REC in this instance), is presented in **Table 16.1**.

Table 16.1 RQOs for the Mzimvubu Estuary to maintain the TEC (Category B)

PES/REC/TEC: B Category		
Components that require interventions to maintain the TEC: ▪ Return some variability to the mouth dynamics through removal of the access road behind the area formerly known as 'First Beach', which has effectively entrained the estuary mouth. ▪ Reinstating local sediment dynamics (also through the removal of the abovementioned access road). The realistic possibility of reversing the loss of 'First Beach' could potentially re-establish this once-popular recreational beach for the town of Port St Johns. ▪ Institute land-use management regulation within the Estuary Functional Zone (EFZ) that focuses on restricting the loss of further habitat within this zone and the estuary floodplain up to the 10 m contour (or 10 m above mean sea level). ▪ Rehabilitate disturbed areas of the estuary EFZ where impacts are reversible; rehabilitation would significantly enhance the functional integrity and importance of the estuary as a whole. ▪ Establish a programme for invasive alien plant management within the estuary floodplain, which would make a significant contribution towards addressing this and enhancing the functional importance of the floodplain as a feature of the estuary. ▪ Manage fishing pressure in the estuary through the possible partial closure of the estuary to fishing in order to protect important fish stocks and sensitive habitats. ▪ Address possible point-source pollution risks from the canalised creek that flows from the town of Port St Johns, as the study has suggested that this canal may be compromising water quality. ▪ Prevent further disturbance and development of the floodplain habitat.		
Component/ indicator	**Target EC**	**RQO**
Hydrology	**A**	Maintain Target EC (> 92%). Protect the flow regime to create the required habitat for birds, fish, macrophytes, microalgae and water quality: ▪ Changes in river inflow distribution patterns (i.e. floods and base flows) less than 5% from that of Scenario 96 (i.e. the target flow scenario).
Hydrodynamics	**A**	Maintain Target EC (> 92%). Maintain a mouth conditions to protect estuarine

		ecosystems and the associated habitat for birds, fish, macrophytes, microalgae and water quality: ▪ Estuary mouth not to close or become very constricted. ▪ Changes in tidal amplitude at the tidal gauge not more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b).
Physical habitat (sediments)	**A/B**	Maintain the Target EC (> 87%). Protect estuarine sediment distributionas suitable habitat for estuarine biota: ▪ River inflow distribution patterns (flood components) not to differ more than 20% (in terms of magnitude, timing and variability) from that simulated for the present state (refer to DWS, 2014a; 2014b and 2017b). ▪ Suspended sediment concentration in river inflow not to deviate by more than 20% of sediment load-discharge relationship of the present state (refer to DWS, 2014a; 2014b and 2017b). ▪ No deviation in sedimentation and erosion patterns in the estuary to occur from the present baseline(refer to DWS, 2014a; 2014b and 2017b).
		Changes in sediment grain size distribution patterns not to cause exceedance tolerance of benthic invertebrates: ▪ Median bed sediment diameter not to deviate by more than a factor of two from levels of the present baseline (refer to DWS, 2014a; 2014b and 2017b). ▪ Sand/mud distribution in middle and upper reaches not to change by more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b). ▪ Changes in tidal amplitude at the tidal gauge not to change more than 20% from the present baseline (refer to DWS, 2014a; 2014b and 2017b). as a result of sediment processes.
Water quality (salinity)	**A/B**	Maintain Target EC (> 87%). Salinity regime to maintain TEC for dependent biotic components. ▪ Salinity in lower reaches higher than 20 for at least 4 to 6 months (i.e. overlapping with winter period). ▪ Salinity in lower reaches higher than 25 and in middle reaches higher than 15 for at least 1 to 2 months (overlapping with winter period).
Water quality (other)	**C**	Maintain the TEC category (≥ 63%). Water quality to be suitable for maintaining the TEC for dependent biotic components. Water quality of river inflow: ▪ pH 7.0 – 8.5. ▪ Dissolved Oxygen (DO) > 6 mg/l. ▪ Turbidity (naturally turbid system). ▪ Dissolved Inorganic Nitrogen (DIN) < 200 µg/l (monthly average). ▪ Dissolved Inorganic Phosphate (DIP) < 30 µg/l (monthly average). *In situ* water quality (in estuary): ▪ pH 7.0 – 8.5 ▪ DO > 6 mg/l. ▪ Turbidity (naturally turbid system in fresher parts). ▪ DIN < 150 µg/l (average across estuary). ▪ DIP < 20 µg/l (average across estuary). ▪ Total metal concentrations in water not to exceed target values as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995 or official future updates thereof). Total metal concentration in sediment not to exceed target values as per West Indian Ocean (WIO) Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009 or official future updates thereof for South Africa). For recreational use areas in estuary (see details in DEA, 2012): ▪ Enterococci < 185 counts per 100 ml (90 percentile), and ▪ *E. coli* < 500 counts per 100 ml (90 percentile).
Microalgae	**C**	Maintain the Target EC (>63%) through: ▪ Maintaining low phytoplankton biomass (average chlorophyll a < 20 µg/l or median chlorophyll a < 3.5 µg/l) and a diversity of phytoplankton groups (cyanobacteria excluded). ▪ Maintain medium intertidal benthic microalgal biomass (median chlorophyll a < 23 mg/m^2).

		▪ No observable blooms and scums in the estuary. ▪ Absence of cyanobacteria.
Macrophytes	**C**	Maintain the Target EC (> 63%) through: ▪ Maintaining diversity of macrophyte habitats in estuary as per present baseline (refer to DWS, 2014a, 2014b and 2017b). ▪ Reeds and sedges cover maintainted at ~16 ha. ▪ No more than 50% loss of reed and sedge habitats in non-flood years (e.g. linked to unfavourable salinity regime). ▪ No increase in invasive species in riparian zone. ▪ No colonisation of main water channel by vegetation (linked to sedimentation).
Invertebrates	**A/B**	Maintain the Target EC category (> 87%) through: ▪ Maintaining low-diversity invertebrate community with representation of original freshwater, opportunistic taxa as per present baseline (refer to DWS, 2014a, 2014b and 2017b) ▪ Maintaining invertebrate community structured as per present baseline (refer to DWS, 2014a, 2014b and 2017b) (defined by inherent physico-chemical drivers, specifically periodic high flows resulting in periods of low salinities and sediment instability) ▪ Maintaining invertebrate community structured as per present baseline (refer to DWS, 2014a, 2014b and 2017b) (linked to channel-like nature of estuary with very few intertidal areas characterised by soft sediments supporting only suitably specialised species).
Fish	**B/C**	Maintain the Target EC category (> 72%) through: ▪ Species assemblage to comprise indigenous species only (i.e. no alien species) (refer to DWS, 2014a, 2014b and 2017b) ▪ Maintain abundance (to be defined as average with prediction limits) of estuarine dependence category IIa species (*Solea bleekeri, Acanthopagrus vagus, Pomadasys commersonnii, Agyrosomus japonicus, Rhabdosargus holubi*), present as young juveniles in winter, spring and early summer. None of these species should be absent from estuary for two consecutive years (i.e. entire lower estuary maintained as nursery for estuarine dependence category IIa species with middle reaches of estuary functioning as nursery to these marine spawned species during low flow periods (Jun-Oct), for 4 out of 5 years on average) ▪ Estuarine resident species to represent core group (Glossogobius spp., *Oligolepis* spp. *Ambassis* spp. and *Gilchistella aestuaria*) (also in upper reaches) ▪ Estuarine-dependent marine species (other than mullet) not to occur abundantly in upper reaches (i.e. should remain fresh) ▪ Mullet to occur throughout estuary throughout year, represented by full array of size classes, with no mullet species (to be defined) being absent for two consecutive years ▪ *Oreochromis mossambicus* (Mozambique tilapia) not to extent into lower estuary for more than two consecutive years ▪ Maintain good trophic basis for predatory estuarine dependant marine species (most notably *Agyrosomus japonicus* and *Pomadasys commersonnii*) ▪ Maintain good connectivity down full length of estuary and into transitional marine waters (i.e. offshore estuary) ▪ Catches (*Agyrosomus japonicus* or *Pomadasys commersonnii*) (not related to gear changes or bag limit restrictions) not to decline.
Birds	**C/D**	Maintain the Target EC (> 60%) through: ▪ Maintaining avifaunal community that includes representatives of all original groups as per present baseline (refer to DWS, 2014a, 2014b and 2017b). ▪ Tern roosts observed from time to time. ▪ Number of waterbird species recorded per count remains above 10 for 3 consecutive seasons. ▪ Summer numbers of waterbirds (other than gulls and terns) remain above 50 for 3 consecutive seasons. ▪ A winter threshold should be determined once more data becomes available.

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APPENDIX A: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment
Ms Nyamande Tovhowani, DWS – 25 May 2018				
Page xiii, Summary table – IUA T33_b: KINIRA, Water Quality	Ensure that turbidity or clarity levels stay within Tolerable limits	• My question according to which guideline was Tolerable limits defined, DWAF 2008b or DWAF 1996a references? • The second part of the question on the same issue is I would expect the Tolerable limit to be site specific to IUA T 33_(unless the other reports produced earlier indicated a table showing limits per IUA). A good example is the Water Quality RQOs of THINA IUA below (same page).	Yes	• Clarification was added regarding use of the relevant guidelines for this table. • Limits are site-specific to the Management Resource Unit in which the EWR site occurs. The sub-quaternary (SQ) catchments to which the limits apply are also specified.
Page xiii, Summary table – IUA T33_b: THINA, Invertebrates.		How will the RQO implementers know how to maintain SASS scores of 160–190 or ASPT at 6.2–7? I would expect the RQOs to set a target like e.g. maintain a flow of $2m^3s$ in order to keep the high scoring taxa which will maintain an ASPT of 7.	No	It is not the responsibility of the implementers to reach these SASS scores. The monitors will test whether these limits are achieved, and the regulators will then use tools, e.g. enforcing compliance to license conditions, so that the required SASS and ASPT ranges can be reached. It is not possible to simply specify a flow as the required scores may still not be met if the water quality in that required flow is poor (for example).
Page xiv, Microalgae RQOs – Absence of cyanobacteria		How is that going to be effected, What needs to be done or avoided? By the time one realizes there is cyanobacteria, it will be already too late as the RQOs would not have been complied with.	No	Information will be provided in the Implementation and Monitoring Report about how these RQOs can be monitored and managed, but should other RQOs be adhered to, cyanobacterial blooms should not be evident. RQOs have to be seen as a collective.
Page 4-4, Fish RQOs	Maintain suitable flows to sustain AMOS	Is the Hydrology (flow) RQOs of T31-2 in page 4-2 aligned to this requirement?	No	Yes; flows are set so that required targets can be met.

Page / Section	Report statement	Comments	Changes made?	Author comment
Page 4-5, Macro-invertebrates, water quality row	No data to support numeric RQO. Maintain very good water quality.	What is the measure of "very good"? In the interim what water quality guidelines can you recommend for use?	Yes	The suite of invertebrates expected at this site points to the water quality being very good (as specified by the MIRAI model); meaning a close-to-natural state of variables such as nutrients, salts, pH, oxygen levels and organics. The text has been modified to show where more information can be found to define a "very good" or A/B-B category water quality state.