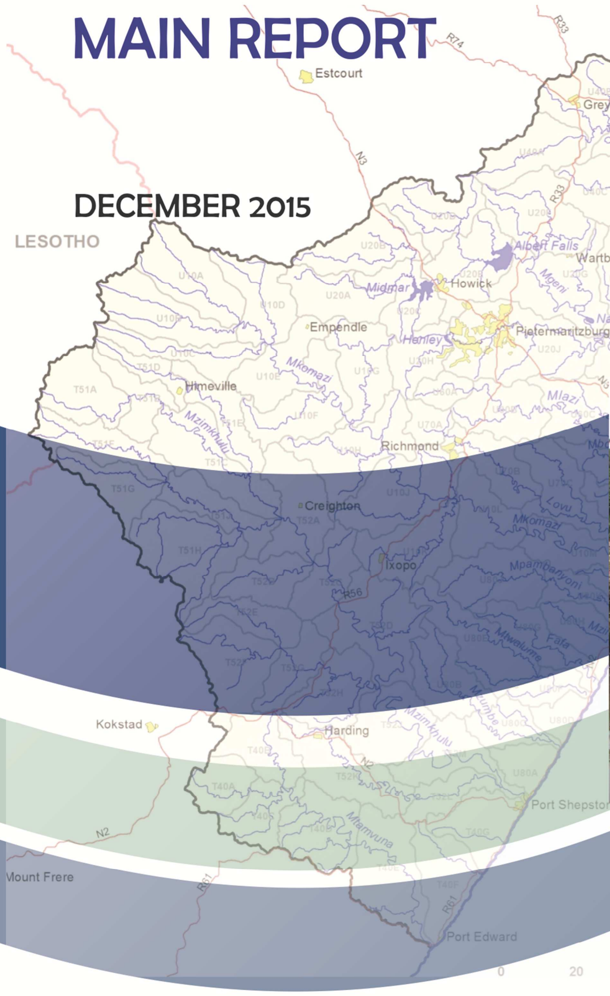
REPORT NUMBER: RDM/WMA11/00/CON/CLA/0815

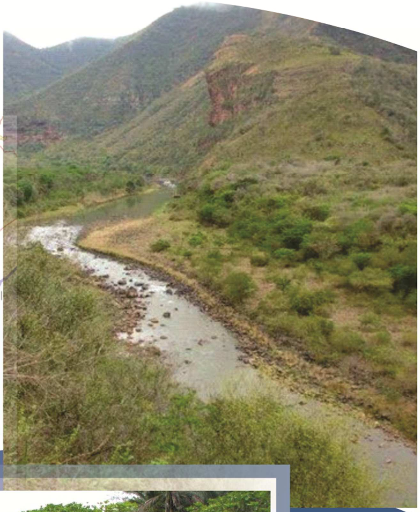
CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

PROJECT NUMBER: WP 10679

MAIN REPORT

DECEMBER 2015





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Water and Sanitation
REPUBLIC OF SOUTH AFRICA

RfA19_2015

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

MAIN REPORT

Report Number: RDM/WMA11/00/CON/CLA/0815

DECEMBER 2015

REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa, December 2015. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Main Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. DWS Report Number: RDM/WMA11/00/CON/CLA/0815.

DOCUMENT INDEX

Index Number	DWS Report Number	Report Title
1	Report Number: RDM/WMA11/00/CON/CLA/0112	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Inception Report**
2	Report Number: RDM/WMA11/00/CON/CLA/0113	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Status Quo assessment, IUA delineation and Biophysical Node identification**
3	Report Number: RDM/WMA11/00/CON/CLA/0213	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **River Resource Units and EWR sites**
4	Report Number: RDM/WMA11/00/CON/CLA/0313	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Desktop Estuary EcoClassification and EWR**
5	**Rivers EWR report volumes**	
5.1	Report Number: RDM/WMA11/00/CON/CLA/0114	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: EWR estimates of the River Desktop Biophysical Nodes**
5.2	Report Number: RDM/WMA11/00/CON/CLA/0214	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2: EcoClassification and EWR assessment on the Mtamvuna, Lovu, uMngeni, Karkloof and uMnsunduze Rivers**
5.3	Report Number: RDM/WMA11/00/CON/CLA/0314	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3: EcoClassification and EWR assessment on the uMkhomazi, uMngeni and Mvoti Rivers**
6	Report Number: RDM/WMA11/00/CON/CLA/0212	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **BHNR**
7	Report Number: RDM/WMA11/00/CON/CLA/0414	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Water Resource Analysis Report**
8	**Operational Scenario and Management Class report volumes**	
8.1	Report Number: RDM/WMA11/00/CON/CLA/0514	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: Supporting Information on the Determination of Water Resource Classes – River Ecological Consequences of Operational Scenarios**
8.2	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2a: Supporting Information on the Determination of Water Resource Classes – Mvoti (U4) Estuary EWR and Ecological Consequences of Operational Scenarios**

Index Number	DWS Report Number	Report Title
	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2b: Supporting Information on the Determination of Water Resource Classes – uMkhomazi (U1) Estuary EWR and Ecological Consequences of Operational Scenarios**
	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2c: Supporting Information on the Determination of Water Resource Classes –Mhlali (U30E) Estuary EWR and Ecological Consequences of Operational Scenarios**
	Report Number: RDM/WMA11/00/CON/CLA/0115	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2d: Supporting Information on the Determination of Water Resource Classes –Ecological Consequences of Estuaries in T4, U2, U3, U5, U6, U7 and U8 of Operational Scenarios**
8.3	Report Number: RDM/WMA11/00/CON/CLA/0714	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3 Supporting Information on the Determination of Water Resource Classes – Estuary specialist appendices (electronic information only)**
8.4	Report Number: RDM/WMA11/00/CON/CLA/0814	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 4: Supporting Information on the Determination of Water Resource Classes - Economic Consequences of Operational Scenarios**
8.5	Report Number: RDM/WMA11/00/CON/CLA/0914	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 5: Supporting Information on the Determination of Water Resource Classes - Ecosystem Services Consequences of Operational Scenarios**
8.6	Report Number: RDM/WMA11/00/CON/CLA/1014	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 6: Supporting Information on the Determination of Water Resource Classes – User Water Quality Consequences of Operational Scenarios**
8.7	Report Number: RDM/WMA11/00/CON/CLA/1114	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River Systems**
	Report Number: RDM/WMA11/00/CON/CLA/0215	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments**
9	**Resource Quality Objectives report volumes**	
9.1	Report Number: RDM/WMA11/00/CON/CLA/0315	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: River RQOs**

Index Number	DWS Report Number	Report Title
9.2	Report Number: RDM/WMA11/00/CON/CLA/0415	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2: Wetland RQOs**
9.3	Report Number: RDM/WMA11/00/CON/CLA/0515	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3: Groundwater RQOs**
9.4	Report Number: RDM/WMA11/00/CON/CLA/0615	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 4: Estuary RQOs**
10	Report Number: RDM/WMA11/00/CON/CLA/0715	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Implementation Report**
11	**Report Number: RDM/WMA11/00/CON/CLA/0815**	**Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Main Report**
12	Report Number: RDM/WMA11/00/CON/CLA/0116	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Closing Report**

DEPARTMENT OF WATER AND SANITATION
CHIEF DIRECTORATE: WATER ECOSYSTEMS

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

MAIN REPORT

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Project Manager

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REPORT SCHEDULE

Version	Date
First draft	December 2015
Final draft	March 2016

EXECUTIVE SUMMARY

INTRODUCTION

There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management Area (WMA) are able to sustain their level of uses and be maintained at their desired states. The determination of the Water Resource Classes of the significant water resources in Mvoti to Umzimkulu WMA will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users (DWA, 2011a). The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu WMA

The purpose of this report is to summarise the results of all the technical reports produced during the study.

STATUS QUO

The purpose of this task was to describe and document the status quo task which includes various components such as water use, economy, river and wetland ecology, identifying water quality problems and Ecosystem Goods, Services and Attributes (EGSA), referred to as Ecosystem Services. This information was used to define the Integrated Unit of Analysis (IUA) and provide background information to assist with the catchment visioning process. Once the IUAs are delineated, RUs and biophysical nodes must be identified for different levels of EWR assessment and setting of RQOs.

INTEGRATED UNITS OF ANALYSIS

The following 29 IUAs were delineated in the Mvoti to Umzimkulu Catchment:

IUA	Delineation	IUA	Delineation
IUA T4	Mtamvuna	IUA U6-3	Mbokodweni
IUA T5-1	Upper Umzimkulu Mountain Zone	IUA CC	Coastal Cluster
IUA T5-2	Middle Umzimkulu and Mzimkulwana Tributary	IUA U2-1	uMngeni: Upstream of Midmar Dam
IUA T5-3	Umzimkulu	IUA U2-2	uMngeni: Midmar Dam to Albert Falls Dam
IUA U8-1	Mzumbe	IUA U2-3	uMngeni Downstream of Albert Falls Dam to Msunduze Confluence
IUA U8-2	Mtwalume	IUA U2-4	Msunduze
IUA SC	Southern Coastal	IUA U2-5	uMngeni downstream of the Msunduze Confluence to Inanda Dam
IUA U1-1	uMkhomazi Mountain Zone	IUA U2-6	Downstream of Inanda Dam to Estuary
IUA U1-2	Middle uMkhomazi	IUA U3-1	uMdloti upstream of Hazelmere Dam
IUA U1-3	uMkhomazi Gorge Zone	IUA U3-2	uMdloti downstream of Hazelmere
IUA U1-4	Lower uMkhomazi	IUA U3-3	uThongathi
IUA U7	Lovu	IUA U4-1	Mvoti Upper Reaches
IUA U6-1	Upper Mlazi	IUA U4-2	Mvoti Middle Reaches
IUA U6-2	Lower Mlazi	IUA U4-3	Mvoti Lower Reaches
		IUA NCC	Northern Coastal Cluster

HOTSPOTS

The hotspot represents a river reach or estuary with a high Integrated Environmental Importance (IEI) and high Water Resource Use Importance (WRUI) which could be under threat due to its importance for water resource use. IEI considers PES, Ecological Importance and Sensitivity (EIS), Freshwater Ecosystem Priority Area (FEPAs) and Socio-Cultural Importance (SCI). The hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future (Louw and Huggins, 2007; Louw *et al.,* 2010).

The rivers where hotspots dominate are:

- Mvoti and uMkhomazi due to the potential for large dam development in the near future.
- uMngeni due to its WRUI importance and existing dam developments.
- uMnsunduze due to its water quality issues.

The estuaries where hotspots dominate are:

- Mvoti and uMkhomazi due to the potential for large dam development in the near future.
- uMngeni and Umgababa due to its existing dam developments.
- Zolwane, Tongazi, Kandandhlovu, Mpenjati, Vungu, Zotsha, Boboyi, Koshwana, Sezela, Mhlanga uMdloti, uThongathi and Mhlali due to water quality and current/future waste water discharges issues.
- Sipingo and Durban Bay due to severe catchment and/or habitat transformation pressure.

RIVER ECOLOGICAL WATER REQUIREMENTS

The main emphasis of this task was on the EcoClassification and Ecological Water Requirement (EWR) determination at various biophysical nodes in the system.

There are 288 biophysical nodes in the study area and an EWR is required at most of these nodes. Due to the large size of the study area and the subsequent large number of nodes, all EWRs cannot be determined at a detailed level. The desktop biophysical nodes are those with a low priority and require desktop EWR estimates. The number of desktop nodes and level of EWR assessments that needs to be undertaken are provided in the table below. The Revised Desktop Reserve Model (RDRM) (Hughes *et al*., 2012) was used to estimate EWRs at desktop biophysical nodes.

Biophysical nodes and levels of EWR assessment

Secondary catchment	Desktop EWR	New EWR sites	Existing EWR sites	Extrapolated from EWR sites	Excluded /Comment
T4	14	1	0	5	17
T5	24	0	14	11	6
U8	14	0	0	0	19
U1	21	3	0	10	5
U7	10	1	0	3	2
U6	10	0	0	0	4
U2	33	4	0	5	11
U3	7	0	0	0	4
U4	22	2	0	3	0
U5	3				
TOTAL	**158**	**11**	**14**	**37**	**68**

The results of the desktop EWR assessments at 158 desktop biophysical nodes have been estimated using appropriate desktop models. The Ecological Category for which the estimation was done was determined following a desktop level of EcoClassification.

Detailed EWR assessments will be undertaken at 11 EWR sites which are key biophysical nodes in the study area. There are 14 existing EWR sites where detailed EWR assessments are available and 37 nodes where results will be extrapolated from EWR sites. Sixty eight nodes will either be addressed by estuarine assessments or are located in protected areas and do not require EWR assessments.

Twelve EWR sites were selected throughout the study area and tabled below.

EWR site summary

EWR site name	SQ	River	EcoRegion (Level II)	Geom[1]. Zone	Alt[2] (m)	MRU[3]	Quat
Mv_I_EWR1	U40B-03770	Heinesspruit	16.02	Lower Foothills	929	MRU Heines A	U40B
Mv_I_EWR2	U40H-04064	Mvoti	17.03	Lower Foothills	203	MRU Mvoti C	U40H
Mg_I_EWR2	U20E-04243	uMngeni	16.03	Upper Foothills	725	MRU Mgeni B	U20E
Mg_I_EWR5	U20L-04435	uMngeni	17.03	Upper Foothills	177	MRU Mgeni D	U20L
Mk_I_EWR1	U10E-04380	uMkhomazi	16.03	Lower Foothills	916	MRU Mkomazi B	U20F
Mk_I_EWR2	U20J-4679	uMkhomazi	16.02	Upper Foothills	537	MRU Mkomazi C	U20J
Mk_I_EWR3	U20M-04746	uMkhomazi	17.01	Lower Foothills	50	MRU Mkomazi D	U10M
Mg_R_EWR1	U20A-04253	uMngeni	16.01	Lower Foothills	1081	MRU Mgeni A	U20A
Mg_R_EWR3	U20E-04170	Karkloof	16.03	Upper Foothills	738	MRU Karkloof C	U20E
Mg_R_EWR4	U20J-04364	uMnsunduze	16.03	Lower Foothills	602	MRU Duze C	U20J
Lo_R_EWR1	U70C-04859	Lovu	17.01	Lower Foothills	44	MRU Lovu D	U70D
Mt_R_EWR1	T40E-5601	Mtamvuna	17.01	Lower Foothills	277	MRU Mtam B	T40E

The EcoClassification results are summarised below.

Summary of EcoClassification results

Mv_I_EWR1: Heinespruit

EIS: MODERATE
Unique fish occur (*B. natalensis* – regional endemic) and instream habitat sensitive to flow changes. Rare and endangered riparian species are present and are intolerant.

PES: C

- Decreased base flows impact to some extent on habitat availability and abundance.
- Deteriorated water quality due to releases from the WWTW. resulting in high nutrient levels as well as the presence of toxics.
- High occurrence of alien vegetation species and the presence of three predatory alien fish species.
- General loss of connectivity and bank modification.

REC: C
The EIS was Moderate and therefore the REC was set to maintain the PES.

AEC down: D

- The scenario included further decreased baseflows and floods:
- Increased sedimentation of riffles and fine accumulation in pools.
- Vegetation species composition change with a higher occurrence of grasses and shrubs, and a decrease in sedges.
- Increased nutrients.

Component	PES & REC	AEC↓
IHI Hydrology	C	
Physico chemical	C	D
Geomorphology	B	C
Fish	C	D
Invertebrates	C	D
Instream	C	D
Riparian vegetation	B/C	C/D
EcoStatus	C	C/D
Instream IHI	C	
Riparian IHI	C	
EIS	**MODERATE**	

Mv_I_EWR2 Mvoti River

EIS: MODERATE
Unique instream fish biota occur (regional freshwater endemics and estuarine fish). There is a diversity of habitat types and the reach is an important migration route for eels. Rare and endangered riparian species are present.

PES: C

- Decreased base flows have impacted to some extent on habitat availability and abundance.
- Deteriorated water quality.
- Catchment erosion.
- Two predatory alien fish species.
- Alien invasive vegetation in the riparian zones along with wood harvesting and clearance has led to a general loss of connectivity and bank modification.

REC: B
The EIS is Moderate, however the instream component of the EIS is High, and improvement can be achieved by non-flow related measures. The REC will therefore indicate the improvement, but an EWR for improved flows will not be set.

AEC down: D
The scenario is based on the impacts of a possible upstream dam which will result in:

- Increased sedimentation of riffles and fines accumulation in pools.
- Vegetation species composition change with a higher occurrence of grasses and shrubs, and a decrease in sedges.
- Increased nutrients.

Component	PES	REC	AEC↓
IHI Hydrology	B/C		
Physico chemical	C	C	D
Geomorphology	C	C	D
Fish	B/C	B	C
Invertebrates	B/C	B	C/D
Instream	B/C	B	C/D
Riparian vegetation	C/D	C/D	D
EcoStatus	C	B	C/D
Instream IHI	C		
Riparian IHI	C		
EIS	MODERATE		

Mg_I_EWR2: uMngeni River

EIS: MODERATE
Highest scoring metrics were diversity of habitat types and migration route. Rare and endangered riparian species occur and intolerant vegetation species are present.

PES: C/D

- Decreased base flows and floods due to Midmar Dam resulting in a loss of flow diversity.
- Alien invasive vegetation, grazing pressure and species composition change in the riparian zone has led to a general loss of connectivity and resulted in bank modification.
- The decrease in baseflows has impacted on habitat availability and abundance.
- Deteriorated water quality impacts (Howick and sediment dam releases has seriously impacted on the fish frequency of occurrence.

REC: C/D
The EIS was moderate and the REC is set to maintain the PES. The fish component is in an unacceptable condition and has to improve to a D EC. This improvement will not require changes in flow.

Component	PES & REC
IHI Hydrology	C/D
Physico chemical	C/D
Geomorphology	D
Fish	E* (D)
Invertebrates	C
Instream	D
Riparian vegetation	C
EcoStatus	C
Instream IHI	D
Riparian IHI	C
EIS	MODERATE
*** Fish to improve**	

Mg_I_EWR5: uMngeni River

- **EIS: MODERATE**
- Highest scoring metrics were diversity of habitat types and features, taxon richness and rare and endangered riparian species.

- **PES: D**
- Decreased baseflows and floods due to upstream dams and general landuse in the upper catchment.
- Reduced habitat abundance.
- Deteriorated water quality (uMnsunduze inflows etc. and increased sedimentation).
- Alien invasive vegetation species, vegetation removal and sand mining leading to a general loss of connectivity and bank modification.
- Presence of two predatory alien fish species in the reach.

- **REC: D**

EIS was Moderate and the REC was therefore set to maintain the PES.

Component	PES & REC
IHI Hydrology	C/D
Physico chemical	C/D
Geomorphology	C/D
Fish	D
Invertebrates	C/D
Instream	C/D
Riparian vegetation	D
EcoStatus	D
Instream IHI	D
Riparian IHI	D
EIS	**MODERATE**

Mg_R_EWR1: uMngeni River

EIS: LOW

Highest scoring metrics were diversity of habitat types and features as well as the presence of rare and endangered riparian species.

PES: C/D

- The presence of aggressive alien fish species and exotic vegetation species.
- Some decrease in base flows due to abstractions for agriculture.

REC: C/D

- As the EIS was LOW no improvement was required. The C/D EcoStatus PES mainly due to non-flow related impacts and not representative of flow related problems in the reach. It was decided to exclude alien fish species from the assessment resulting in a PES of a C EC for fish and an instream PES of a C EC for which flow requirements were set.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B
Fish	D (C)
Invertebrates	C
Instream	C/D (C)
Riparian vegetation	C/D
EcoStatus	C/D
Instream IHI	C
Riparian IHI	C
EIS	**LOW**

Mg_R_EWR3: Karkloof River

EIS: HIGH

The reach falls within a private nature reserve and serves as critical instream refuge from uMngeni which is impacted by bottom releases from Midmar Dam at times. Rare and endangered riparian species occur and therefore this reach is important in terms of refugia and critical riparian habitat.

PES: B

- Reduced baseflows due to upstream irrigation activities.
- Localised impacts of roads, small farm dams, crossings and water quality problems from upstream irrigation.

REC: B

Although the EIS was HIGH, the instream components were all in a B EC and therefore no improvement was required. The REC was therefore set to maintain the PES.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B
Fish	B/C
Invertebrates	B
Instream	B
Riparian vegetation	B
EcoStatus	B
Instream IHI	C
Riparian IHI	B
EIS	**HIGH**

Mg_R_EWR4: uMnsunduze River

EIS: LOW
Highest scoring metrics were diversity of habitat types and features as well as the presence of rare and endangered riparian species

PES: D/E
- Increased floods and baseflows that exceed thresholds are important flow related impacts in the reach.
- Water quality is the major impact which drives the deteriorated ecological condition and is exacerbated by poor sewer infrastructure and industrial pollution leading to low oxygenation rates, high faecal coliform counts and excessive nutrient loading within the system.
- Intense alien vegetation infestation

REC: D
As the EIS was LOW no improvement was required. All components were in an unsustainable EC (lower than a D EC), and therefore the REC had to be set at a D. As the water quality issues are the primary problem, these need to be addressed at source first prior to any attention being given to addressing the flow issues. Therefore, no flow requirement was set for this EWR site.

Component	PES	REC
IHI Hydrology	E/F	N/A
Physico chemical	E/F	D
Fish	E	D
Invertebrates	E	D
Instream	E	D
Riparian vegetation	D/E	D
EcoStatus	D/E	D
Instream IHI	E/F	D
Riparian IHI	D/E	D
EIS	LOW	LOW

Mk_I_EWR1: uMkhomazi River

EIS: MODERATE
Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types and features and rare and endangered riparian species.

PES: C
- Overgrazing and alien invasive vegetation in the riparian zones have led to substrate exposure and increased erosion.
- Increased sedimentation has resulted in higher turbidity.
- Migration barriers and alien fish species.

REC: C
- EIS was Moderate and the REC was therefore to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR was set for the instream EC of a B/C.

AEC down: D
- The scenario is based on the impacts of a possible upstream dam which will result in:
- Decreased base flows and floods, change in water temperature.
- Erosion of the marginal zone due to scour and decreased fines
- Increased alien vegetation due to decreased floods.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B/C
Geomorphology	A/B	C
Fish	B/C	C
Invertebrates	B/C	C/D
Instream	B/C	C/D
Riparian vegetation	C	C/D
EcoStatus	C	C/D
Instream IHI	B	
Riparian IHI	C	
EIS	MODERATE	

Mk_I_EWR2: uMkhomazi River

EIS: HIGH
Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types, migration route, rare and endangered riparian species, riparian species intolerant to flow and migration corridor for birds.

PES: B
- Increased catchment erosion and alien invasive vegetation in the upper riparian zone leading to substrate exposure.
- Alien predatory fish species.

REC: B
The EIS was High; however most components are already in a B EC except for fish which is impacted by alien species. The REC was therefore set to maintain the PES.

AEC down: C
- Decreased base flows and floods, change in temperature and decreased turbidity from a possible dam.
- Encroachment of non-woody vegetation and more reeds in the marginal zone.
- Reduced scour (increased sedimentation), less mobile beds.
- Increased alien vegetation due to decreased floods.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B
Geomorphology	B	C
Fish	B	C
Invertebrates	B	C
Instream	B	C
Riparian vegetation	B	C
EcoStatus	B	C
Instream IHI	B	
Riparian IHI	B/C	
EIS	HIGH	

Mk_I_EWR3: uMkhomazi River

EIS: MODERATE

- Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types and features and rare and endangered riparian species.

PES: C

- Overgrazing, trampling and alien invasive vegetation impact the riparian zone and has resulted in substrate exposure and increased erosion.
- The structural changes in vegetation impact on longitudinal and lateral connectivity

REC: C

- The EIS was Moderate and the REC was therefore set to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR was set for the instream EC of a B.

AEC down: D

- The scenario is based on the impacts of a possible upstream dam which will result in:
- Decreased base flows and large floods.
- More islands, fewer secondary channels and less quality instream habitats.
- Increased woody vegetation on islands.
- Loss of non-woody vegetation as it will be out-shaded by the increased woody vegetation.

Increased marginal vegetation encroachment.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B
Geomorphology	B	B/C
Fish	B	C
Invertebrates	B	C
Instream	B	C
Riparian vegetation	D	D
EcoStatus	C	C
Instream IHI	C	
Riparian IHI	C	
EIS	MODERATE	

Lo_R_EWR1: Lovu River

EIS: MODERATE

Highest scoring metrics were diversity of habitat types and features, the reach is important for the migration of eel species and macroinvertebrates in the system and rare and endangered riparian species are present.

PES: B/C

- Reduced base flows due to dams and general landuse in the upper catchment.
- Deteriorated water quality and increased sedimentation due to livestock farming, WWTW, sand mining and sugarcane farming.
- Alien invasive vegetation and wood removal in the riparian zones.

REC: B/C

EIS was MODERATE and the REC was therefore to maintain the PES.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B/C
Fish	B/C
Invertebrates	B/C
Instream	B/C
Riparian vegetation	B/C
EcoStatus	B/C
Instream IHI	B/C
Riparian IHI	B/C
EIS	MODERATE

Mt_R_EWR1: Mtamvuna River

EIS: MODERATE

Highest scoring metrics were migration route for eel species in the system. Rare and endangered riparian species occur and therefore this reach is important in terms of refugia and critical riparian habitat.

PES: C

- General loss of connectivity and bank modification due to overgrazing, trampling, alien invasive vegetation and wood removal in the riparian zones.
- Increased nutrients due to deteriorated water quality.

REC: C

As the EIS was MODERATE no improvement was required. The REC was therefore set to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR were set for the instream EC of a B.

Component	PES & REC
IHI Hydrology	A/B
Physico chemical	A/B
Fish	B/C
Invertebrates	B
Instream	B
Riparian vegetation	C/D
EcoStatus	C
Instream IHI	B/C
Riparian IHI	C
EIS	MODERATE

EWR results at the EWR sites are summarised below.

EWR summary expressed as a % of nMAR

				Long term mean					
EWR site	**EC**	**nMAR[1] (MCM)[2]**	**pMAR[3] (MCM)**	**Low flows (MCM)**	**Low flows (%nMAR)**	**High flows (MCM)**	**High flows (%nMAR)**	**Total flows (MCM)**	**TOTAL (%nMAR)**
Mv_I_EWR1	PES/REC: C	17.36	7.08	3.16	18.2	1.69	9.7	4.85	27.9
	AEC: D			2.26	13	1.6	9.2	3.85	22.2
Mv_I_EWR2	PES/REC instream: B/C	273.96	168.84	48.3	17.6	19.4	7.1	67.7	24.7
	AEC instream: C/D			33.4	12.2	17.6	6.4	51	18.6
Mg_I_EWR2	PES/REC: C/D (RDRM C)	228.19	105.4	33.5	14.7	12.1	5.3	45.6	20
Mg_I_EWR5	PES/REC instream: C/D	583.7	245.3	133.57	22.9	17.03	2.9	150.6	25.8
Mg_R_EWR1	Instream: C	79.22	60.46	10.88	13.70	9.86	12.50	20.74	26.20
Mg_R_EWR3	PES/REC: B	70.11	56.50	19.11	27.30	11.38	16.20	30.49	43.50
Mk_I_EWR1	PES/REC instream: B/C	683.17	660.72	171.78	25.1	67.31	9.9	239.09	35
	AEC: C/D			88.96	13	57.57	8.4	146.53	21.4
Mk_I_EWR2	PES/REC: B	890.91	838.35	220.59	24.8	94.44	10.6	315.03	35.4
	AEC: C			166.69	18.7	81.6	9.2	248.29	27.9
Mk_I_EWR3	PES/REC instream: B	1068.6	983.23	223.42	20.9	104.6	9.8	328.02	30.7
	AEC: C			151.2	14.2	90.35	8.4	241.55	22.6
Lo_R_EWR1	B/C	87.76	73.42	20.04	22.80	13.19	15.10	33.23	37.90
Mt_R_EWR1	Instream: B	233.15	200.69	60.99	26.20	35.08	15.00	96.07	41.20

1 Natural Mean Annual Runoff 2 Million Cubic Metres 3 Present Day Mean Annual Runoff

ESTUARINE ECOLOGICAL WATER REQUIREMENTS

uMkhomazi (U1) EcoClassification

The uMkhomazi Estuary in its present state is 69% similar to the natural condition, which translates into a PES of a C EC and attributed to the following factors:

- The weir in the upper reaches reducing the connectivity between the river and estuary and contributing to loss of estuarine habitat.
- Sandmining that has taken away the sandbanks in the upper reaches (Zone C), resulting in loss of intertidal and backwater refuge areas. It has also impacted on access to cattle grazing areas as the river cannot be crossed in this section anymore.
- Recreational activities (e.g. boat launching) in the lower reaches affecting bird abundance.
- Over exploitation of living resources (e.g. cast netting and line fishing); and
- Agricultural activities and disturbance in the Estuary Functional Zone (EFZ) causing loss of estuarine habitat.

Estuary Importance was estimated at 85, i.e. the estuary is rated as “Highly Important”. **The functional Importance of the uMkhomazi Estuary is very high. It serves as an important nursery for exploited fish stock and plays a very important role from a fish egg production perspective. In addition, it is also an important movement corridor for eels (CITES listed species).**

The PES for the uMkhomazi Estuary is a C, but the Estuary is rated as “Very Important” from a biodiversity perspective and should therefore be in a B Category. Taking into account the current conditions (PES = C), the reversibility of the impacts, the ecological importance and the conservation requirements of the uMkhomazi Estuary the REC for the system is a B Category.

Mvoti (U4) EcoClassification

The Mvoti Estuary in its present state is estimated to be 55% similar to natural condition, which translates into a PES of D Category. The PES is mostly attributed to the following factors:

- The high organic load in effluent from the SAPPI Stanger mill just upstream of the estuary head, which contribute to regular low oxygen events (< 4 mg/l).
- Increased nutrient input as a result of poor catchment practises, causing excessive growth of reeds and aquatic invasive plants in intertidal and subtidal habitats.
- Significant loss of habitat in the EFZ as a result of sugarcane farming;
- Changes in sediment structure due to sand mining; and
- The loss of resetting floods which otherwise assist in removing excess vegetation growth from intertidal, subtidal and supratidal areas (important bird habitat).

The Mvoti Estuary is rated as “Important”. Even though the Mvoti Estuary tends to recruit high numbers of estuarine associated fish in spring and summer, it is of low nursery value as river flow is relatively high (for its size) for most of the year and there are few backwater areas for fish to take refuge in from the main currents. However the Mvoti Estuary is an important movement corridor for eels. This places significance on ecological flow and water quality requirements for the estuary (and the river).

The Mvoti Estuary is rated as “Important” from a biodiversity perspective and the REC should therefore be in a C Category. The estuary also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets defined in the National Estuaries Biodiversity Plan and the NBA 2011 (Turpie *et al*.,2013, Van Niekerk and Turpie, 2012).

Mhlali (U3) EcoClassification

The scores allocated to the various abiotic and biotic health parameters for the Mhlali Estuary and the overall PES for the system are calculated by Estuarine Health Index (EHI) (see below). The Mhlali Estuary present state was estimated to be 57 (i.e. 57% similar to natural condition), which translates into a PES of Category D. The PES is mostly attributed to the following factors:

- Increase in nutrient input as a result of WWTW and poor catchments practises, causing excessive growth of reed and aquatic invasive plants in intertidal and subtidal habitats.
- Significant loss of habitat in the Estuary Functional Zone as a result of sugar cane farming; and
- Artificial breaching of the estuary mouth at lower than natural levels.

The Mhlali Estuary is on a steep trajectory downwards as significant further deterioration in estuary health is anticipated once the Shakaskraal WWTW runs at full capacity and the Tinley Manor WWTW (planned for 2015) discharges into the estuary.

The Mhlali Estuary is rated as “Important” from a biodiversity perspective and the REC therefore should be in a C Category. In addition, the system also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets as defined in the National Estuaries Biodiversity Plan and the NBA 2011.

SCENARIO DESCRIPTION

Scenarios, in context of water resource management and planning, are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole (System's context). Different levels of water use and protection are evaluated with the aim to find a preferred scenario. NWRC is the process to **evaluate and recommend** what that scenario entails.

Scenarios can include:

- Maintaining the status quo
- Catering for future growth (domestic, irrigation, industrial etc)
- Various levels of EWRs
- Development of new infrastructure.

It must be noted that Water Resource Class recommendations do not imply acceptance or approval of scenarios. Future scenarios are considered to ensure that Classes can accommodate the scenarios that provide a balance between protection and use. The NWRCS therefore tests wheter a sufficient spread of scenarios has been investigated that the work has been done to an acceptable standard.

The range of scenarios finally selected through an extensive process with stakeholders are summarised in the tables below.

Summarised description of Mvoti Scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	Yes	No	No	No	No
MV21	Yes	No	REC tot[2]	No	No
MV22	Yes	No	REC low[3]	No	No
MV3	Yes	Yes	No	Yes	Yes
MV41	Yes	Yes	REC tot[2]	Yes	Yes
MV42	Yes	Yes	REC low[3]	Yes	Yes
MV43	Yes	Yes	REC low+[4]	Yes	Yes

1 Mvoti River Development Project (Isithundu Dam). 2 Recommended Ecological Category (Total Flows)
3 Recommended Ecological Category (Low Flows).
4 Recommended Ecological Category (Total Flows for January, February, March and Low Flows for remaining months).

Lovu: Summary of operational scenarios

Scenario	Scenario variables			
	Update water demands	Ultimate development demands and return flows (2040)	EWR	Reduced abstraction and afforested areas
LO1	Yes	No	No	No
LO2	Yes	Yes	No	No
LO3	Yes	Yes	No	Yes (25% reduction)
LO4	Yes	Yes	No	Yes (50% reduction)

uMngeni Summary of operational scenarios

Scenario	Scenario Variables							
	Update water demands	Update demands and return flows (2022)	Ultimate development demands and return flows (2040)	EWR	MMTS2	uMWP-1[1]	Darvill re-use	eThekwini re-use
UM1	Yes	No	No	No	No	No	No	No
UM2	No	Yes	No	No	Yes	No	No	No
UM41	Yes	No	Yes[2]	No	Yes	No	No	No
UM42	Yes	No	Yes[3]	No	Yes	No	No	No
UM51	Yes	No	Yes[2]	No	Yes	No	Yes	Yes
UM52	Yes	No	Yes[3]	No	Yes	No	Yes	Yes

uMkhomazi: Summary of operational scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini OCD
MK1	Yes	No	No	No	No
MK2	Yes	Yes	No	Yes	Yes (no support)
MK21	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (no support)
MK22	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (no support)
MK23	Yes	Yes	REC low+[3] (EWR 2)	Yes	Yes (no support)
MK31	Yes	Yes	REC tot[1] (EWR 3)	Yes	Yes (no support)
MK32	Yes	Yes	REC low[2] (EWR 3)	Yes	Yes (no support)
MK33	Yes	Yes	REC low+[3] (EWR 3)	Yes	Yes (no support)
MK4	Yes	Yes	No	Yes	Yes (with support)
MK41	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (with support)
MK42	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (with support)

1 Recommended Ecological Category (Total Flows).
2 Recommended Ecological Category (Low Flows).
3 Recommended Ecological Category (Total Flows for January, February, March and Low Flows remaining months).

Waste Water Management Scenarios

A key factor that was identified to influence the ecological health of several estuaries in the study area was ‘treated wastewater discharges’ servicing the various urban areas located along the coast.

Twenty five (25) of the sixty four (64) estuaries are affected by the wastewater discharges and the scenarios were formulated along selected themes as presented below.

For each scenario theme, a subset of scenarios considering the following management measures was formulated:

- Additional treatment processes to reduce the nutrient pollution load discharged.
- Transferring treated waste from a sensitive estuary to a river and estuary system that is able to assimilate the additional load.
- Discharge of wastewater through sea outfall works - discharges to estuaries are reduced or eliminated.
- Re-use of treated wastewater, both direct and indirect.

Primary themes defining wastewater management scenarios

Label	Scenario Description
A	Ecological protection is priority (minimum discharge to estuaries).
B	Minimum costs scenario (highest flow through estuaries).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.
E	Indirect re-use (consider volume and practicalities). Remainder According to Scenario C.
F	Direct re-use (consider volume and practicalities). Remainder According to Scenario C.
X	Alternative scenarios (combinations of alternative).

Definition of waste water management scenario applied in the comparison and evaluation process

Sc	Scenario Description	Comment
Ai	Ecological protection is priority (minimum discharge to estuaries)	Northern and Southern Cluster: 30% of future ww flow to estuary, remainder through alternative means.
Aii	Ecological protection is priority (minimum discharge to estuaries)	Northern and Southern Cluster: Discharge current capacity, remainder disposal through alternative means.
Aiii	Ecological protection is priority (minimum discharge to estuaries)	All Clusters: Discharge current capacity, remainder disposal through alternative means.
Av	Ecological protection is priority (minimum discharge to estuaries)	As Ai: Option for Central Cluster (discharge to iSipingo as an alternative option to Ai).
Bi	Minimum costs scenario (highest flow through estuaries)	Options for Central Cluster: Low nutrient discharge from (high costs)
Bii	Minimum costs scenario (highest flow through estuaries)	As Bi: Different infrastructure options for Central Cluster (lower costs). uMkhomazi estuary received 50Ml/day WW flow .
Biii	Minimum costs scenario (highest flow through estuaries)	As Bi: Current treatment (high) nutrient discharge (low costs).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Short term increases in discharges. Central Cluster: Short term increases in discharges with low nutrient discharge (high costs)
Ci	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Short term increases in discharges. Central Cluster: As C: Current treatment (high) nutrient discharge (low costs)
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Medium term increases in discharges. Central Cluster: Low nutrient discharge (high costs)
Di	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Medium term increases in discharges. Central Cluster: As D: Current treatment (high) nutrient discharge WWTW (low costs)
E	Indirect re-use (consider volume and practicalities) Remainder According to Scenario C.	Northern and Southern Clusters: Reuse 50% if future ww flow. Central Cluster: Reuse via Hazelmere Dam.
F	Direct re-use (consider volume and practicalities) Remainder According to Scenario C.	Northern and Southern Clusters: Reuse 50% if future ww flow. Central Cluster: High level of treatment (high operating costs), supply into distribution system.

Note: The grey shaded scenarios were selected for presentation to the Project Steering Committee.

ECOLOGICAL CONSEQUENCES OF SCENARIOS

uMkhomazi and Mvoti Estuaries

The consequences of the scenarios on the estuarine health are illustrated in the table below.

uMkhomazi Estuary Health Index score and corresponding ECs under the different runoff scenarios

Variable	Scenario Group								
	Present	A (MK2, 4)	B (MK21, 42)	C (MK22, 23, 43)	D (MK31)	E (MK32, 33)	F (MK21, 42) + WWTW	G MK21, 42 –Anth but with weir	H MK21, 42 – Anth & remove the Weir
Hydrology	66.8	**45**	63	62	59	57	63	63	63
Hydrodynamics and mouth condition	95	**75**	95	95	38	38	95	95	97
Water quality	66.6	**61**	66	67	66	67	34	66	66
Physical habitat alteration	78	**70**	75	75	75	75	75	84	90
Habitat health score	**76**	**63**	**75**	**75**	**60**	**59**	**67**	**77**	**79**
Microalgae	80	**65**	80	80	80	80	50	80	90
Macrophytes	21	**20**	26	31	33	34	15	46	46
Invertebrates	75	**60**	75	75	70	70	50	85	90
Fish	60	**35**	60	60	60	55	50	70	75
Birds	60	**50**	55	55	55	55	50	57	65
Biotic health score	**59**	**46**	**59**	**60**	**60**	**59**	**43**	**68**	**73**
ESTUARY HEALTH SCORE	**68**	**54**	**67**	**67**	**60**	**59**	**55**	**72**	**76**
ECOLOGICAL STATUS	**C**	**D**	**C**	**C**	**D**	**D**	**D**	**C**	**B**

None of the scenarios achieved the REC of a B Category. Therefore, Scenario H (Group B (Sc MK21 and MK42)) in conjunction with a number of management interventions) is the recommended ecological flow scenario. Scenario Group C (Sc MK22, MK23 and MK43) will also achieve the REC. The following management interventions are required to achieve the uMkhomazi REC:

- Remove sandmining from the upper reaches below the Sappi Weir to increase natural function, i.e. restore intertidal area;
- Restoration of vegetation in the upper reaches and along the northern bank in the middle and lower reaches, e.g. remove alien vegetation and allow disturbed land to revert to natural land cover (is already on upwards trajectory);
- Curb recreational activities in the lower reaches through zonation and improved compliance;
- Reduce/remove castnetting in the mouth area through estuary zonation or increased compliance; and
- Relocate upstream, or remove, the Sappi Weir to restore upper 15% of the estuary.

Since these scenarios include the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, a combination of the PES and the REC will be recommended. The improvements required to meet the REC are mostly non-flow related measures. **The non-flow related (or anthropogenic) measures required to improve the estuary (apart from the removal or changing of the SAPPI weir location) can be applied and should improve the estuary to a B/C – this is recommended as the target ecological health status.**

Mvoti Estuary Health Index score and corresponding ECs under the different runoff scenarios

Variable	**Scenario Group**				
	Present	**A (MV 21, 22, 41)**	**B (MV3)**	**C (MV42 & 43)**	**E (MV21, 22 & MV 41 with ANT reduced)**
Hydrology	53.4	59	42	55	59
Hydrodynamics	95	99	95	99	99
Water quality	58.4	59	54	59	65
Physical habitat alteration	73	73	69	70	73
Habitat health score	**70**	**72**	**65**	**71**	**74**
Microalgae	80	80	65	80	85
Macrophytes	32	33	33	33	50
Invertebrates	25	25	15	25	60
Fish	55	55	55	55	75
Birds	10	10	10	10	45
Biotic health score	**40**	**41**	**36**	**14**	**63**
ESTUARY HEALTH SCORE	**55**	**56**	**50**	**56**	**68**
ECOLOGICAL STATUS	**D**	**D**	**D**	**D**	**C**

Scenario Group E (Sc MV21, 22 and 41 – Anthropogenic Impacts) achieved the REC of a C. Scenario Group C (Sc MV42 and MV43) with the same management intervention will also achieve the REC (Table 6.2). Since these scenarios include the construction of a new dam, this is seen as a medium to long term recommendation. In the short term, a combination of the PES and the REC (in the same category) will be recommended. The improvements required to meet the REC are mostly non-flow related measures. The non-flow related (or anthropogenic) measures required to improve the estuary can be applied and should improve the estuary to a C.

A range of scenarios consisting of various wastewater management scnearios were evaluated on a range of estuaries. The smaller estuaries have very little assimilative capacity. They are at a high risk of becoming eutrophic when their inlets close during low flow and drought conditions. If during the closed phase, there is a constant input of nutrients, it will cause increased primary productivity. Die-off of vegetation can result in high detrital loads. High detrital input, in turn, reduces the oxygen levels in the system with related consequences for fish and invertebrates (e.g. fish kills which is a sign of an ecosystem reaching a tipping point). The consequences of the scenarios are summarised below.

Southern Cluster 1 and 2 IUA

The scenarios resulted in the following changes:

- Sezela: Most of the scenarios maintain the current condition, but the removal of the wastewater will improve the system's condition. Under the worst case scenarios (e.g Scenario B) the estuary decline in condition.
- Koshwana: Most scenarios maintain the current condition. While ScA1 shows an improvement and the worst case scenarios (e.g. Scenario B) indicate a significant decline in health. The recent fish kill in this estuary shows that it is at its tipping point.

- Mbango: Most of the scenarios maintain the current state (PES = E). Under ScA1 (reduction in waste water) the systems shows a significant improvement in condition, while under the worst case scenarios (e.g. ScB) it shows a further decline.
- Boboyi, Mhlangeni, Vungu: Most of the scenario maintain their current health conditions, with a decline under the worst case wastewater scenarios (e.g. Scenario B).
- Kongweni: Most of the scenarios show a further significant decline in health (PES = D/E). A reduction in the wastewater does not achieve the REC of a D, without further interventions.
- Mvutshi: Most of the scenarios show a significant decline in health from the present good condition (PES = B).
- Tongazi and Zolwane: These systems were sensitive to the wastewater scenarios. About half of the scenarios indicate a (significant) decline in condition, while others maintain or improve the present state.

Central Cluster IUA

The estuary health is in a very poor state along this coast, with five systems in a degraded condition (< D): Little Manzimtoti, aManzimtoti, Mbokodweni, Sipingo, Durban Bay, Mgeni. The small systems was also relative insensitive to level of wastewater treatment as they have very little assimilative capacity.

- uThongathi: Most of the scenarios show a severe decline in health due to nutrient loading. The only improvement in condition occurred under Scenario A if wastewater is removed.
- uMdloti: Most of scenarios show a decline in health due to increase nutrient loading. This estuary does NOT improve under Scenario A, if wastewater removed, as the catchment water quality is very poor. Less wastewater means more closed mouth conditions, which in combination with poor water quality, leads to more oxygen stress in the system.
- uMngeni: This estuary may show a improvement in condition as a result of higher inflows.
- Mbokodweni: Shows a declining health under most scenarios due to increase nutrient loading. The system improves significantly under Scenario A if the wastewater is removed.
- Little aManzintoti: Most of the scenarios show a severe decline in health. The system improves significantly in condition if wastewater is reduced/removed.
- uMkhomazi: All “flow” scenarios maintain the current state as the system requires other interventions to attain the REC. Most of the wastewater scenarios degrade the condition.. The scenario of discharging 5 Ml/d which potentially, under average flow condition, will maintain the current condition, holds a high risk of fish kills when the system closes (i.e. low occurrences of closure but a big risk/impact when it happens).

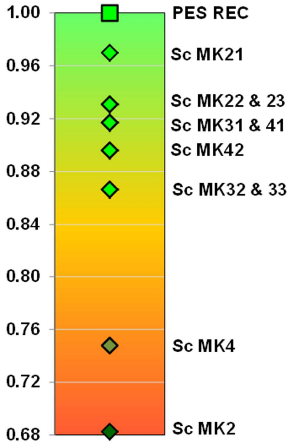
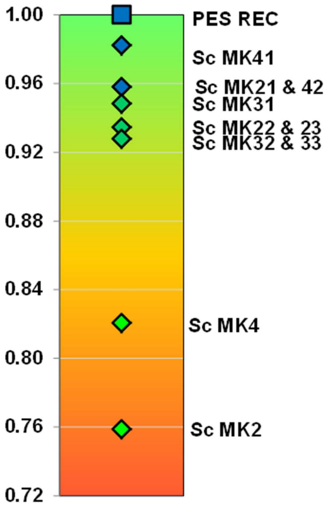
Northern Cluster IUA

- Nonoti: Most wastewater scenarios maintain the current condition. Scenario A1 showed an improvement in condition and the worst case scenarios (e.g. ScB) shows a decline in health.
- Mvoti: Under most flow scenarios the system maintains its current health state. The system require other intervention to attain the REC. Additional wastewater will reduce the current condition, but likely to maintain the class.
- uMhlali: Most of the future scenarios will result in a further declining health due to excessive nutrient loading in a small estuary. The only scenario that showed some improvement in condition is Scenario A, in which the wastewater is removed.

Rivers

- The consequences of the scenarios in terms of the impact on the ecological state or Ecological Category are summarised in the tables below.

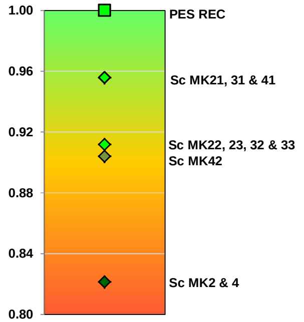
uMkhomazi River System: Summary of ecological consequences at the EWR sites

<table>
<tr><th>Ecological consequences as ECs</th><th>Ecological consequences</th><th>Ranked scenarios</th><th>Ranking rationale</th></tr>
<tr><td colspan="4">MK_I_EWR1 (uMKHOMAZI RIVER)</td></tr>
<tr><td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MK2</th><th>Sc MK21</th><th>Sc MK22, 23</th><th>Sc MK31</th><th>Sc MK32, 33</th><th>Sc MK4</th><th>Sc MK41</th><th>Sc MK42</th></tr>
<tr><td>Physico chemical</td><td>A/B</td><td>C</td><td>A/B</td><td>A/B</td><td>B</td><td>B</td><td>B</td><td>A/B</td><td>A/B</td></tr>
<tr><td>Geom</td><td>A/B</td><td>C/D</td><td>B/C</td><td>C</td><td>B/C</td><td>C</td><td>C</td><td>B/C</td><td>C</td></tr>
<tr><td>Fish</td><td>B</td><td>D</td><td>B/C</td><td>C</td><td>C</td><td>C</td><td>D</td><td>C</td><td>C</td></tr>
<tr><td>Invertebrates</td><td>B/C</td><td>D</td><td>B/C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C</td><td>C</td></tr>
<tr><td>Riparian vegetation</td><td>C</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C/D</td><td>C/D</td></tr>
<tr><td>EcoStatus</td><td>C</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C</td><td>C</td></tr>
</table>
</td>
<td>Geomorphology is reduced to different degrees under all scenarios due to the impact of the dam on sedimentation and possible erosion and accumulation of fines. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and 4 as they do not include EWR releases. This results in a lack of fast flowing habitats and possible reduction and/or eradication of <i>Amphilius natalensis and Barbus natalensis</i>. Scenarios that include EWR releases are an improvement, but the unseasonal releases and at times higher flows than natural are problematic.</td>
<td>
</td>
<td>The results illustrate that most of the scenarios meet the ecological objectives in terms of EcoStatus except for Sc MK4 and MK2. These two scenarios do not cater for EWR requirements and are similar, however under Sc MK2 lower flows occur in all months and zero flows occur during drought periods in Oct – Dec and therefore Sc MK2 has the greatest impact. None of the scenarios meet the ecological objectives for all the components. Sc Mk 21 are the best of the options overall and is therefore ranked the highest.</td></tr>
<tr><td colspan="4">MK_I_EWR2 (uMKHOMAZI RIVER)</td></tr>
<tr><td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MK2</th><th>Sc MK21</th><th>Sc MK22, 23, 32, 33</th><th>Sc MK31</th><th>Sc MK4</th><th>Sc MK41</th><th>Sc MK42</th></tr>
<tr><td>Physico chemical</td><td>A/B</td><td>C</td><td>A/B</td><td>A/B</td><td>A/B</td><td>B</td><td>A</td><td>A</td></tr>
<tr><td>Geom</td><td>B</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>Fish</td><td>B</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>B/C</td><td>B/C</td></tr>
<tr><td>Invertebrates</td><td>B</td><td>D</td><td>B/C</td><td>B/C</td><td>B/C</td><td>C</td><td>B</td><td>B/C</td></tr>
<tr><td>Riparian vegetation</td><td>B</td><td>C</td><td>B</td><td>B/C</td><td>B</td><td>C</td><td>B</td><td>B</td></tr>
<tr><td>EcoStatus</td><td>B</td><td>C</td><td>B</td><td>B/C</td><td>B/C</td><td>C</td><td>B</td><td>B</td></tr>
</table>
</td>
<td>Geomorphology is reduced to a C under all scenarios due to the impact of the dam on sedimentation, channel narrowing and an increase in embeddedness. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and MK4 as they do not include EWR releases. The other scenarios include increased high flows in the dry season with a loss of slow habitats which impact on <i>Barbus anoplus</i> and <i>Barbus viviparus</i>.</td>
<td>
</td>
<td>None of the scenarios meet the ecological objectives. Although Sc MK21, 41 and 42 results in the same EcoStatus, the instream biota are impacted by the reduced wet season base flows and reduced floods. Sc MK41 is the best scenario of these three scenarios because it provides more flows during wet season. Scenario MK2 and MK4 has the worst impact due to reductions in baseflows during dry and wet seasons.</td></tr>
</table>

MK_I_EWR3 (uMKHOMAZI RIVER)

Component	PES & REC	Sc MK2	Sc MK21, 31, 41	Sc MK22, 23, 32, 33	Sc MK4	Sc MK42
Physico chemical	A/B	B/C	A/B	B	B/C	B
Geom	B	C	B/C	C	C	C
Fish	B	C	B/C	C	C	C
Invertebrates	B	C/D	B/C	C	C/D	C
Riparian vegetation	D	D	D	D	D	D
EcoStatus	C	D	C	C	D	C/D

Geomorphology impacts are not as severe as at EWR 1 and 2 due to the distance of the dam. The reduction of large flood and delayed early wet season floods still cause impacts. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and 4 as they do not include EWR releases. The deterioration in fish and inverts, albeit mostly small, is related to the low flows for drought in wet months and impact on spawning. There is no impact on the riparian vegetation.



The results illustrate that none of the scenarios meet the ecological objectives. Sc MK 21, MK31 and MK41 results in the same EcoStatus and has the least impact with a slight deterioration in geomorphology and instream biota. Sc MK22, MK23, MK32 and MK33 also has the same EcoStatus as the PES/REC but there is further deterioration in the instream biota as well as geomorphology and water quality. Scenario MK2 and MK4 have the biggest impact as overall they drop a category for while Sc MK42 only caters for the low flow EWR and the impact is therefore slightly less, i.e. it drops half a category

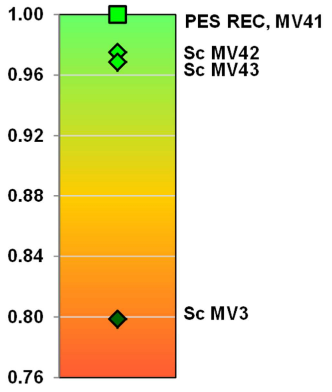
Mvoti River System: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale

MV_I_EWR2 (MVOTI RIVER)

Component	PES & REC	Sc MV3	Sc MV41	Sc MV42, 43
Physico chemical	C	C/D	C	B/C
Geom	C	C/D	C	C/D
Fish	B/C	C/D	B/C	C
Invertebrates	B/C	C/D	B/C	B/C
Riparian vegetation	C/D	D	C/D	C/D
EcoStatus	C	D	C	C

Scenario MV3 is the worst case as it does not include EWR releases. The channel will narrow with vegetation encroachment. An overall loss of fast habitats will impact on the instream biota. Impacts associated with Sc MV42 and MV43 are less pronounced as it includes EWR releases to some degree. Scenario MV 41 supplied the total EWR and therefore meets the ecological objectives.



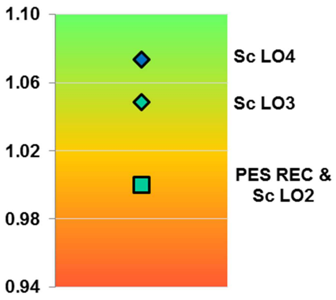
The results illustrate that Sc MV41 meet the ecological objectives. Although Sc MV42 and MV43 results in the same EcoStatus the ecological objectives are not met due to a slight deterioration in geomorphology and fish. Scenario MV3 has the biggest impact with deterioration in all components as the EWR are not provided.

Lovu and uMngeni River Systems: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale
Lo_R_EWR (LOVU RIVER)			

Component	PES & REC	Sc LO2	Sc LO3	Sc LO4
Physico chemical	B/C	B/C	B	A/B
Geomorphology	B	B	B	B
Fish	B/C	B/C	B	A/B
Invertebrates	B/C	B/C	B	A/B
Riparian vegetation	B/C	B/C	B/C	B/C
EcoStatus	B/C	B/C	B/C	B

Sc LO2 maintains the REC. Sc LO3 and LO4 improves the instream biota due to increased base (low flows). These flows will improve water quality, clean backwaters and provide more frequency of desired velocity-depth classes.



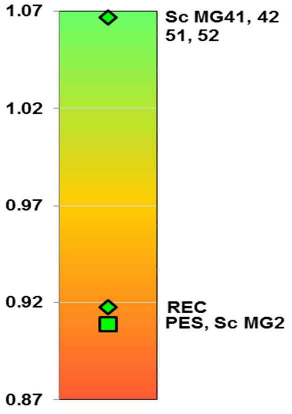
All the scenarios meet the REC while two scenarios improve the REC. Although improvement is not required, it would decrease the risk that the REC will not be maintained and may result reflect positively in the estuary.

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale
MG_I_EWR2 (UMNGENI RIVER)			

Component	PES	REC	Sc MG2	Sc MG41	Sc MG42	Sc MG51	Sc MG52
Physico chemical	C/D	C/D	C	C	C	C	C
Geomorphology	D	D	D	D	D	D	D
Fish	E	D	E	D	D	D	D
Invertebrates	C	C	C	B/C	B/C	B/C	B/C
Riparian vegetation	C	C	C	C	C	C	C
EcoStatus	C	C	C	C	C	C	C

The results illustrate that Sc MG41, 42, 51 and 52 meet the ecological objectives of the REC when the presence of alien fish species is excluded from FRAI calculations. Sc MG2 meets the ecological objectives of the PES but not the REC due to the lower flows and smaller improvements in water quality compared to other scenarios which do not result in the improvement of habitat or fish availability; and therefore the presence of alien fish species.

Note that although there are improvements, the EcoStatus stays a C for al scenarios.

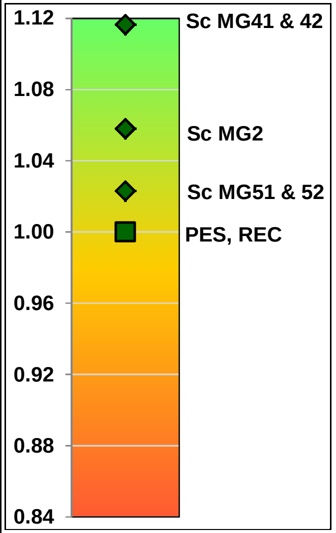


The objectives are set to maintain the PES but to improve the fish. The problems with fish are partly due to the presence of alien fish, migratory barriers, flow changes and water quality problems. Scenarios only effect the last two issues. These (flow & quality) are improved by all the scenarios apart from Sc MG2 and therefore are all acceptable/desirable from an ecological viewpoint.

MG_I_EWR5 (UMNGENI RIVER)

Component	PES & REC	Sc MG2	Sc MG41	Sc MG42	Sc MG51	Sc MG52
Physico chemical	C/D	C	C	C	C	C
Geomorphology	C/D	C/D	C/D	C/D	D	D
Fish	D	C/D	C	C	D	D
Invertebrates	C/D	C	C	C	C	C
Riparian vegetation	D	D	D	D	D	D
EcoStatus	D	D	D	D	D	D

The results illustrate that Sc MG2, 41, 42, 51 and 52 meet the ecological objectives of the REC and is an improvement in some cases. Note that this improvement also relies on an eradication programme for alien fish. Sc MG 51 and 52 shows a decrease in geomorphology but an improvement in invertebrates and water quality.



As the ecological objectives are set to maintain the REC, all scenarios are acceptable. Sc MG41 and 42 would decrease the risk of the D dropping to an E EC.

uMkhomazi River Consequences:
The ranking shows that Sc MK2 and MK4 are the lowest in the ranking order at all sites and significantly lower than the other scenarios. This is because Sc MK2 and MK4 include Smithfield Dam with no EWRs. All the rest of the scenarios still maintain the EcoStatus of a C at Mk_I_EWR1 but do not achieve the REC (PES). The major problem at Mk_I_EWR 1 is that the site is close to the dam and therefore only received the water being released from the dam or spills. As the river acts as a conduit to convey water from the dam down the system, the main reasons for not achieving the REC (PES) is the increased (above natural) and unseasonal base flows as well as the decrease in floods. As one moves further downstream of the dam, the impacts become less pronounced. At Mk_I_EWR 2, tributary inflows mitigate some of the impacts of the unseasonal flows and the lack of floods. However the main users are downstream of Mk_I_EWR 2, and therefore the impacts are still felt to some degree. Sc MK 21, MK41 and MK42 still maintain the EcoStatus of a B with Sc MK41 being the better scenario. Sc MK 21 and MK41 are the best options at Mk_I_EWR 3 as they are the closest to meeting the ecological objectives. Both these scenarios include the total EWR flows and the impacts are mostly due to the impacts on the dam itself, such as the barrier effect, impact on larger frequency of floods and largely due to the increased (above natural) base flows.

Mvoti River consequences:
Scenario MV41 which includes the dam and releases the full EWR will meet the ecological objectives. Scenario MV42 and MV43 are very similar, still maintain the REC EcoStatus but overall do not comply with all the objectives. Scenario MV3 is the least acceptable as it drops a category overall (D EC) and for most of the components.

uMngeni River consequences:
The only scenario that does not meet the REC is Sc MG2. All other scenarios are an improvement of the REC and therefore are all rated equal.

Lovu River consequences:
All scenarios improve the ecological state.

CONSEQUENCES OF SCENARIOS ON ECOSYSTEM SERVICES

uMkhomazi River: Scenarios that were assessed generally result in negligible overall changes. Scenario MK2 shows the highest reduction in Ecosystem Services of all the scenarios, Scenario MK21 shows slight improvements in provisioning and regulating services, although this is considered to be minor and related to improvement in tree abundance due to improved flood attenuation. Scenarios MK22, MK32 and MK42 are considered to be largely static in terms of any potential changes in Ecosystem Services. Only very slight reductions in provisioning services (reduced provisioning services of fish) are noted.

uMkhomazi Estuary: The uMkhomazi Estuary provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation and fish species) which is utilised by people to a moderate degree. Scenarios that were assessed generally result in variable changes. Scenario Group A and Scenario Group F show the greatest reduction in service provision. This is attributed to the reduction in fish abundance, waste dilution potential as well as increases in water-borne diseases. Scenario Group C, as well as Group D and Group E are considered to be largely static in terms of any potential changes in ecosystem services. Only very slight reductions in provisioning services (reduced fish abundance) and regulating services are noted. Scenarios Sc MK21 and MK41 + anth, Scenario Group G and Scenario Group H are the only that show positive trends in service provision. This is largely related to improved fish abundance, cultural use and improvement in human health.

Mvoti River: Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (See Table 7.5). Scenario MV42 and MV43 are considered as equivalent in terms of the impact on Ecosystem Services including an improvement in riparian vegetation growth, water quality, waste dilution and groundwater recharge. Scenario MV3 shows some potential reduction in provisioning services, but an improvement in regulating services around flood regulation from stabilised baseflows.

Mvoti Estuary: The estury provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation which is underutilised. The estuary provides moderate levels of regulating services, specifically flood attenuation, storm control, and sediment supply to beach; but also has elevated levels of water-borne diseases (bilharzia and cholera).

Scenarios, where the PES EWRs are reduced show a commensurate drop in Ecosystem Services. The reduction is likely in provisioning, regulating and cultural services. Provisioning services are likely impacted by the reduction in fish abundance, while there is likely to be reductions in regulating services associated with flood attenuation and increases in water-borne diseases. Cultural services, related to aesthetic value, ritual use and birding is likely to be reduced.

The maintenance of the PES with a reduction in organics will see improvements in provisioning, regulating and cultural services. This includes greater abundance of fish species, reduction in water-borne diseases and improved cultural services.

Southern Cluster 1 and 2 IUA:

- All scenarios for the Mbango Estuary are generally neutral.
- Boboyi and Mhlangeni Estuaries: The scenarios involving loss of fish stocks (increased wastewater discharge) are marginally negative. Most scenarios are neutral or marginally positive.
- Vungu Estuary: Scenarios with elevated levels of discharge from the current state are all negative. Here the driver is largely the negative impact that the scenarios would have on recreational fishing.
- Kongweni Estuary: Scenarios that propose reduced wastewater discharge are positive. Scenarios with greatly increased wastewater discharge are all significantly negative. Impacts on recreational fishing and the presence of invertebrates harvested for food or bait are largely responsible for the rating. It should be noted that the estuary is associated with the Blue flag beach at Margate.
- Mvuthsini Estuary: The scenarios that increase wastewaterdischarge from the present state of no discharge are all negative. Here again impacts on fishing, contact recreation, and harvesting of invertabrates are important components of the rating. It should be noted that negative scenarios may also be associated with and impact on the Ramsgate Blue Flag beach. Scenarios with major increases in discharge are significantly negative.
- Tongazi Estuary: Scenarios that increase discharge are moderaltey negative but those that decrease from present day are marginally positive.
- Zolwane Estuary: Scenarios involving increased wastewaterdischarge from the current sitution where there is no disharge are negative. Fishing, both recreational and subsistence, is the main driver in terms of the rating.

- Most scenarios for the Mpambanyoni Estuary are neutral as there is already relatively significant discharge of wastewater although scenarios with elevated discharge are marginally negative. Impacts on recreational fishing being the main issue.
- Sezela Estuary: Scenarios are mostly neutral, those that propose small increases in wastewater discharge, and these are marginally negative. Recreational fishing and some impact on contact recreation are the main factors. The consideration of the Scenarios at the Sezela Estuary may be important with potential impacts on the Pennington Blue Flag Beach.
- Koshwana Estuary: Most scenarios are positive. This is largely related to potential improvements with respect to fishing and related to reduced wastewater discharge. Scenarios with elevated wastewater discharges are negative for the reverse reasons.

Central Cluster IUA:

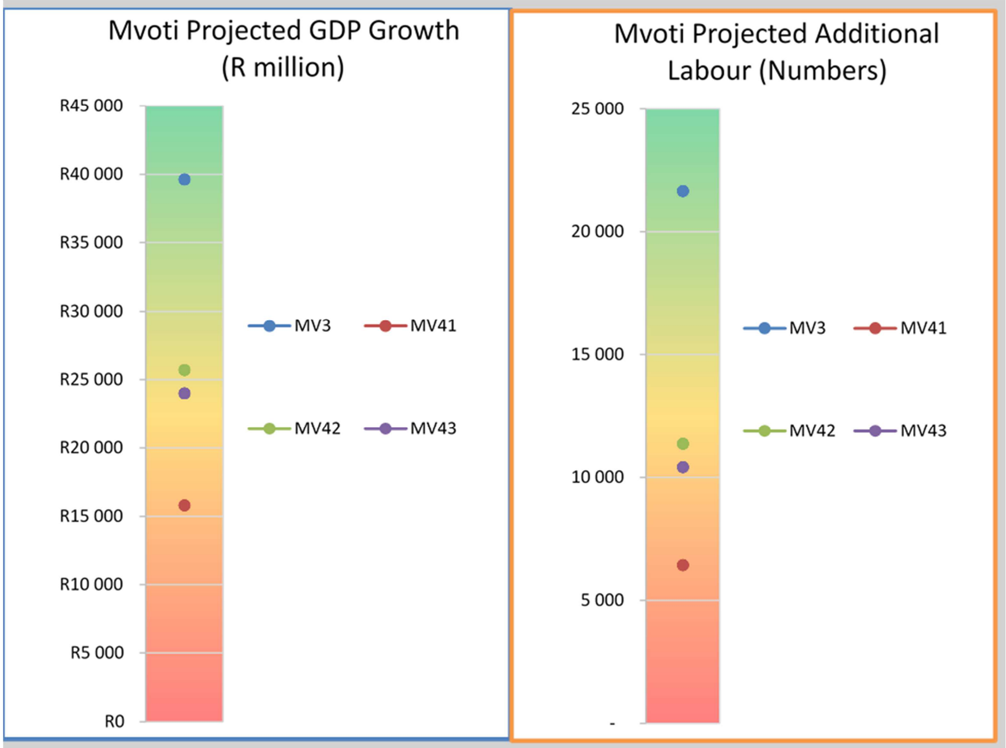
- uThongathi and Mbokodweni Estuary scenarios that remove the wastewater discharge are generally significantly positive. Impacts on increased yields of fish and harvested invertebrates as well as potential improvements to contact recreation are the main reasons. Scenarios that increase to the ultimate wastewater capacity show reverse with very major negative impact.
- uMdloti Estuary scenarios with increases in plant capacity are significantly negative. Impacts on fish availability, harvested invertebrates, and vegetation, as well as declining conditions for contact recreation are responsible. Intermediate wastewater development is less significant but still negative.
- Little Manzimtoti Estuary: Scenarios that remove the discharge are significantly positive. Impacts on increased yields of fish and harvested invertebrates as well as potential improvements to contact recreation are the main reasons; by contrast scenarios that increase wastewater to ultimate capacity are negative for reverse impact reasons.
- uMkhomazi Estuary: Scenarios with wastewater development and transfer from Kingsburgh are all negative with Scenario D being the most negative. Impacts on decreased yields of fish and harvested invertebrates and vegetation as well as potential decline in conditions for contact recreation are the main reasons.

Northern Cluster IUA:

- Nonoti Estuary: Only scenarios with minimum discharge to estuaries show an improvement due to increased availability of fish. Discharge cenarios show a decline in fish. All other scenarios maintain status quo.
- uMhlali Estuary: A group of scenarios that either maintain current state or have increased wastewater shows an improvement due to overall improvement in ecological functioning. Scenarios that impact negatively on water quality and mouth closure show negative ecosystem services for invertebrate and fish presence.
- All Scenarios for the Mvoti Estuary with increased discharge is likely to maintain the current state.

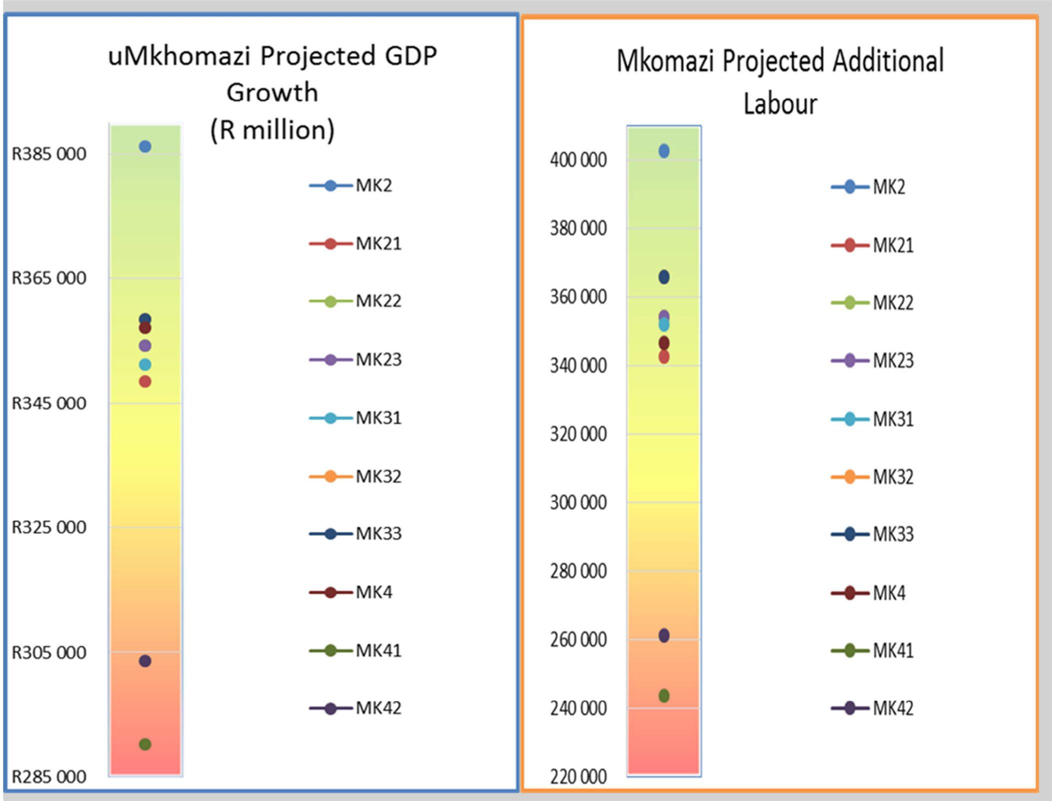
CONSEQUENCES OF THE SCENARIOS ON THE ECONOMICS

uMkhomazi and Mvoti systems:



Mvoti projected GDP growth and additional labour

The above figure indicates that in economic terms Sc MV3 is the most preferable option with Sc MV41 the worst option.



uMkhomazi projected GDP growth and additional labour

All the scenarios provide positive results, but differ in the lower rankings. For both measuring instruments Sc MK2 is the preferable option. Scenario MK42 is economically the least preferred option.

Economic consequences of the wastewater management scenarios for estuaries in the Southern, Central and Northern Cluster IUAs

The ranking of the different scenarios were assessed in terms of their impact on Gross Domestic Product (GDP), for each of the systems. The outcomes were as follows:

Southern Cluster 1 and 2 IUA: The scenarios for this system have many duplicates since the capital and maintenance costs were derived in the same manner. The scenarios which yielded the best Net Present Value of Gross Domestic Product is Scenario Aii (ecological protection is priority with minimum discharge (allow to current capacity of treatment works) to estuaries achieved through alternative discharge systems).
Central Cluster IUA: Scenario Biii again yields the highest Net Present Value of Gross Domestic Product. The biggest impact is a result of the low capital and operational cost of Scenario Biii.
Northern Cluster IUA: The scenarios for this system have many duplicates since the capital and maintenance costs were derived in the same manner. The scenarios which yielded the best Net Present Value of Gross Domestic Product is Scenario D and Scenario Di (an alternative to Scenario D - reduction in treatment costs by applying standard nutrient removal wastewater treatment processes), this is again because of the low capital and operational costs.

MULTI-CRITERIA ANALYSIS

A mutli-criteria analysis approach is followed to compare alternatives where the outcomes (consequences) are in different numerical terms. Ecological cosnequences is a relative rating while economy is in monetary terms and employment in numbers. The numerical ranking results from the multi-criterian analysis model serve as a guide for selecting the most appropriate scenario. It also provides the configuration of Ecological Categories at all the nodes and derives the Water Resource Class for an IUA for any of the scenarios.

Weights are allocated to the variables such as ecological status, ecosystem services, economic indicators and employment. As a starting point, a 50% weight is allocated to the ecology to comply to the balance between protection and use that Classification sets out to achieve. The model does however allow for any other weight distribution to be tested.

DRAFT WATER RESOURCE CLASSES

The catchment configuration associated with the Water Resource Class is provided in the tables below. The catchment configuration is provided as Target Ecological Categories (TECs) at each biophysical node. It must be noted that various nodes require improvements based largely on non flow-related/anthropogenic issues that have to be addressed. Where it is deemed that the REC is attainable, it has been included in the catchment configuration. The red outlined cells in the TEC columns indicates that there are actions required to improve the PES to the TEC.

Mvoti to Umzimkulu WMA: Recommended ECs and Water Resource Classes for the river dominated IUAs

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
T4: Mtamvuna					
T4-1	II	T40A-05450	Mafadobo	19.3	B
		T40A-05487	Goxe	36.2	B
		T40B-05337	Weza	43.0	C
		T40C-05510	Mtamvuna	13.6	B
		T40C-05520	Mtamvuna	19.2	C
		T40C-05530	Mtamvuna	5.4	B
		T40C-05566	Ludeke	9.3	B
		T40C-05589	KuNtlamvukazi	20.5	B
		T40C-05600	Ludeke	18.8	B
		T40D-05537	Mtamvuna	8.8	C
		T40D-05584	Mtamvuna	31.5	C
		T40D-05615	Tungwana	10.5	B
		T40D-05643	Gwala	19.1	B
		T40D-05683	Ntelekweni	28.7	B/C
		T40D-05707	Mtamvuna	0.8	C
		T40D-05719	Londobezi	17.5	B
		Mt_R_EWR1	Mtamvuna	49.5	C
		T40E-05767	Hlolweni	25.4	B
T5: Umzimkulu					
T5-1	I	T51A-04431	Mzimkhulu	27.4	B
		T51A-04522	Mzimude	34.2	B
		T51A-04608		3.0	B
		T51A-04551	Mzimude	16.1	B
		T51B-04421	Mzimkhulu	23.1	B
		T51D-04404	Pholela	30.8	B
		T51F-04566	Boesmans	12.6	A
		T51F-04674		6.4	C
		T51G-04669	Ndawana	19.4	B
		T51G-04722	Ndawana	26.2	C
T5-2	II	T51C-04606		6.4	C
		MzEWR2i	Mzimkhulu	76.0	B
		T51D-04460	Pholelana	12.4	D/E
		T51E-04536		14.1	C
		MzEWR9r	Pholela	73.0	B/C
		T51F-04611	Ngwangwane	12.6	A
		MzEWR8r	Ngwangwane	123.0	C
		T51G-04751		5.0	B
		T51H-04828	Gungununu	13.6	A/B
		T51H-04846	Lubhukwini	18.7	A

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
		T51H-04913	Nonginqa	23.2	B/C
		T51H-04923	Malenge	36.9	B
		T51H-04808	Gungununu	30.7	B
		T51H-04884	Gungununu	10.1	B/C
		T51H-04908	Gungununu	3.1	B/C
		MzEWR3i	Mzimkhulu	21.4	B
		T52B-04947	Cabane	46.4	B
		T52C-04880		15.9	C
		T52C-04960	Mzimkhulu	4.8	B
		T52D-05024	Ncalu	20.4	B
		T52D-05061	Mgodi	26.3	B
		T52D-04948	Mzimkhulu	50.6	B
		T52D-05137	Mzimkhulu	4.7	B
		T52E-05053	Upper Bisi	49.7	B
		T52F-05104	Little Bisi	39.2	C
		T52F-05190	Mbumba	33.1	B/C
		T52F-05139	Little Bisi	13.8	B
		T52G-05226	uMbumbane	19.8	B/C
		T52G-05171	Bisi	10.3	B
		T52H-05244	Mahobe	22.0	B/C
		T52H-05178	Bisi	16.9	B
		T52K-05475	Nkondwana	20.4	B/C
		MzEWR17i	Mzimkhulwana	87.2	B
T5-3	I	T52H-05295	Magogo	28.6	B
		MzEWR14r	Bisi	20.1	B/C
		T52H-05189	Bisi	12.0	B
		MzEWR6i	Mzimkhulu	133.2	A/B
U1: uMkhomazi					
U1-1	I	U10A-04115	Lotheni	27.0	A/B
		U10A-04202	Nhlathimbe	25.7	B
		U10A-04301	Lotheni	18.9	B
		U10B-04239	uMkhomazi	18.3	B
		U10B-04251	uMkhomazi	8.3	A
		U10B-04274	Nhlangeni	9.7	A
		U10B-04337	uMkhomazi	28.1	B
		U10B-04343	Mqatsheni	25.1	B
		U10C-04347	Mkhomazana	68.4	B
		U10D-04199	Nzinga	19.3	A
		U10D-04222	Rooidraai	13.0	B
		U10D-04298	Nzinga	27.1	B
		U10D-04349	uMkhomazi	17.2	B

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
		U10D-04434	uMkhomazi	1.4	**B**
U1-2	**II**	U10E-04380	uMkhomazi	39.5	**C**
		U10F-04528	uMkhomazi	7.0	**C**
		Mk_I_EWR1	uMkhomazi	14.0	**C**
		U10G-04388	Elands	26.5	**B**
		U10G-04405		12.2	**C**
		U10G-04473	Elands	44.5	**B**
U1-3	**I**	U10H-04576	Tholeni	15.8	**B**
		U10H-04666	Ngudwini	36.1	**B**
		U10H-04708	Ngudwini	7.5	**B**
		U10H-04729	Mzalanyoni	24.4	**C**
		Mk_I_EWR2	uMkhomazi	49.0	**B**
		U10J-04721	Pateni	13.8	**B**
U1-4	**II**	U10J-04713	Mkobeni	24.2	**B**
		U10J-04820	Lufafa	43.2	**B**
		U10J-04837		4.0	**A/B**
		U10K-04842	Nhlavini	26.2	**B**
		U10K-04899	Xobho	44.3	**C/D**
		U10K-04946	Nhlavini	21.8	**B/C**
		Mk_I_EWR3	uMkhomazi	113.0	**C**
U2: uMngeni					
U2-1	II	Mg_R_EWR1	uMngeni	62.1	**C/D**
		U20B-04074	Ndiza	21.1	**B**
		U20B-04144	Mpofana	20.1	**C**
		U20B-04173	Lions	50.4	**B**
		U20B-04185	Lions	9.2	**B/C**
		U20C-04190	Lions	18.1	**B**
		U20C-04332	Gqishi	14.8	**B**
		U20C-04340	Nguklu	14.5	**C**
U2-2	III	U20D-04029	Yarrow	18.8	**B**
		U20D-04032	Karkloof	39.4	**C**
		U20D-04098	Kusane	34.2	**D**
		U20D-04151	Karkloof	5.5	**B**
		U20E-04136	Nculwane	23.0	**C**
		Mg_R_EWR3	Karkloof	17.6	**B**
		U20E-04221	uMngeni	5.5	**B/C**
		Mg_I_EWR 2	uMngeni	22.8	**C**
		U20E-04271	Doring Spruit	12.9	**B/C**
		U20F-04011	Sterkspruit	43.2	**C/D**
U2-3	III	U20F-04095	Mpolweni	30.0	**C/D**
		U20F-04131	Mhlalane	18.8	**C/D**

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
		U20F-04204	Sterkspruit	11.5	**B/C**
		U20F-04224	Mpolweni	7.4	**B/C**
		U20G-04194	Mkabela	35.5	**C/D**
		U20G-04215	Cramond Stream	3.8	**B/C**
		U20G-04240	uMngeni	9.5	**B/C**
		U20G-04259	uMngeni	38.8	**B/C**
		U20G-04385US	uMngeni	3.8	**B/C**
U2-4	II	U20H-04410	Nqabeni	10.1	**C**
		U20H-04449	uMnsunduze	38.1	**C**
		Mg_R_EWR4	uMnsunduze	23.9	**D**
		U20J-04391	uMnsunduze	29.2	**C**
		U20J-04401	uMnsunduze	20.7	**D**
		U20J-04452	Mpushini	22.6	**B**
		U20J-04459	uMnsunduze	19.4	**C**
		U20J-04461	Slang Spruit	13.8	**C/D**
		U20J-04488	Mshwati	23.5	**B**
U2-5	III	U20K-04181	Mqeku	30.4	**C**
		U20K-04296	Tholeni	21.2	**B/C**
		U20K-04411	Mqeku	7.3	**B**
		Mg_I_EWR 5	uMngeni	30.5	**D**
U2-6	III	U20M-04625		2.4	**D**
		U20M-04639	Palmiet	1.1	**D**
		U20M-04642	Palmiet	7.8	**D**
		U20M-04649	Mbongokazi	5.7	**C**
		U20M-04653	Palmiet	0.9	**C/D**
		U20M-04659	Palmiet	11.3	**C**
		U20M-04682		1.3	**C/D**
U3: uMdloti and uThongathi					
U3-1	III	U30A-04228	uMdloti	36.0	**B**
		U30A-04360	uMdloti	37.4	**D**
		U30A-04363	Mwangala	17.6	**B**
U3-2	II	U30B-04465	Black Mhlashini	17.3	**B/C**
U3-3	II	U30C-04227	uThongathi	44.4	**B/C**
		U30C-04272	Mona	39.7	**B**
U4-Mvoti					
U4-1	**II**	U40A-03869	Mvoti	54.5	**B**
		U40B-03708	Intinda	18.7	**C**
		U40B-03740	Mvozana	11.0	**C**
		Mv_I_EWR_1	Heinespruit	27.8	**C**
		U40B-03832	Mvozana	16.7	**C/D**

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
		U40B-03896	Mvoti	9.7	**C**
		U40C-03982	Khamanzi	40.2	**B**
		U40D-03867	Mvoti	18.6	**B**
U4-2	**I**	U40D-03908	Mtize	18.9	**B**
		U40D-03957	Mvoti	27.7	**B**
		U40E-03967	Mvoti	8.4	**B/C**
		U40E-03985	Mvoti	27.7	**B**
		U40E-04079	Faye	21.2	**B**
		U40E-04082	Sikoto	8.0	**B**
		U40E-04137	Sikoto	23.1	**B**
		U40F-03690	Potspruit	17.3	**C**
		U40F-03694	Hlimbitwa	11.0	**C**
		U40F-03730	Cubhu	24.3	**C**
		U40F-03769	Hlimbitwa	13.3	**C**
		U40F-03790	Nseleni	5.9	**B/C**
		U40F-03806	Hlimbitwa	6.1	**B**
		U40G-03843	Hlimbitwa	42.5	**B**
U4-3	**II**	Mv_I_EWR_2	Mvoti	62.9	**C**
		U40H-04091	Pambela	17.5	**B**
		U40H-04117	Nsuze	2.7	**B**
		U40H-04133	Nsuze	27.9	**B**
U6: uMlazi					
U6-1	III	U60A-04533	uMlazi	43.2	**C**
		U60B-04614	Mkuzane	26.8	**C/D**
		U60C-04555	uMlazi	52.9	**C/D**
		U60C-04556	Sterkspruit	60.9	**D**
		U60C-04613	Wekeweke	31.8	**C**
U6-2	III	U60D-04661	uMlazi	42.1	**C/D**
U6-3	I	U60E-04714	Mbokodweni	54.5	**B**
		U60E-04792	Mbokodweni	31.4	**C**
		U60E-04795	Bivane	60.7	**B**
U7: Lovu					
U7-1	III	U70A-04599	Serpentine	12.0	**C**
		U70A-04609	Lovu	4.7	**B/C**
		U70A-04618		7.1	**C**
		U70A-04685	Lovu	5.4	**C**
		U70B-04655	Lovu	95.8	**C/D**
		U70C-04710	Mgwahumbe	46.6	**C**
		U70C-04724		1.0	**C**
		U70C-04732		0.9	**C**
		Lo_R_EWR1	Lovu	28.3	**B/C**

IUA	Water Resource Class	Nodes	River	Length (Km)	TEC
		U70D-04800	Nungwane	30.4	B/C
U8: Mtwalume and Mzumbe					
U8-1	I	U80B-05145	Mzumbe_Est	23.1	B
		U80B-05161	Mhlabatshane	24.6	B
		U80C-05231	Mzumbe	56.8	B
		U80C-05329	Kwa-Malukaka	27.4	B
U8-2	II	U80E-05028	Mtwalume	74.6	C
		U80E-05212	Quha	35.8	B
		U80F-05258	Mtwalume	9.0	B
		U80F-05301	uMgeni	20.1	B

Mvoti to Umzimkulu WMA: Recommended ECs and Water Resource Classes for the estuary dominated IUAs

IUA	Water Resource Class	Nodes/Estuaries	River	Length / hectares* (km/ha)	TEC
SC.1	I	T40F-05666	Mbizana	6.7	B
		T40G-05616	Vungu	7.5	B
		Mtamvuma		54.15	A/B
		Zolwane		0.44	B
		Sandhlunlu		4.73	C
		Kuboyoyi		0.73	B
		Tongazi		0.73	B/C
		Kandanhlovu		1.29	B
		Mpenjati		14.90	B
		Umhlangankulu		5.61	C
		Kaba		2.42	C
		Mbizana		13.41	B
		Mvuthsini		0.63	B/C
		Bilanhlolo		2.01	C
		Umvazana		0.36	C
		Kongweni		1.52	EF
		Vungu		0.28	B
		Mhlangeni		5.85	C
		Zotsha		8.54	B
		Boboyi		1.83	B/C
		Mbango		0.37	EF
		Umzimkulu		107.03	B
SC.2	II	U80G-05097	Fafa	14.68	B
		U80H-05109	Mzinto	7.66	C
		U80H-05120	Mzimayi	0.23	C
		U80H-05186	Mkhumbane	0.23	C

IUA	Water Resource Class	Nodes/Estuaries	River	Length / hectares* (km/ha)	TEC
		U80H-05202	Sezela	0.23	C
		U80H-05229	Mdesingane	0.23	C
		U80J-04979	Mpambanyoni	8.36	B
		U80J-05043	Ndonyane	4.14	B/C
		U80K-04952	Mpambanyoni	15.46	C
		Mtentwini		7.76	C
		Mhlangamkulo		2.78	C
		Domba		3.57	D
		Koshwani		1.01	C
		Inhshambili		0.68	C
		Mzumbe		6.68	C/D
		Mhlabatshane		3.00	B
		Mhlungwa		5.94	C
		Mfazazana		1.08	C
		KwaMakozi		2.46	B
		Mnamfu		1.31	C
		Mtwalume		5.01	C
		Mvuzi		0.92	C
		Fafa		14.30	C
		Mdesingane		0.17	D
		Sezela		6.58	C
		Mkumbane		1.08	C
		Mzinto		5.76	C/D
		Nkomba		0.07	C
		Mzimayi		0.50	C/D
		Mpambanyoni		2.92	C
CC	III	U80L-05020	aMahlongwa	7.26	B/C
		U70E-04942	Umsimbazi	2.39	C
		U70E-04974	uMgababa	29.38	C
		U70F-04845	Manzimtoti	30.08	C
		U70F-04893	Little Manzimtoti	16.51	C
		aMahlongwa		7.64	B
		Mahlangwana		6.53	B
		Mkomazi		70.33	B/C
		Ngane		1.86	C
		Umgababa		17.08	B/C
		Msimbazi		20.42	B
		Lovu		35.62	B/C
		Little Manzimtoti		2.58	EF

IUA	Water Resource Class	Nodes/Estuaries	River	Length / hectares* (km/ha)	TEC
		aManzimtoti		5.20	D
		Mmbokotwini		8.75	EF
		Sipingo		0.00	EF
		Durban Bay		0.00	EF
		Durban Bay Shallow Zone		--	D
		Mgeni		84.54	D
		Mhlanga		11.21	B
		Mdloti		28.46	D
		Tongati		3.66	D
NC	III	U30E-04207	uMhlali	25.55	C
		U50A-04018	Zinkwazi	12.64	B/C
		U50A-04021	Nonoti	46.17	B/C
		U50A-04141	Mdlotane	5.32	B/C
		Mhlali		19.26	D
		Bobs Stream		0.38	B/C
		Seteni		0.89	B/C
		Mvoti		28.33	C/D
		Mdlotane		8.97	A/B
		Nonoti		12.13	C
		Zinkwazi		32.22	B

* Note that there are short rivers which are included in the IUAs. The numbers in these columns refer to river length (km) whereas the numbers for estuaries refer to area (ha). This information is used to calculate the Water Resource Class.

The implications and conclusions of the proposed Classes and Catchment Configuration is provided below.

Mtanvuna system (IUA T4-1 and SC1)

- Improve (i.e addressing catchment management of informal agriculture) in Goze and Hlolweni tributaries of the main river and in one reach of the upper Mtamvuna River.
- The current state is recommended for the rivers in the rest of the IUA.
- Improve the estuary by restoring riparian habitat and reducing or controlling recreational fishing.

Umzimkulu system (IUA T5-1, 2, 3 and SC1

- The current state is recommended for the main Umzimkulu River.
- Institute measures (addressing flow in the Mzimude River and non-flow interventions such as riparian buffer reinstatement, reducing sedimentation etc. in Malenge, Ncalu, Mgodi and Upper Bisi tributaries) to achieve the recommended ecological improvement. These measures focus mainly on establishing and maintaining the riparian buffer.
- Institute non-flow related measures in the estuary to counteract the downward trajectory.

uMkhomazi system (IUA U1-1, 2, 3, 4 and CC)

- Institute measures (non flow-related, i.e. manage sedimentation, overgrazing, alien vegetation removal etc) to achieve the recommended ecological improvement in Nzinga,

Elands, Ngudwini, Mkobeni tributaries of the main river and in two reaches of the upper uMkhomazi River.
- The current state is recommended for the rivers in the rest of the IUA.
- Improve the estuary through various non-flow related interventions

Implications:

- A dam such as Smithfield Dam with specific EWR releases can be developed. This will have no impact on the Class and Catchment Configuration. Specific riverine components (geomorphology, fish, invertebrates) will be degraded from present state.
- There will be no impacts on the socio-economics. If Smithfield Dam is implemented and operated according to the recommended scenario, the GDP and jobs will improve.
- Although the estuary will improve, the required degree of improvement will not be achieved as this will require the removal or relocation of the SAPPI weir.
- No further waste can be discharged into the estuary in the future.

uMngeni system (IUA U2-1, 2, 3, 4, 5, 6 and CC)

- The current state is recommended for the main uMngeni River.
- Improve (addressing the riparian buffer zone and water quality in the Ndiza, Lions, Gqishi, Yarrow, Karkloof, uMnsunduze, Mpushini, Mshwati, Tholeni, Mqeku, Mdloti, Mwangala, and Mona tributary reaches.
- The estuary improvement requires implementation of the EWR flow release from Inanda Dam as well as various non-flow related improvements.

Implications:

- Increased waste (to a certain level) can be accommodated in the uMngeni estuary.
- Scenarios that include the ultimate developed demands and return flows, and the Mooi Mgeni Transfer Scheme Phase 2 can be implemented in the future.
- There is no impact on the socio-economics implications of the Water Resource Class and catchment configuration. The future scenarios will have a positive impact on GDP and jobs.

uMdloti and uThongathi systems (IUA U3-1, 2, 3, and CC)

- Improve (addressing non flow-related, i.e. riparian buffer zone issues) Mwangala and Mona tributaries of the main river and the uMdloti River.
- The current state is recommended for the rivers in the rest of the IUA.
- Maintain and/or improve the current state of the estuaries over the long term.

Implications:

- Increased waste in the short term in the estuaries can be accommodated and this may decrease the condition of the estuaries.
- In the long term, all waste must be removed and other options such as indirect re-use must be implemented. The estuaries will return to the present state and may even improve.
- Despite the benefit of reuse, the cost exceeds the benefit; i.e. there are economic implications.

Mvoti systems (IUA U4-1, 2, 3, and CC)

- The current state is recommended for the main Mvoti River.
- Improve (mostly addressing informal agriculture and over grazing) in Khamanzi, Pambela and Nsuze tributary reaches.
- Improve the estuary through various non-flow related interventions.

Implications:

- The proposed Isithundu Dam with specific EWR releases can be developed in the Mvoti River. This will have no impact on the Class. Specific riverine components (geomorphology, fish) will be degraded from present state.

- If the dam is implemented and operated according to the recommended scenario, the GDP and jobs will improve.
- Although the estuary will improve, it will not achieve the required degree of improvement without significant improvement of oxygen levels in the estuary.
- Limited increased waste can be accommodated as long as the estuary remains open.

uMlazi system (IUA U6-1, 2)

- The current river state is recommended apart from Mona and Bivane river reaches which require improvement (mostly addressing informal agriculture and over grazing).
- There is no estuary anymore as it has been canalysed.

Lovu system (IUA U7-1 and CC)

- The current river state is recommended.
- Improve the estuary through various non-flow related interventions.

Implications:

- Although the estuary can improve, the required degree of improvement cannot be met without improving baseflows. This has significant economic implications in terms of los of GDP and jobs.

Mtwalume & Mzumbe (IUA U8-1, 2 and SC2)

- The Mtwalume and Mzumbe Rivers are in a good ecological condition which needs to be maintained.

Southern Cluster 1 IUA (uMzimkulu to Mtamvuna Estuaries)

- Improved estuarine states are recommended at the Zotsha, Mpenjati and Mtamvuna through non-flow related interventions such as managing sedimentation etc.
- Improve the Mtamvuna estuary by restoring riparian habitat and reducing or controlling recreational fishing.
- Institute non-flow related measures (i.e manage sedimentation, overgrazing, alien vegetation removal etc.) in the uMzimkulu estuary to prevent further degradation.

Implications:

- No waste must be discharged in the Vungu and Zotsha Estuaries.
- Scenarios that allow some increase in waste can be allowed in the Zolwane, Mvutshini and Tongazi estuaries.

Southern Cluster 2 IUA (Mtentweni to Mpambanyoni Estuaries)

- The current estuarine states are recommended at the Mpambanyoni, Mzimayi, Nkomba, Mzinto, Mkumbane, Sezela, Mdesingane, Mvuzi, Mtwalume, Mnamfu, Mhlungwa, Mzumbe, Mhlangamkulu and Mtentweni estuaries.
- Improved estuarine states are recommended at the Fafa, Kwa-Makosi, Mhlabatsjane, and Koshwna estuaries through non-flow related interventions such as addressing riparian buffer zone issues etc.

Implications:

- Although the Mhlabatshane and Koshwana Estuaries will improve, they will not achieve the required degree of improvement.
- No further waste must be discharged in the Intshambili estuary.
- Limited additional waste can be allowed in the Sezela estuary.

Central Cluster IUA (uThongathi to Mahlongwa Estuaries)

Note: The uThongati, Mdloti, uMngeni, Lovu, uMkhomazi, Mahlongwana and Mahlongwa estuaries have been dealt with as part of the river systems discussed above.

- Improved estuarine states are recommended at the Umhlanga, Durban Bay zone, Amanzimtoi, and Umgababa estuaries through non-flow related interventions (i.e. manage sedimentation, overgrazing, alien vegetation removal etc.).

Implications:

- The Isipingo estuary is in a very degraded state due to airport developments and further degradation should be prevented. In the Umgababa estuary, partial improvement has been met through non-flow interventions (i.e. manage sedimentation, overgrazing, alien vegetation removal etc.).

Northern Cluster IUA (uThongathi to Mahlongwani Estuaries)

Note: The Mvoti estuary has been dealt with as part of the river system discussed above.

- The current estuarine states are recommended at the Nonoti, Seteni and Bob's Stream estuaries.
- Improved estuarine states are recommended at the Zinkwazi and Mdlotane estuaries through non-flow related interventions.
- A predicted new state based on newly built Waste Water Treatment Works (WWTW) is recommended for the Mhlali River. This is lower than the present ecological state.

Implications:

- Although the estuaries improve, the required degree of improvement could not be met at the Zinkwazi Estuary.
- Increased waste water discharges can be accommodated in the short term in the Nonoti Estuary.

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) therefore 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".

Rivers and Estuaries

Hydrology, habitat, biota and water quality RQOs at high priority river RUs (EWR sites) and high priority water quality RUs are provided in Chapter 14. Estuary RQOs are also provided.

Groundwater

The following groundwater data were then synthesised for each quaternary catchment in each IUA in order to determine the RQOs:

- Borehole yields and groundwater quality as limiting factors for groundwater use.
- Existing groundwater use and stress index (total use/aquifer recharge).
- The Harvest Potential of each catchment.
- Recharge and aquifer recharge (which excludes the component of recharge lost as interflow and not available to groundwater users).
- Natural or virgin groundwater contribution to baseflow, interflow and total baseflow from WRSM2000.
- The groundwater baseflow that would occur under present day present day groundwater abstraction and afforestation and AIPs from WRSM2000.
- The mean annual baseflow under present day afforestation, alien invasive plants (AIPs) and groundwater abstraction from WRSM2000.

Groundwater RQOs are provided in Chapter 15.

CONSIDERATIONS FOR IMPLEMENTTION

The RQO implementation plan consists of three components:

- Firstly activities ensuring that the RQOs determined are adhered too (e.g. releasing or transferring water usually from storage).
- Secondly, monitoring (measuring) various aspects in order to determine whether or not the required RQOs are met or the resulting ecological health objectives are achieved.
- Lastly, if the intended outcomes are not observed from the monitoring process, adaptive management needs to take place in order to rectify the situation such that the desired RQOs are met.

This is best demonstrated through what is needed for the flow RQOs:

- Activity: Release flow from a dam according to set rules.
- Monitoring: Record the flow at flow gauges and compare against EWR flow EWR at a downstream site as well as monitoring related to wastewater discharges affecting the estuaries.
- Adaptive Management: Inform operator to increase flow if target levels are not achieved.

It was recognised that the implementation plan should take account of the varying characteristics of the river reaches across the Study Area, availability and need for monitoring information, the ability (currently and in the future) to regulate flow in the river reaches as well as the existing water resource management activities taking place or being planned.

The overarching approach to be followed in the execution of the implementation plan is that a sequence of activities needs to be introduced to accommodate proposed future infrastructure developments, rollout of ongoing water resource management activities such as the verification of the lawful water use as well as seeking alignment with the progressive implementation of the DWS Reconciliation Strategy and the strategies of the Provincial and Local Authorities.

Chapter 17 details all the activities required for RQO implementation.

It is recommended that an Implementation Plan Management Committee (IPMC) be formulated to oversee the roll out of the actions of the plan. Since there are already several forums and committees functioning in the study area, it is suggested that the proposed functions of the IPMC be discussed at the existing forums to determine the most suitable institutional arrangements.

The committee’s activities will entail coordination of monitoring activities among institutions, evaluation of monitoring information against RQO specifications as well as making recommendation on the required adaptive management measures where noncompliance occurs.

It is anticipated that the majority of the communication amongst the committee members take place electronically, with a meeting held once a year. The meeting will discuss monitoring results obtained in the previous year, as well as set goals and targets to achieve the RQOs for the upcoming year.

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ACRONYMS AND ABBREVIATIONS

AEC	Alternative Ecological Category
AIPs	Alien Invasive Plants
BAS	Best Attainable State
CC	Central Cluster
CD: WE	Chief Directorate: Water Ecosystems
CS	Current State
DBNs	Desktop Biophysical Nodes
DM	District Municipality
DO	Dissolved Oxygen
DSS	Decision Support Systems
DWA	Department Water Affairs (Name change applicable after April 2009
DWAF	Department Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation (Change after May 2014)
EC	Ecological Category
EcoSpecs	Ecological Specifications
EFY	Excess Firm Yield
EFZ	Estuary Functional Zone
EGSA	Ecosystem Goods, Services and Attributes
EHI	Estuarine Health Index
EI-ES	Ecological Importance and Ecological Sensitivity
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Area
FRAI	Fish Response Assessment Index
FSC	Full Supply Capacity
GDP	Gross Domestic Product
GRU	Groundwater Resource Unit
IBA	Important Bird Area
IBT	Interbasin Transfer
IEI	Integrated Environmental Importance
IPMC	Implementation Plan Management Committee
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
KZN	KwaZulu-Natal
MAR	Mean Annual Runoff
MCM	Million Cubic Meters
MIRAI	Macro Invertebrate Response Assessment Index
MM	Metropolitan Municipality
MMTS	Mooi-Mgeni Transfer Scheme
MMTS2	Mooi-Mgeni Transfer Scheme Phase 2
MRDP	Mvoti River Development Project
MRU	Management Resource Unit
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NC	Northern Cluster
NFEPA	National Freshwater Ecosystem Priority Area
nMAR	Natural Mean Annual Runoff
NRU	Natural Resource Unit
NWRC	National Water Resource Classification

OCD	Off-channel Dam
PD	Present Day
PES	Present Ecological State
PESEIS	Present Ecological State and Ecological Importance - Ecological Sensitivity study
pMAR	Present Day Mean Annual Runoff
PSD	Particle Size Distribution
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecologic0al Category
RQO	Resource Quality Objective
RU	Resource Unit
SASS5	South African Scoring System version
SC	Southern Cluster
Sc	Scenario
SCI	Socio-Cultural Importance
SOF	System Operating Forum
SQ	Sub Quaternary
SRP	Soluble Reactive Phosphorous
TEC	Target Ecological Category
TPC	Threshold of Potential Concern
TWQR	Target Water Quality Range
uMWP-1	uMkhomazi Water Project Phase 1
URV	Unit Reference Value
VEGRAI	Vegetation Response Assessment Index
WMA	Water Management Area
WMS	Water Management System
WQ	Water quality
WRSM2000	Water Resources Simulation Model 2000
WRUI	Water Resource Use Importance
WRYM	Water Resource Yield Model
WSS	Water Supply Scheme
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Work

1 INTRODUCTION

1.1 BACKGROUND

There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management Area (WMA) are able to sustain their level of uses and be maintained at their desired states. The determination of the Water Resource Classes of the significant water resources in Mvoti to Umzimkulu WMA will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised is maintained and adequately managed within the economic, social and ecological goals of the water users (DWA, 2011a). The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu WMA.

1.2 STUDY AREA OVERVIEW

The Mvoti to Umzimkulu WMA encompasses a total catchment area of approximately 27,000 km^2 and is situated within Kwazulu-Natal. A small portion of the Mtamvuna River and the upper and lower segments of the Umzimkulu River straddle the Eastern Cape, close to the Mzimvubu and Keiskamma WMA in the south (DWA, 2011a).

The WMA extends from the town of Zinkwazi, in the north to Port Edward and on the south along the KwaZulu-Natal coastline and envelopes the inland towns of Underberg and Greytown also incorporating the Drakensberg escarpment. The WMA spans across the primary catchment “U” and incorporates the secondary drainage areas of T40 (Mtamvuna River in Port Shepstone) and T52 (Umzimkulu River). Ninety quaternary catchments constitute the water management area and the major rivers draining this WMA include the Mvoti, uMngeni, uMkhomazi, Umzimkulu and Mtamvuna (DWA, 2011a).

Two large river systems, the Umzimkulu and uMkhomazi rise in the Drakensberg. Two medium-sized river systems the uMngeni and Mvoti rise in the Natal Midlands and have been largely modified by human activities, mainly intensive agriculture, forestry and urban settlements. Several smaller river systems (e.g. Mzumbe, Mdloti, Tongaat, Fafa, and Lovu Rivers) are also present within the WMA (DWAF, 2004). Several parallel rivers arise in the escarpment and discharges into the Indian Ocean and the water courses in the study area display a prominent southeasterly flow direction (DWA, 2011a). The WMA is very rugged and very steep slopes characterise the river valleys in the inland areas for all rivers and moderate slopes are found but comprise only 3% of the area of the WMA (DWAF, 2004a).

1.3 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the Water Resource Classification, the Reserve and RQOs (DWA, 2012a) are supplied in Table 1.1.

Table 1.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units (RUs), and describe the status quo of the water resource(s).
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the Ecological Water Requirements (EWRs) and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This report summarises the technical report produced as part of step 1, 3, 4, 5, 6 and 7. References are made to each report at the start of the chapter and more detail can be found within the relevant reports.

1.4 NAMING OF RIVERS AND ESTUARIES

Names of the rivers and estuaries used are according to the Government Gazette No. 848 (1 October 2010). All other names are according to what is used in the existing databasis used. For reference, the Ezimvelo KwaZulu-Natal (KZN) Wildlife list of names or synonyms for KZN estuaries is included as Appendix B.

1.5 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to summarise the technical outcomes of the study.

The report outline is provided below.

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

Chapter 2: Status Quo
This chapter provides a summary of the current status of the water resources in the study area in terms of the water resource systems, the ecological characteristics, the socio-economic conditions and the community well-being based on various multi-disciplinary methodologies adopted during this task of the project.

Chapter 3: Integrated Units of Analysis
The Chapter summarises the delineation of Integrated Units of Analysis (IUA) in order to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on ecological conditions at a sub-quaternary scale.

Chapter 4: Hotspot Identification
The Chapter outlines hotspots which are river reaches with a high Integrated Environmental Importance and could be under threat due to its importance for water resource use. The areas would require detailed investigations if development was being considered.

Chapter 5: River Ecological Water Requirements

The main aspect of the Chapter is EcoClassification and EWR determination at various biophysical nodes in the river systems of the Study Area. This chapter summarises the EWRs set during the step 3 of the integrated water resource management process.

Chapter 6: Estuarine Ecological Water Requirements

This chapter provides the EcoClassification results of the uMkhomazi, Mvoti and uMhlali Estuaries.

Chapter 7: Description of Scenarios

The results of the Water Resource Analyses are documented in this Chapter and focuses on identifying and describing the various operational scenarios that were evaluated during the study.

Chapter 8 - 12: Ecological Scenario Consequences

The objective of this task was to provide the scenario analysis, assumptions and results and document the consequences of the scenarios for the various components which include:

- River Ecological Consequences: Chapter 8: This Chapter focuses on the results of the river ecological consequences of the operational scenarios at the key biophysical nodes (EWR sites) by evaluating and determining the impact on the Ecological Category (EC).
- Estuarine Ecological Consequences: Chapter 9: This Chapter focuses on the results of the estuarine ecological consequences of the operational scenarios.
- Ecosystem Services Consequences: Chapter 10: The results of impact of the different scenarios on Ecosystem Services are presented in this Chapter.
- Economic Scenario Consequences: Chapter 11: The results of different scenarios as it impacted on the different economic sectors are presented in this Chapter.
- Water Quality (User) Consequences: Chapter 12: The approach undertaken to include non-ecological water quality into the consequences evaluation and the results are provided in this Chapter.

Chapter 13: Water Resource Classes

The recommended Water Resource Classes among the scenarios are presented. Conclusions and recommendations are provided.

Chapter 14: River Resource Quality Objectives

This chapter outlines the RQOs of rivers and estuaries. RQOs are provided for hydrology of Rivers expressed in terms of flow at biophysical nodes and EWR sites and river habitat, biota and water quality. RQOs of Estuaries for water quality, geomorphology, vegetation, invertebrates, fish and birds, respectively are provided for the uMkhomazi and Mvoti Estuaries.

Chapter 15: Groundwater Resource Quality Objectives

The delineation of Groundwater Units is outlined in this Chapter and the process followed to develop groundwater RQOs is also provided. A summary of the criteria used for identifying groundwater priority areas and groundwater RQOs are included.

Chapter 16: Implementation Considerations

The chapter describes the principles and aspects to consider for implementing the National Water Resources Classification System including the actions needed as well as a timeline to give effect to the RQOs. Monitoring to measure whether the RQOs are being achieved is also provided.

Chapter 17: References

Chapter 18: Appendix A: Operational SCenario Descriptions

This appendix provides the definitions of all scenarios with the identification labels referenced in the reports and serve as a lookup reference.

Chapter 19: Appendix B: Estuary Synonym List for KZN Estuaries

Estuary synonym list for KZN estuaries are listed.

Chapter 20: Appendix C: IUA Maps and the Water Resource Classes

Two maps illustrating the IUAs and shaded according to the Water Resource Class recommended for the IUA are provided

.

Chapter 21: Appendix D: Catchment Visioning

These visions were documented in the form of narrative descriptions and captured for the twelve delineated IUAs and provided as Appendix D.

Chapter 22: Appendix E: Report Comments

Report comments from the Client are provided.

2 STATUS QUO

This chapter is an extract from the following reports:
Department of Water Affairs (DWA), South Africa. 2013a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Status quo assessment, IUA delineation and biophysical node identification. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. July 2013. DWA Report: RDM/WMA11/00/CON/CLA/0113.

Department of Water Affairs (DWA), South Africa. 2013b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Desktop Estuary EcoClassification and Ecological Water Requirement. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. June 2013. DWA Report: RDM/WMA11/00/CON/CLA/0313.

2.1 BACKGROUND

The purpose of this task was to describe and document the status quo task which includes various components such as water use, economy, river and wetland ecology, identifying water quality problems and Ecosystem Goods, Services and Attributes (EGSA), referred to as Ecosystem Services. This information was used to define the Integrated Unit of Analysis (IUA) and provide background information to assist with the catchment visioning process. Once the IUAs are delineated, RUs and biophysical nodes must be identified for different levels of EWR assessment and setting of RQOs.

2.2 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the Water Resource Classification, the Reserve and RQOs are supplied in Table 2.1.

Table 2.1 Integrated study steps

Step	Description
1	**Delineate the units of analysis and RUs, and describe the status quo of the water resource(s).**
2	Initiation of stakeholder process and catchment visioning*.
3	Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

* Outcomes of the catchment visioning is provided as Appendix D.

This Chapter as well as Chapters 3 and 4 form part of Step 1, i.e. delineating the IUAs and describing the status quo of the water resources for each IUA.

2.3 WATER RESOURCES STATUS QUO ASSESSMENT

Water resource zones based on similar water resource operation, location of significant water resource infrastructure (including proposed infrastructure) and distinctive functions of the catchments in context of the larger system were selected and are summarised below.

Mvoti (Tertiary catchments U40 and U50): Land use consists mostly of communal land inland (Mapamulo), commercial timber in the upper reaches of the catchment, dryland and irrigated sugar cane along the coastal strip, and urban areas of Stanger and Greytown. The water resources of the Mvoti catchment are poorly developed and have not kept pace with the water requirements. As a result the requirements far exceed the available resources and the catchment can be considered to be stressed.

uMdloti (Tertiary catchment U30): The uMdloti Key Area includes both the uMdloti and the uThongathi rivers. The major dams in the area include Hazelmere Dam on the uMdloti River and the smaller Dudley Pringle Dam in the uThongathi River catchment. Land use in the uMdloti Key Area consists mostly of dryland and irrigated sugar cane, mostly on communal land. Water is transferred out of the catchment to the Mvoti catchment. The water quality of the catchment is generally poor due to point source pollution, especially along the coastal strip. The inland regions generally enjoy better water quality but erosion and resultant sedimentation is a problem.

uMngeni (Tertiary catchment U20): The uMngeni River system is largely regulated and developed. The catchment is currently serviced by the following four major dams on the uMngeni River as well as the Mooi-uMngeni transfer scheme; Midmar Dam, Nagle Dam, Albert Falls Dam and Inanda Dam. The water requirements in the Key Area are currently approximately in balance with the available yield. Water quality in the lower uMngeni River and in the Msunduze River is generally poor. This is due to the dense human population in and around Durban and Pietermaritzburg, some of which is not serviced with adequate sanitation.

uMlazi and Lovu (Tertiary catchments U60 and U70): The catchment is dominated by irrigation and afforestation, with irrigation being by far the dominant water user. Much of this irrigation use is for intensive vegetable farming to supply Durban and Pietermaritzburg. This is important from a food supply perspective. The catchment is largely unregulated. However, large farm dams are present in the upper reaches of the Lovu River. The Shongweni Dam on the uMlazi River has silted up over the years and is now only used for recreational and educational purposes. The water quality in the catchment is poor, especially the uMlazi River.

uMkhomazi (Tertiary catchment U10): The two largest water users in the catchment are industry, with SAPPI-SAICCOR's water requirement of 44 million m^3/annum at the mouth of the uMkhomazi River, and the irrigation sector. Forestry and dryland sugar cane are also significant in the area. The catchment is unregulated and development of major water resources infrastructure is reserved for the transfer of water to the uMngeni River System.

South Coast (Tertiary catchment U80): The South Coast is a largely undeveloped area with limited water requirements. Forestry and dryland sugar cane are also very limited in the area and are not significant factors from a water resources point of view. The catchment as a whole is experiencing a small deficit, which is experienced by some of the coastal resorts and the Sezela sugar mill. Water shortages have been experience in the urban sector are due to the seasonality of the tourism industry. The water-related infrastructure (including the water resources) cannot cope with the large influx of holiday-makers in December.

Mtamvuna (Tertiary catchment T40): The Mtamvuna is a largely undeveloped catchment. The only significant water requirement is that of the coastal towns which are mostly supplied through transfers from the Umzimkulu River. There are large areas of dryland sugar cane in the catchment but the reduction in runoff due to this has little impact on the available yield because of its location along the coast. Irrigation in the catchment is insignificant.

Umzimkulu (Tertiary catchments T51 and T52): This is characterised by relatively large rural use and extensive afforestation, which has a significant impact on the low flow in the catchment. The catchment is unregulated in the sense that there is no major dams in the catchment.

2.4 GROUNDWATER STATUS QUO

The aquifer recharge and discharge (Table 2.2) and groundwater exploitation potential and current use (Table 2.3) is provided below.

Table 2.2 Aquifer recharge and discharge

Quat	Area (km^2)	MAP[1] (mm/a)	Recharge (mm/a)	Baseflow (mm/a)	Aquifer recharge (mm/a)	Groundwater baseflow (mm/a)	Interflow (mm/a)
T4: Mtamvuna							
T40A	208	997	117.0	113.1	6.9	3.6	109.6
T40B	278	981	115.0	109.2	9.6	3.6	105.7
T40C	237	831	84.4	77.0	11.6	3.9	73.0
T40D	372	816	58.9	51.6	11.0	4.2	47.4
T40E	486	822	64.1	56.7	15.5	8.3	48.5
T40F	335	1069	111.1	107.5	17.7	14.3	93.3
T40G	300	1054	107.4	103.9	18.0	14.4	89.6
T5: Umzimkulu							
T51A	328	1255	166.4	166.1	5.7	5.9	160.0
T51B	210	1175	145.2	144.7	6.5	6.1	138.4
T51C	462	948	91.6	89.8	9.0	7.5	82.3
T51D	142	1229	159.1	159.0	6.3	6.0	152.8
T51E	256	953	92.6	90.9	9.1	7.5	83.4
T51F	307	1137	129.8	128.8	7.0	6.3	122.2
T51G	256	1082	117.3	115.7	7.6	6.5	109.0
T51H	520	943	90.7	88.8	8.9	7.5	81.3
T52A	382	902	89.1	86.8	8.9	7.5	79.3
T52B	256	877	84.1	81.8	9.3	7.6	74.2
T52C	261	832	75.4	73.2	9.8	7.8	65.3
T52D	531	792	54.5	46.4	16.4	8.4	38.0
T52E	233	899	92.8	86.2	13.7	7.4	78.7
T52F	418	904	93.9	87.2	13.4	7.4	79.8
T52G	221	899	92.8	86.2	13.7	7.4	78.7
T52H	344	779	47.4	44.6	7.5	4.3	40.4
T52J	368	827	63.1	55.7	11.3	4.2	51.6
T52K	426	804	59.3	52.1	11.6	4.2	48.0
T52L	179	894	74.6	68.7	42.6	37.2	31.7
T52M	313	903	73.9	68.8	20.8	15.5	53.4
U1: uMkhomazi							
U10A	418	1285	180.8	178.7	27.9	25.8	152.9
U10B	392	1174	155.2	151.2	30.1	26.7	124.4

Quat	Area (km^2)	MAP[1] (mm/a)	Recharge (mm/a)	Baseflow (mm/a)	Aquifer recharge (mm/a)	Groundwater baseflow (mm/a)	Interflow (mm/a)
U10C	267	1089	136.0	131.3	32.0	27.3	103.9
U10D	337	997	116.3	111.0	31.8	26.4	84.5
U10E	327	1032	124.1	118.5	31.1	26.2	92.3
U10F	379	965	89.7	83.8	23.2	17.8	65.9
U10G	353	983	97.8	93.0	22.3	17.6	75.3
U10H	458	926	88.3	83.5	22.1	17.3	66.2
U10J	505	880	54.7	49.0	23.4	17.9	31.0
U10K	364	795	42.4	37.8	21.9	17.9	19.9
U10L	307	760	43.2	35.2	27.0	19.7	15.5
U10M	280	860	56.2	48.9	26.7	20.4	28.5
U2: uMngeni							
U20A	293	1006	136.6	129.1	24.9	18.4	110.7
U20B	353	984	98.6	91.8	26.4	19.6	72.2
U20C	279	928	92.9	86.3	26.8	19.9	66.4
U20D	338	1027	99.4	93.0	25.1	18.8	74.2
U20E	390	962	70.6	65.1	22.9	17.8	47.3
U20F	435	975	72.5	67.6	22.5	17.8	49.7
U20G	494	887	62.8	53.3	28.2	18.2	35.2
U20H	220	933	99.0	93.5	25.5	19.7	73.7
U20J	678	831	52.7	45.9	26.9	20.1	25.8
U20K	271	940	70.0	62.4	28.2	18.7	43.7
U20L	328	802	46.1	43.5	22.6	20.5	23.1
U20M	360	917	71.1	59.7	31.3	20.1	39.6
U3: uMdloti and uThongathi							
U30A	376	956	80.9	70.5	29.3	19.3	51.1
U30B	221	971	84.8	74.1	30.3	20.1	54.1
U30C	242	988	86.2	76.0	28.8	19.2	56.7
U30D	181	975	84.1	73.7	29.1	19.3	54.4
U30E	290	1008	89.6	79.6	28.3	19.2	60.4
U4: Mvoti							
U40A	317	915	92.5	86.0	26.5	20.1	65.9
U40B	388	865	55.9	48.8	25.7	19.1	29.7
U40C	264	876	60.9	54.5	25.2	19.2	35.2
U40D	267	862	63.3	52.5	29.6	19.2	33.3
U40E	318	835	61.0	51.7	28.7	20.0	31.7
U40F	290	838	52.8	45.4	26.1	19.1	26.2
U40G	253	890	66.4	55.4	30.7	19.8	35.6
U40H	361	916	74.2	63.9	29.2	19.8	44.2
U40J	279	988	80.7	70.6	28.8	19.5	51.2
U5: Nonoti							
U50A	298	1047	94.4	85.3	18.9	9.8	75.5
U6: uMlazi							
U60A	105	980	76.0	70.3	16.0	10.1	60.2

Quat	Area (km^2)	MAP[1] (mm/a)	Recharge (mm/a)	Baseflow (mm/a)	Aquifer recharge (mm/a)	Groundwater baseflow (mm/a)	Interflow (mm/a)
U60B	316	822	57.7	45.8	22.4	10.5	35.3
U60C	365	771	54.2	40.1	23.6	9.5	30.5
U60D	185	885	66.6	55.0	26.9	15.3	39.7
U60E	280	904	69.7	57.9	26.4	15.3	42.6
U60F	272	964	78.3	67.5	25.3	15.1	52.4
U7: Lovu							
U70A	114	1039	86.4	80.9	15.2	9.8	71.1
U70B	272	849	61.4	49.5	26.8	15.5	34.0
U70C	350	857	63.4	51.7	27.1	15.6	36.1
U70D	208	936	74.6	63.7	25.7	15.3	48.5
U70E	87	996	84.2	74.1	25.0	15.0	59.2
U70F	59	994	84.8	73.8	25.5	15.0	58.9
U8: Mzumbe and Mtwalume							
U80A	158	1034	90.2	80.1	24.1	14.8	65.5
U80B	339	799	56.6	43.9	28.4	15.6	28.4
U80C	202	959	77.9	67.1	25.4	15.1	52.1
U80D	120	1045	92.0	82.1	24.1	14.7	67.5
U80E	415	829	60.0	47.9	27.8	15.5	32.5
U80F	137	932	73.6	62.9	26.1	15.2	47.8
U80G	415	829	60.0	47.9	27.8	15.5	32.5
U80H	137	932	73.6	62.9	26.1	15.2	47.8
U80J	261	936	74.2	63.5	25.8	15.2	48.4
U80K	243	1010	85.5	75.9	24.4	14.9	61.2
U80L	371	838	61.4	49.1	27.7	15.5	33.7

Table 2.3 Groundwater exploitation potential and current use

Quat	Harvest potential (million m^3/a)	Exploitation potential (million m^3/a)	Utilisable exploitation potential (Potable) (million m^3/a)	Current use (million m^3/a)	Main water use sector
T4: Mtamvuna T4: Mtamvuna					
T40A	2.83	1.41	1.31	0.00	-
T40B	3.78	1.89	1.75	0.00	-
T40C	3.22	1.61	1.48	0.00	-
T40D	5.06	1.52	1.52	0.00	-
T40E	19.93	9.96	9.34	0.04	Rural
T40F	15.96	4.79	3.42	0.02	Rural
T40G	10.52	4.21	3.61	0.03	Rural
T5: Umzimkulu					
T51A	5.50	2.75	2.34	0.03	Livestock
T51B	3.71	2.23	1.89	0.02	Livestock
T51C	7.06	3.53	3.53	0.12	Rural
T51D	2.48	1.74	1.48	0.01	Livestock
T51E	4.14	1.66	1.41	0.10	Rural
T51F	5.08	3.05	3.05	0.03	Livestock

Quat	Harvest potential (million m^3/a)	Exploitation potential (million m^3/a)	Utilisable exploitation potential (Potable) (million m^3/a)	Current use (million m^3/a)	Main water use sector
T51G	4.40	2.20	1.87	0.01	Livestock
T51H	7.58	3.79	3.22	0.00	-
T52A	5.20	2.60	1.95	0.15	Rural
T52B	3.48	1.74	1.48	0.00	-
T52C	3.55	2.48	2.29	0.00	-
T52D	7.71	3.86	3.86	0.03	Rural
T52E	3.17	1.58	1.35	0.00	-
T52F	5.68	2.84	2.42	0.00	-
T52G	3.01	1.50	1.38	0.00	-
T52H	5.05	2.53	2.33	0.00	-
T52J	7.80	2.34	2.34	0.01	Rural
T52K	5.79	2.90	2.57	0.34	Municipal
T52L	13.41	6.71	6.37	0.20	Rural
T52M	12.29	4.92	3.93	0.15	Rural
U1: uMkhomazi					
U10A	7.12	2.14	1.82	0.00	-
U10B	6.78	2.03	1.73	0.03	Rural / Livestock
U10C	4.44	1.33	1.13	0.02	Rural / Livestock
U10D	5.50	1.65	1.40	0.01	Rural
U10E	4.83	1.45	1.38	0.07	Rural
U10F	5.51	1.65	1.57	0.19	Rural
U10G	4.89	1.47	1.25	0.03	Rural
U10H	6.23	2.49	2.49	0.20	Rural
U10J	6.87	2.06	1.65	0.02	Rural
U10K	4.95	3.47	3.47	0.00	-
U10L	12.41	4.96	4.96	0.03	Rural
U10M	9.70	2.91	1.75	0.17	Rural
U2: uMngeni					
U20A	4.44	2.22	2.11	0.00	-
U20B	4.83	3.38	2.87	0.00	-
U20C	3.79	2.66	2.26	0.01	Livestock
U20D	338	1027	99.4	93.0	25.1
U20E	390	962	70.6	65.1	22.9
U20F	16.43	9.86	5.91	0.03	Livestock
U20G	27.35	19.15	19.15	0.16	Rural
U20H	2.99	1.50	1.38	0.67	Rural
U20J	14.11	7.06	6.00	0.12	Rural
U20K	14.18	8.51	7.23	0.07	Rural
U20L	12.90	9.03	7.05	0.26	Rural
U20M	27.00	16.20	8.10	0.00	-
U3: uMdloti and uThongathi					
U30A	30.87	12.35	10.49	0.04	Rural

Quat	Harvest potential (million m^3/a)	Exploitation potential (million m^3/a)	Utilisable exploitation potential (Potable) (million m^3/a)	Current use (million m^3/a)	Main water use sector
U30B	6.09	3.04	1.22	0.00	-
U30C	242	988	86.2	76.0	28.8
U30D	6.36	3.82	1.53	0.00	-
U30E	17.63	8.82	4.41	0.02	Rural
U4: Mvoti					
U40A	2.83	1.41	1.31	0	-
U40B	3.78	1.89	1.75	0	-
U40C	3.22	1.61	1.48	0	-
U40D	5.06	1.52	1.52	0	-
U40E	19.93	9.96	9.34	0.04	Rural
U40F	15.96	4.79	3.42	0.02	Rural
U40G	10.52	4.21	3.61	0.03	Rural
U40H	19.47	5.84	3.89	0.08	Rural
U40J	18.67	9.33	6.53	0.00	-
U5: Nonoti					
U50A	12.42	7.45	6.21	0.24	Municipal
U6: uMlazi					
U60A	1.43	0.71	0.66	0.01	Rural
U60B	5.40	3.24	3.01	0.01	Livestock
U60C	25.07	12.53	10.65	0.06	Livestock
U60D	11.54	3.46	2.42	0.00	-
U60E	16.62	6.65	3.32	0.03	Rural / Livestock
U60F	15.83	7.91	3.96	0.00	-
U7: Lovu					
U70A	1.55	0.62	0.57	0.00	-
U70B	12.36	4.94	4.20	0.01	Rural
U70C	22.94	11.47	9.75	0.01	Livestock
U70D	13.70	4.11	2.88	0.06	Rural
U70E	2.09	1.26	0.50	0.05	Rural
U70F	2.26	1.13	0.79	0.00	-
U8: Mzumbe and Mtwalume					
U80A	5.42	2.71	1.50	0.37	Rural
U80B	10.68	3.20	3.20	0.07	Rural
U80C	7.27	2.91	2.91	0.23	Rural
U80D	3.57	1.43	1.24	0.11	Rural
U80E	18.05	5.42	3.79	0.14	Rural
U80F	4.52	1.36	1.36	0.16	Rural
U80G	14.60	5.84	4.59	0.10	Rural
U80H	8.45	2.53	2.53	0.03	Rural
U80J	17.75	5.32	4.50	0.09	Rural
U80K	5.89	1.77	0.96	0.07	Rural
U80L	2.58	0.77	0.35	0.05	Rural

2.5 STATUS QUO OF THE ECONOMY

The current situational reality of the socio economic position in the Water Management Area must be taken into consideration in the evaluation of the possible impact on the current economic activities by identified scenarios. This involves the establishment of a current economic baseline from which any deviation can be measured during the evaluation of the identified scenarios involving the availability of water.

It is of course primarily the socio-economic features of a province which shapes the developmental challenge. In KwaZulu-Natal (KZN), despite the concerted efforts of the Provincial Government to address the twin challenges of poverty and unemployment in the first two decades of democracy, poverty and unemployment rates have remained chronic and rising. KZN remains a predominantly rural province, with dependency ratios and poverty levels highest in the rural areas, although the greatest numbers of poor people (poverty density) are to be found in the major urban centres.

The economic significance of water uses in the Mvoti to Umzimkulu WMA is dominated by primary sectors such as irrigated agriculture and commercial forestry, subsequently by secondary industries in particular saw and sugar mills as well as a pulp and paper factories which has become service centres for the local population. Tertiary flow of the economy represents the tourism sector. The WMA covers the very important economic hubs of eThekwini Metropolitan Municipality (MM) (Durban) and Msunduzi Local Municipality (Pietermaritzburg) which together represent more than 60% of the industrial output of the KZN Province.

As already mentioned it is also a very important agricultural region hosting large sugar cane production areas throughout the WMA with the accompanying sugar mills. A large variety of other agricultural products are produced varying from beef and dairy production in the inland areas to crop and horticultural production in both the coastal and inland areas.

This area includes some of the most popular tourist and holiday areas in the country varying from a number of coastal holiday towns/resorts, Durban beaches and inland tourist destinations such as the Drakensberg region and very popular game parks. The Durban port together with the N3 highway, accompanying railway and fuel lines are the most important transport nodes in the country.

Eight Economic Regions were identified and conform to the secondary catchments of WMA 11. In all the regions, agricultural related industry (i.e. sugar and saw mills) is prominent. The dominant activity for the rural section of the catchment is the agricultural related industry.

2.6 WATER QUALITY ISSUES

T4 Mtamvuna: Rivers: Due to the undeveloped nature of the catchment, water quality status is generally Good throughout the area. No water quality hotspots were identified in this catchment area.

T5 Umzimkulu: Rivers: A comprehensive assessment of the water quality situation of the Umzimkulu catchment area was undertaken, with data collected up to 1999, as part of the Southern KwaZulu-Natal Water Resources Prefeasibility Study (DWAF, 2002). This study found that water quality data indicated Good water quality with no significant signs of pollution, or any adverse trends in water quality, for the Upper Umzimkulu Basin.

DWA (2011a) noted specific concerns about the state of the river near the town of Umzimkulu in the Middle Umzimkulu Basin. It was recommended that a water quality study be undertaken in that area to identify potential pollution sources and management interventions to address local impacts.

Quality in the Mzimkhulwana River of the Lower Basin was found not to be as good as that in the other basins, probably due to agricultural use (DWA, 2011b).

The following paragraph is summarized from DWA (2011b): Despite the developments that have taken place in the catchment area, the water quality remains relatively Good due to the non-polluting nature of the development in the area and the relative isolation of settlements from open water. The greatest water quality risk is the town of Umzimkulu which discharges effluent directly to the river. These issues are exacerbated by large-scale water abstraction from the system.

No riverine water quality hotspots were found in this catchment area. Impacts of Port Shepstone and Mzimkhulu Sugar Mill are on the estuary and not the riverine component.

U1 uMkhomazi: Rivers: Primary impacts in the area are elevated sediment loads due to activities such as overgrazing and high population numbers, resulting in elevated instream turbidity (uMngeni Water, 1998). However, no major water quality issues or hotspots were identified in tertiary catchment U10 and the water quality of the uMkhomazi is considered Good (DWAF, 1999a). The major water quality concern for the uMkhomazi catchment is microbiological water quality (DWAF, 2008a). No water quality hotspots were identified in this catchment area.

U2 uMngeni: Rivers: Water quality deteriorates downstream from Midmar Dam, although user requirements are met. Deterioration is mainly linked to an increase in nutrients, linked to agricultural activities, particularly dairies, piggeries and maize production. There is also increased pollution from growing settlements such as Mphophomeni (WRC, 2002).

The water quality in the uMnsunduze downstream of Henley Dam is seriously affected by sewer infrastructure problems, including ingress of rainwater into the sewer system which results in surcharges, overloading Darvill Waste Water Treatment Works (WWTW). Pit latrines are also extensively used in the area. The Darvill WWTW is the single most important contributor of nutrients to the downstream system, with poorly managed subsistence agriculture, overgrazing and poor sanitation systems downstream (WRC, 2002). The water quality of the middle and lower uMnsunduze is very poor, with a high faecal coliform content and nutrient enrichment, resulting in significant risks of health effect if the water is used for drinking and contact recreation, e.g. the annual Dusi canoe marathon.

The nutrient concentrations in the lower uMnsunduze River are also very high and contribute significantly to the eutrophication processes of the lower uMngeni River.

Water quality hotspots across U20 are shown in Table 2.4 below.

Table 2.4 Water quality hotspots in Catchment U20

SQ[1] reach	River name	Water quality impact (rating)	Water quality issues
U20C-04340	Nguklu	Large (3)	Elevated nutrient loads.
U20E-04243	uMngeni	Large (3)	Elevated nutrient loads; urban run-off.
U20F-04224	Mpolweni	Large (3)	High nutrient load.

SQ[1] reach	River name	Water quality impact (rating)	Water quality issues
U20G-04194	Mkabela	Large (3)	High nutrient load; toxics may be present.
U20G-04215	Cramond Stream	Large (3)	High nutrient load; toxics may be present.
U20G-04240	uMngeni	Large (3)	High nutrient load.
U20G-04385	uMngeni	Large (3)	High nutrient load; urban impacts.
U20J-04364	uMnsunduze	Serious (4)	Industrial discharges; elevated nutrients and salts.
U20J-04391	uMnsunduze	Critical (5)	WWTW; industrial discharges; elevated nutrients and salts.
U20J-04401	uMnsunduze	Critical (5)	Industrial discharges; elevated nutrients and salts.
U20J-04461	Slang Spruit	Critical (5)	Urban and industrial discharges.
U20J-04488	Mshwati	Large (3)	Urban impacts; nutrient elevations.
U20L-04435	uMngeni	Large (3)	Urban impacts; nutrient elevations.
U20M-04396	uMngeni	Serious (4)	Urban impacts; nutrient elevations; aquatic plants in upstream dam so low Dissolved Oxygen (DO) levels; treated effluent coming in from the Piesang in the north (below Inanda). Note the input of the Mhlangane River, which is a hotspot identified by eThekweni MM.
U20M-04639	Palmiet	Large (3)	Elevated nutrients.
U20M-04642	Palmiet	Serious (4)	Elevated nutrients and industrial discharges.
U20M-04653	Palmiet	Large (3)	Elevated nutrients.

1 Sub Quaternary

U3 uMdloti: Rivers: The water quality of the catchment is generally Poor along the coastal strip due to point source pollution. The water quality state of the inland regions is generally better, although erosion and resultant sedimentation is a problem (DWAF, 2004a).

Water quality hotspots across U30 are shown in Table 2.5. Note that water quality hotspots falling into reaches with estuarine components are shown in red text.

Water quality hotspots across U30 are shown in Table 2.5. Note that hotspots that fall into reaches with estuary components are shown in red text.

Table 2.5 Water quality hotspots in Catchment U30

SQ reach	River name	Water quality impact (rating)	Water quality issues
U30A-04360	uMdloti	Large (3)	Elevated nutrients, industrial discharges and high sediment loads.
U30B-04465	Black Mhlashini	Large (3)	Elevated nutrients.
U30B-04475	uMdloti	Critical (5)	Elevated nutrients and blue-green algae; WWTW; ID by eThekwini MM as a hotspot.
U30B-04498	Ohlanga	Critical (5)	Elevated nutrients; WWTW (Phoenix return flows and Umhlanga WWTW at head of estuary).
U30D-04315	uThongathi	Large (3)	Elevated nutrients and fertilizers; industrial discharges.
U30E-04207	uMhlali	Large (3)	Elevated nutrients; WWTW discharges.

U4 Mvoti: Rivers: Potential water quality issues raised in the Internal Strategic Perspective (ISP): Mvoti to Umzimkulu WMA (DWA, 2004a,b) include:

- Erosion potential in the upper catchment owing to inadequate forestry practices.
- Faecal contamination around Greytown (Heinespruit River or SQ catchment U40B; i.e. the location of the WWTW) and agricultural run-off contamination (pesticides and nutrients).
- Potential impacts of pesticides and nutrients due to intensive agriculture.
- Serious erosion due to steep slopes and inadequate farming practices in the middle and lower reaches of the Mvoti Catchment, with some faecal contamination and potential of industrial effluent contamination in the lower reaches

Nutrient loading evident in the catchment is most likely the result of non-point source pollution from the extensive sugarcane and banana plantations. The majority of the rivers reflect Good water quality status, although there are some water quality hotspots.

Water quality hotspots across U40 are shown in Table 2.6.

Table 2.6 Water quality hotspots in Catchment U40

SQ reach	River name	Water quality impact (rating)	Water quality issues
U40B-03770	Heinespruit	Serious (4)	Pesticides and nutrients; WWTW.
U40B-03832	Mvozana	Large (3)	Elevated nutrients and salts.
U40H-04064	Mvoti	Large (3)	Discharge from agriculture, urban and industrial areas.
U40J-03998	Mvoti	Large (3), esp around KwaDukuzu	Sugar (Illovo) and paper mill effluents; WWTW so elevated nutrients; high turbidity levels; urban impacts (Stanger).

U5 Nonoti: Rivers: Note that the ISP for the Mvoti to Umzimkulu WMA highlights that intensive agriculture could result in pesticide and nutrient pollution (DWA, 2004a), which is probable for U50A due to intensive sugarcane plantations. According to the PES study (DWA, 2012b), there is a small impact on water quality in terms of nutrient loading, but no other water quality impacts occur. Nutrient loading is most likely due to the sugarcane plantations resulting in non-point source pollution. However, rivers generally reflect a Good water quality status. There are no water quality hotspots in U50A.

U6 uMlazi: Rivers: This tertiary catchment is highly impacted, particularly in the middle and lower reaches of all the river catchments. On average, 45% natural vegetation cover remains in U60, with nine of the 14 SQ catchments comprising less than 50% natural cover, representing extensive transformation. Water quality is Poor in the lower reaches of the uMlazi River, although it is Good in the upper reaches. There are extensive nutrient inputs from agricultural activities in the upper reaches and four wastewater works in the middle and lower reaches, which has led eutrophication and invasion by aquatic weeds (water hyacinth). Faecal contamination is also an issue due to stormwater contamination and inadequate infrastructure. Water quality in both the Mhlatuzana and Umbilo rivers is Poor due to urban and industrial effluents, as well as the Sipingo due to high *Escherichia coli* (or *E. coli)* counts (WRC, 2002).

Water quality issues are caused by the following:

- Non-point source pollution (pesticides, fertilizers) from agriculture (sugarcane plantations) in Wekeweke (U60C), Mbokodweni (U60E) and Mhlatuzana (U60F) catchments.
- Non-point source pollution from residential areas (urban and rural townships) e.g. stormwater run-off, washing in rivers. Water quality problems are particularly evident along the high density coastal development areas.

- Point source pollution from industrial discharge points (e.g. textile (dye) factories) and urban infrastructure (e.g. sewage, wastewater treatment works non-compliance).
- Nutrient concentrations are problematic in most catchments. The aquatic weed, water hyacinth, often signalling this impact on water quality.
- The presence of alien invasive plants (IAPs) within the riparian zone of rivers which can result in erosion and sedimentation.
- Dams are scattered throughout the catchment, sited on most rivers, which impact on the movement of sediment, temperature and oxygen levels in particular.

Water quality hotspots across U60 are shown in the Table 2.7.

Table 2.7 Water quality hotspots in Catchment U60

SQ reach	River name	Water quality impact (rating)	Water quality issues
U60C-4555	uMlazi	Large (3)	Urban and industrial effluents, so high nutrient and salt load.
U60C-4556	Sterkspruit	Serious (4)	Elevated salts, nutrients, toxicants; ID by eThekwini MM as a hotspot.
U60C-4613	Wekeweke	Large (3)	Elevated nutrients and fertilizers.
U60C-4697	Sterkspruit	Large (3)	Urban and industrial effluents.
U60D-4661	uMlazi	Critical (5)	Elevated salts, nutrients, toxicants; ID by eThekwini MM as a hotspot.
U60E-4792	Mbokodweni	Serious (4) - esp Isipingo River	High organic and nutrient load; Isipingo River ID by eThekwini MM as a hotspot.
U60F-4597	Mhlatuzana	Critical (5)	Urban and industrial effluents, so high nutrient and salt load.
U60F-4632	Umbilo	Critical (5)	Urban and industrial effluents, so high nutrient and salt load.

- Serious water quality impacts have occurred on the uMlazi River (U60D-4661), where, below the Fongozi Stream, *E. coli* counts of up to 720 000 have been recorded due to leakage from sewerage works located at uMlazi township. The eThekwini SOR Report recorded high *E. coli* counts, nutrient loading (phosphate and nitrogen) and in some instances potentially toxic levels of unionised ammonias, including low dissolved oxygen concentrations in the lower reaches. Impacts at KwaNdengezi show high nutrient concentrations and moderate bacterial loads. Water quality below the N2 is poor, presenting high Soluble Reactive Phosphorous (SRP) and nitrogenous nutrients with bacterial loads evident (eThekwini SoR, 2006).
- Serious water quality impacts have occurred on the Mbokodweni River (U60E-4792). The eThekwini Unicity River Quality Index (2011) also classifies river reaches as Poor to Critical due to ineffective sanitation, while the eThekwini SOR (2006) states that it is highly polluted. The monitoring site above the Old Main Road and below the eThekwini Municipal Izimbokodweni sewer station is highly polluted with *E. coli*, phosphorus and unionised ammonia, with solid waste disposal occurring and a high density of aquatic water hyacinth (eThekwini SoR, 2006).
- Serious water quality impacts have occurred on the Umbilo River (U60F-4632), with high *E. coli* counts occur at Paradise Valley Nature Reserve and below the WWTW, with high nutrient loading and potentially toxic levels of unionised ammonias. Downstream of the confluence with the Umkhumbane numerous point and diffuse source pollution discharges have impacted water quality e.g. SRP concentrations were 24 times in excess of the Target

Water Quality Range (TWQR). Nitrogenous nutrients were very high. Downstream of the Umbilo WWTW SRP concentrations were 44 times in excess of the TWQR, the toxic form of ammonia was within the chronic effect range and high faecal contamination (110 000 *E. coli* counts recorded per 100 ml) (eThekwini SoR, 2006).

Critical water quality impacts have occurred on the Mhlatuzana (U60F-4597) SQ catchments. Above the Sipingo WWTW, *E. coli* counts of up to 10 000 000; and exceeding 100 000 60% of the time, have been recorded due to broken sewerage infrastructure. According to the eThekwini SoR (2006), discharged of effluents from the upstream WWTW is causing very poor water quality in the Sipingo (upstream of the confluence with Mbokodweni). The report also states that the Mhlatuzana is highly polluted, with high *E. coli* counts at Kenneth Stainbank Nature Reserve, high nutrient loading and potentially toxic levels of unionised ammonias due to point and non-point pollution (note that the upper Umhlatuzane catchment, at Lello Road Bridge, water quality conditions are very good) (eThekwini SoR, 2006). The eThekwini Unicity River Quality Index (2011) also classifies the Sipingo river reaches as Poor to Critical due to ineffective sanitation.

U7 Lovu: Rivers: The majority of the sub-quaternary catchments (11 of the 16) have a small impact on water quality. The Lovu SQ catchment (U70B2-4655) has a moderate impact due to a combination of factors, e.g. nutrient loading, sand mining and waste disposal. The Lovu SQ catchment (U70D3-4905), including the Manzimtoti and Little Manzimtoti SQ catchments, are also moderately impacted due to nutrient loading and high density urbanization. The Ngane SQ catchment (U70E-5010) has a large impact on water quality due to wastewater effluents from the WWTW in the lower reaches. The eThekwini Unicity River Quality Indices (2011) demonstrate that all the coastal rivers (includes the lower reaches of the Lovu River) are either in a poor or critical category due to ineffective sanitation, which is indicative of high density urban development along the coastline. Water quality hotspots across U70 are shown in the Table 2.8.

Table 2.8 Water quality hotspots in Catchment U70

SQ reach	River name	Water quality impact (rating)	Water quality issues
U70B-4655	Lovu	Serious (4) - around Richmond only	WWTW and urban centre; fertilizers and pesticides.
U70D-4905	Lovu	Large (3)	Oil and diesel pollution; sugar mill; elevated nutrients.

U8 Mtwalume and Mzumbe: Rivers: Urban, agricultural (sugarcane) and industrial land use activities in the upper reaches of the Mzimayi River catchment (U80H) have caused increased nutrient concentrations in the past. Excess nutrients however still impact the system due to the surrounding informal settlements and poor sewage infrastructure, as recorded in the EJ Smith Dam. Algal counts exceeded the RQO threshold during 2010 in the Mtwalume River, while sand mining upstream of the Mtwalume Water Treatment Plant (WTP) has caused an increase in turbidity levels (uMngeni Water, 2011). The uMuziwezinto SQ catchment (U80H-5109) shows nutrient loading from high density urban development and agriculture, while the Mahglongwana SQ catchment (U80L-5020) is moderately impacted as a result of surrounding rural settlements and sand mining.

Note that the Illovo Sugar Mill is on the Sezela Estuary and impacts on the estuary rather than the river.

Water quality hotspots across U80 are shown in the Table 2.9 below.

Table 2.9 Water quality hotspots in Catchment U80

SQ reach	River name	Water quality impact (rating)	Water quality issues
U80H-5109	uMuziwezinto	Serious (4)	Elevated nutrients; possible impact of WWTW.
U80H-5120	Mzimayi	Large (3)	Possible impact of WWTW in Umzinto; low confidence.
U80L-5056	Mahglongwana	Large (3)	Elevated nutrients (including pesticides and fertilizers).

2.7 ECOLOGICAL GOODS, SERVICES AND ATTRIBUTES STATUS QUO

The present-day status in terms of Ecosystem Services, based on the economic and social importance assessed from a literature review as well as mapping information, is described. The objective of describing communities and their well-being is to provide the baseline against which to estimate changes in social wellbeing for each of the scenarios that will be evaluated. It should be noted that the objective in describing and valuing the use of aquatic ecosystems is to determine the way in which aquatic ecosystems are currently being used in each IUA, and to qualitatively estimate the value generated by that use. This will provide the baseline against which the scenarios can be compared.

Provisioning services are the most familiar category of benefit, often referred to as ecosystem ‘goods’, such as foods, fuels, fibres, medicine, etc., that are in many cases directly consumed. Other services include cultural services (ritual use of rivers, aesthetic or historical importance), regulating services (e.g. water quality inputs), and supporting services (e.g. nutrient formation).

Based on Census 2011, a total population of just fewer than 7 million individual is located in the study area. The average population density is 166 individuals per square kilometre (km^2). The spatial distribution of this population shows a sharp transition from low density rural populations with limited development to high density urban environments where water is largely sourced from formal systems. The study area, because of the nature of the communities that it intersects, plays an important role in maintaining important EGSA on-site as well as other users.

For the purposes of this catchment five different land use forms that reflect types of EGSA that might be associated with the usage have been identified.

The land use based zones are:

- Commercial Agriculture and plantation: This is largely given over to zones dominated by commercial farming entities. Utilisation of EGSA tends to be low and restricted often to farm workers or incidental recreational aspects.
- Subsistence agriculture: These areas are dominated by subsistence agriculture but in areas where population densities are relatively low. Utilisation of EGSA tends to be higher here and the populations that make use are often poor and marginal. For the most part these are areas that were part of the former homelands of KZN and the Transkei.
- Rural Closer Settlement – Subsistence: These are the former homeland areas that have generally higher population densities than the purely subsistence areas. In some instance densities are high enough to be categorised as closer settlement/informal urban. Utilisation of EGSA tends to be higher here and the populations that make use are often poor and marginal. However, the population densities are such that resources tend to be under pressure.
- High Density Formal Urban: These are the SQs heavily influenced by the cities of Durban and Pietermaritzburg as well as a number of other hinterland towns and the highly developed

coastal belt. The utilisation of EGSA tends to be low as the populations tend to be urbanised and alienated from direct use of the resources.

- Drakensberg/Recreational/Dams/Game Farms. These are SQs within the Drakensberg mountain belt, game farms as well as SQs dominated by dams. Recreational usage tends to dominate EGSA.

The following rivers have sections of high EGSA importance (Table 2.10):

- U1 uMkhomazi: uMkhomazi, Lufafa and Xobho Rivers have areas that are entirely rural with a significant dependance on EGSA, especially informal agriculture.
- U2 uMngeni: Tholeni, and 2 sections of uMngeni River have rural areas and informal agriculture.
- U3 uMdloti: uMdloti, Mona, Mwangala and uThongathi Rivers are almost entirely rural with scattered households along the river. Informal agriculture occurs.
- U4 Mvoti: One section on the Mvoti River is entirely rural with settlements and informal agriculture.
- U6 uMlazi: On section on the Bivane River is entirely rural with settlements and informal agriculture.
- U7 Lovu: Rural and urban areas.
- U8 Ifafa: Kwa-Malukaka, Mtwalume, uMngeni and aMahlongwa River include reaches that are entirely rural with extensive informal agriculture.
- T4 Mtamvuna: Sections of the Goxe, Weza, Mtamvuna, Ludeke, Ku-Ntlamvukazi, Tungwana, Londobezi, and Hlolweni Rivers include areas of significant informal agriculture and are mostly entirely rural.
- T5 Umzimkulu: Sections of the Gungununu, Malenge, Ngwangwane, Umzimkulu, Little Bisi, Bisi, Mzim-khulwana and Mbumba include areas of signficant informal agriculture and townships

Table 2.10 Sub Quaternary reaches with high Ecosystem Services dependence

SQ number	River	Summary of Status Quo and linked EGSA Importance
U1 uMkhomazi		
U10D-04349	uMkhomazi	River section is 9 km in extent. Extent is entirely rural with rural, scattered (hamlets) households located along much of the river extent. There is informal agriculture taking place. Evidence of significant dependence on EGSA among households proximate to river.
U10J-04820	Lufafa	River section is 33 km in extent. Extent is entirely rural with subsistence linked scattered households extending for 36% of the river extent. There is evidence of considerable subsistence agriculture.
U10K-04899	Xobho	River section is 36 km in extent. Extent is entirely rural with urban elements linked to Ixopo town which is located on the south bank of the river. Lower reaches of the river (50%) largely comprised of river-bank linked informal agriculture with settlement, although not in proximity to the river they are custodians of agricultural endeavours.
U10M-04746	uMkhomazi	River section is 30 km in extent. Extent is rural inland, while it includes urban elements near the coast. The upper reaches (20%) are open terrain/natural vegetation due to the deeply incised river banks. The middle and lower 60% of the river extent is largely comprised of rural, scattered household settlement, that are located near the river bank where possible or on elevated areas where the bank slope is steep. There is evidence of, informal subsistence agriculture along the river bank near the settlements.
U2 uMngeni		
U20K-04296	Tholeni	River section is 20 km in extent, and is entirely rural. Upper reaches (10%) comprised of formal agriculture. Remaining river extent is comprised of extensive rural settlements (with low to moderate densities) and extensive informal agriculture and links to EGSA.
U20L-04435	uMngeni	River section is 16 km in extent, and entirely rural. Land-use is a mixture of rural settlement and open terrain. The former is restricted to gentle slopes along the river banks and entails low density households and informal agriculture. Open terrain/natural vegetation is restricted to steep river banks that limit human activities.

SQ number	River	Summary of Status Quo and linked EGSA Importance
U20M-04396	uMngeni	River section is 45 km in extent, and contains rural and urban elements. Upper reaches (15%) comprised of open terrain/natural vegetation with some rural, low density settlements. A third of the river extent is within Inanda Dam which is surrounded by extensive low to moderate density settlements. Lower reaches of the river extent, comprised of deeply incised river valleys and extensive urban settlement on the plateaus, and on the river banks where slopes are more gentle. River extends into the Springfield industrial area.
U3 uMdloti and environs		
U30C-04272	Mona	River section is 36 km in extent. Land-use is rural and nearly exclusively comprised of rural, scattered households along the entire extent of the river. Informal agriculture was noted along the river banks in proximity to the households. Other land-uses are limited to open terrain/natural vegetation.
U30A-04228	uMdloti	River section is 30 km in extent. Land-use is rural and nearly exclusively comprised of rural, scattered households along the entire extent of the river. Considerable informal agriculture was noted along the river banks in proximity to the households.
U30A-04363	Mwangala	River section is 15 km in extent. Land-use is rural and nearly exclusively comprised of rural, scattered households along the entire extent of the river. Informal agriculture lined to poorer households was noted along the river banks in proximity to the households. Other land-uses are limited to open terrain/natural vegetation where steep slopes limit land-use options.
U30C-04227	uThongathi	River section is 36 km in extent. Land-use is rural and nearly exclusively comprised of rural, scattered households along the upper reaches (27%) of the river, as well as along the southern side of the river for its remaining extent. There is evidence of informal agriculture. Open terrain/natural vegetation is a dominant land-use and is located between the scattered households.
U4 Mvoti		
U40E-03985	Mvoti	River section 26 km in extent, and entirely rural. Deeply incised valley but broad valley bottom therefore open terrain/natural vegetation dominant. Considerable rural, low density settlements located along river extent and informal agriculture noted. Poorly developed and impoverished.
U6 uMlazi and environs		
U60E-4795	Bivane	River section is 22 km in extent. Extent is entirely rural. Upper reaches (30%) is comprised exclusively of rural, low density settlements with extensive cultivation along the river banks. Lower reaches (70%) comprise of deeply incised valley bottoms with rural, low density settlements on the ridges. Links to EGSA evident.
U7 Lovu and environs		
U70D-4905	Lovu	River section is 10 km in extent, and contains rural and urban elements. Upper reaches (60%) comprised of rural, low to moderate density settlements nearly continuously along this stretch. Limited agriculture noted. Lower reaches include sugar cane (30%) and the system estuary (10%) and associated residential area (Illovo) linked to the system estuary. Moderate amenity value but high EGSA value.
U70E-4942		River section is 10 km in extent, and contains rural and urban elements. Entire river extent is comprised of rural, low density settlement and high density townships near the coast. There is limited formal agriculture (sugar) on the north bank of 30% of the river extent but the rest appears to be informal and subsistence utilisation.
U8 Ifafa and environs		
U80C-5329	Kwa-Malukaka	River section is 25 km in extent, and is entirely rural. The landform of much of the river extent (90%) is gentle and is largely comprised of rural settlements and extensive informal agriculture. Lower 10% is comprised of deeply incised river valleys limiting land-use to open terrain/natural vegetation.
U80E-5028	Mtwalume	River section is 60 km in extent, and is entirely rural. Upper reaches (33%) comprised for plantation forestry. Mid-reaches (33%) comprised of extensive rural settlement (low-density) although limited to due to steep river banks, however EGSA appears to be important given status of communities. Lower reaches (33%) comprised of open terrain/natural vegetation due to deeply incised river banks.
U80F-5301	uMngeni	River section is 17 km in extent, and is entirely rural. Upper reaches (11%) is comprised of natural forest. Thereafter river extends into open terrain/natural vegetation with a low density of rural villages (45% of river extent). Lower reaches (45%) comprised on formal agriculture (sugar). Additional settlements and extensive informal agriculture located at river confluence with high EGSA importance.
U80L-5020	aMahlongwa	River section is 30 km in extent, and is entirely rural. Extent is nearly exclusively comprised of rural settlements of varying density (low density to high density townships). Informal agriculture present and abundant. High EGSA importance. Natural vegetation/open terrain noted on the system estuary, with a residential area (formal,

SQ number	River	Summary of Status Quo and linked EGSA Importance
		established) on the south bank of the estuary.
T4 Mtamvuna		
T40A-5487	Goxe	River section is 29 km in extent, and is entirely rural. Seven rural settlements noted (scattered, low density households) noted on the remainder of the river extent, including evidence of significant informal agriculture near the settlements and on the river banks. Remaining land-use is open terrain/natural vegetation between the settlements.
T40B-5337	Weza	River section is 30 km in extent, and is entirely rural. The lower reach (50%) is comprised of near continuous rural settlements (scattered, low density households), including evidence of significant informal agriculture near the settlements and on the river banks.
T40C-5530	Mtamvuna	River section is 5 km in extent, and is entirely rural. The river extent shows rural settlements (scattered, low density households), but significant informal agriculture on the river banks.
T40C-5566	Ludeke	River section is 10 km in extent, and is entirely rural. The river extent shows rural settlements (scattered, low density households), but significant informal agriculture on the river banks.
T40C-5589	Ku-Ntlamvukazi	River section is 20 km in extent, and is entirely rural. Upper reaches (25%) is comprised of open terrain/natural vegetation. Six rural settlement noted on the remainder of the river extent, including evidence of significant informal agriculture near the settlements and on the river banks.
T40C-5600	Ludeke	River section is 17 km in extent, and is entirely rural. Upper reaches (15%) is comprised of open terrain/natural vegetation. Multiple rural settlements noted) noted on the remainder of the river extent, including evidence of significant informal agriculture near the settlements and on the river banks.
T40D-5615	Tungwana	River section is 10 km in extent, and is entirely rural. The river extent shows limited rural settlements, but significant informal agriculture on the river banks. Density of such settlement is low therefore there is considerable open terrain/natural vegetation along the river extent and some evidence of high use of EGSA.
T40D-5719	Londobezi	River section is 15 km in extent, and is entirely rural. The river extent is comprised of rural settlements on the upper 40% of the river extent, including evidence of significant informal agriculture near the settlements and on the river banks.
T40E-5601	Mtamvuna	River section is 44 km in extent, and is entirely rural. The river extent is comprised of rural settlement (on much of the west river bank. There is evidence of informal agriculture. There is extensive formal agriculture on the lower reaches (35%) of the river but limited to the east bank, and opposite the rural settlements. Upper reaches (34%) comprised of open terrain/natural vegetation due to steep river valley, which extends through into much of the river extent.
T40E-5767	Hlolweni	River section is 24 km in extent, and is entirely rural. The upper reaches (45%) comprised of rural settlements (scattered, low-moderate density households) with extensive informal agriculture.
T40E-5869	Mtamvuna	River section is 15 km in extent, and is entirely rural with urban elements at the river mouth. The upper reaches (20%) are open terrain/natural vegetation linked to a nature reserves. Much of the remaining (70%) of the south-west bank is a township (low to moderate density households). The north-east bank is comprised of formal smallholding and residential areas. The Wild Coast Sun is located at the Estuary suggesting tourism/recreational activities.
T40F-5770		River section is 9 km in extent, and entirely rural. Upper 20% comprised of open terrain. Mid reaches (33%) extend through the township of KwaNzimakwe (moderate density, large) with informal farmland along the river banks. Low reaches comprised of formal farmland, and some residential areas.
T5 Umzimkulu		
T51H-04808	Gungununu	River section is 30 km in extent. Extent is entirely rural but with a significant presence of townships totalling 10 and accounting for approximately 75% of the river extent. There is significant presence of informal agriculture in proximity to the townships and along the river banks. Remaining land-use is predominantly open terrain/natural vegetation with a limited presence of plantations forestry but linkage to EGSA.
T51H-04923	Malenge	River section is 30 km in extent. Extent is entirely rural but with a significant presence of townships totalling 11 and accounting for approximately 50% of the river extent. There is significant presence of informal agriculture in proximity to the townships and along the river banks.
T51J-04844	Ngwangwane	River section is 17 km in extent. Extent is entirely rural but with a significant presence of townships totalling 5 and accounting for approximately all of the north bank of river. There is significant presence of informal agriculture in proximity to the townships and along the river banks.

SQ number	River	Summary of Status Quo and linked EGSA Importance
T52A-04690	Umzimkulu	River section is 20 km in extent. Extent is entirely rural but with the presence of 4 townships largely limited to the south bank of river. There is low presence of informal agriculture in proximity to the townships and along the river banks.
T52F-05104	Little Bisi	River section is 31 km in extent. Extent is entirely rural but with the presence of 6 townships interspersed throughout the river extent. There is evidence of informal agriculture in proximity to the villages, and near the river banks.
T52F-05190	Mbumba	River section is 20 km in extent. Extent is entirely rural but with the presence of 4 townships located in proximity to the river. There is evidence of informal agriculture in proximity to the villages.
T52F-05139	Little Bisi	River section is 13 km in extent. Extent is entirely rural but with the presence of 4 townships located within 2 km of the river. There is evidence of informal agriculture in proximity to the villages. Other than the townships, the river extent is nearly exclusively open terrain/natural vegetation but with high potential EGSA use.
T52H-05121	Bisi	River section is 18 km in extent. Extent is entirely rural with a small urban element linked to the town of Ibisi and two neighbouring townships, accounting for 30% of the river extent. Land-use on the remaining river extent is comprised of open terrain/natural vegetation with informal extensive agriculture near the towns.
T52K-05467	Mzim-khulwana	River section is 77 km in extent. Extent is entirely rural with the presence of 3 townships extending along 25% of the river extent. There is evidence of considerable informal agriculture linked to these townships.

2.8 ECOLOGICAL STATUS QUO: RIVERS

Data from the Present Ecological State (PES) and Ecological Importance - Ecological Sensitivity (EI-ES); referred to as the PESEIS project (DWS, 2014a) was used as the baseline for the status quo assessment of 288 river reaches covering the study area. The PES is described in terms of Ecological Categories (ECs) of A to F with A being largely natural and F meaning critically modified. Reasons for the change from natural are provided and it is indicated whether these are flow (e.g. abstraction) or non-flow (e.g. riparian vegetation removal or land use practices) related.

The status quo assessment is provided per secondary and consists of a table and short summary for each secondary. No key PES drivers are provided for rivers in a B or higher PES as the changes from natural are minor. The secondaries are discussed as they occur from south (Mtamvuna, T4) to north (Nonoti, U5).

2.8.1 T4: Mtamvuna

Table 2.11 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
T40A-05450	Mafadobo	B	n/a
T40A-05487	Goxe	B/C	Non-flow[1]: Sediment, overgrazing.
T40B-05337	Weza	C	Flow[2]: Forestry. Non-Flow: Forestry, vegetation clearing.
T40C-05510	Mtamvuna	B/C	Non-flow: Sedimentation, alien veg., agricultural practices.
T40C-05520	Mtamvuna	B/C	Flow: Abstraction. Non-flow: Sedimentation, alien veg., agricultural practices.
T40C-05530	Mtamvuna	B	n/a
T40C-05566	Ludeke	B	n/a
T40C-05589	KuNtlamvukazi	B	n/a
T40C-05600	Ludeke	B	n/a
T40D-05537	Mtamvuna	B	n/a
T40D-05584	Mtamvuna	B	n/a
T40D-05615	Tungwana	B	n/a
T40D-05643	Gwala	B	n/a
T40D-05683	Ntelekweni	B/C	Non-flow: Forestry, water quality.
T40D-05707	Mtamvuna	C	Non-flow: Water quality, sedimentation, veg removal.

SQ number	River	River PES (EC)	Key PES Driver
T40D-05719	Londobezi	B	n/a
T40E-05601	Mtamvuna	B/C	Non-flow: Sedimentation, dryland sugar cane, overgrazing.
T40E-05767	Hlolweni	B/C	Non-flow: Informal agriculture, sedimentation.
T40F-05666	Mbizana	B	n/a
T40G-05616	Vungu	B/C	Non-flow: All impacts from Uvongo, US section in slightly better condition - also non-flow.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.2 T5: Umzimkulu

Table 2.12 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
T51A-04431	Umzimkulu	B	n/a
T51A-04522	Mzimude	B	n/a
T51A-04608		B	n/a
T51A-04551	Mzimude	B/C	Non-flow[1]: Agriculture; Flow[2]: Centre-pivot.
T51B-04421	Umzimkulu	B	n/a
T51C-04606		C	Non-flow: Agriculture and barrier/dam; Flow: Centre-pivot.
T51C-04582	Umzimkulu	C	Non-flow: Water quality issues, vegetation removal, alien veg.
T51C-04760	Umzimkulu	C	Non-flow: Vegetation removal, agriculture and forestry.
T51D-04404	Pholela	B	n/a
T51D-04460	Pholelana	D/E	Flow, non-flow due to presence of many dams. Inundation and barrier effect high.
T51E-04536		C	Non-flow: Barrier effect, alien veg. Flow: Irrigation.
T51E-04478	Pholela	C	Non-flow: Vegetation removal, alien vegetation. Flow: Irrigation.
T51E-04604	Pholela	B/C	Non-flow: Vegetation removal (forestry, alien veg).
T51F-04566	Boesmans	A	n/a
T51F-04611	Ngwangwane	A	n/a
T51F-04674		C	Flow and Non-flow: Agriculture, presence of dams, riparian zone impacts.
T51F-04605	Ngwangwane	B/C	Non-Flow: Sedimentation, vegetation removal.
T51F-04621	Ngwangwane	B/C	Flow: Dams and extensive irrigation. Non-flow: Agriculture and riparian zone impacts.
T51G-04669	Ndawana	B	n/a
T51G-04751		B	n/a
T51G-04722	Ndawana	C	Flow: Dams and extensive irrigation. Non-flow: Agriculture and riparian zone impacts.
T51H-04828	Gungununu	A/B	n/a
T51H-04846	Lubhukwini	A	n/a
T51H-04913	Nonginqa	B/C	Non-flow: Forestry and subsistence farming.
T51H-04923	Malenge	B/C	Non-Flow: Informal agriculture (removal of vegetation).
T51H-04808	Gungununu	B	n/a
T51H-04884	Gungununu	B/C	Non-flow: Subsistence farming, grazing, erosion.
T51H-04908	Gungununu	B/C	Non-flow: Subsistence farming, grazing, erosion.
T51J-04747	Ngwangwane	C	Non-flow: Subsistence farming, grazing, erosion.
T51J-04844	Ngwangwane	C	Water quality issue, agriculture.
T52A-04690	Umzimkulu	C	Non-flow: Irrigation, forestry, grazing.
T52B-04947	Cabane	B	n/a
T52C-04880		C	Flow: Forestry, irrigation. Non-flow: Forestry, roads.
T52C-04960	Umzimkulu	B	n/a

SQ number	River	River PES (EC)	Key PES Driver
T52D-05024	Ncalu	B/C	Non-flow: Forestry and subsistence farming.
T52D-05061	Mgodi	B/C	Non-flow: Subsistence farming, irrigation.
T52D-04948	Umzimkulu	C	Non-flow: Subsistence farming.
T52D-05137	Umzimkulu	B	n/a
T52D-05155	Umzimkulu	B	n/a
T52E-05053	Upper Bisi	B/C	Non-flow: Vegetation removal (forestry, farming).
T52F-05104	Little Bisi	C	Non-flow: Vegetation removal (forestry, farming).
T52F-05190	Mbumba	B/C	Non-flow: Vegetation removal over grazing, farming.
T52F-05139	Little Bisi	B	Non-flow: Vegetation removal over grazing, farming.
T52G-05226	uMbumbane	B/C	n/a
T52G-05171	Bisi	B	Non-flow: Vegetation removal over grazing, farming.
T52H-05244	Mahobe	B/C	n/a
T52H-05295	Magogo	B	n/a
T52H-05121	Bisi	B/C	n/a
T52H-05178	Bisi	B	n/a
T52H-05189	Bisi	B	n/a
T52J-05276	Umzimkulu	B	n/a
T52K-05353	Mzimkhulwana	C	Flow: Dam, irrigation. Non-flow: Agriculture.
T52K-05475	Nkondwana	B/C	Non flow: Agriculture, irrigation (sugar cane), subsistence farming.
T52K-05467	Mzimkhulwana	B/C	Some abstraction and various other non-flow activities.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.3 U8: Mzumbe and Mtwalume

Table 2.13 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U80B-05145	Mzumbe	B	n/a
U80B-05161	Mhlabatshane	B	n/a
U80C-05231	Mzumbe	B	n/a
U80C-05329	Kwa-Malukaka	B	n/a
U80E-05028	Mtwalume	C	Non-flow[1]: Subsistence farming, grazing. Flow[2]: Forestry, small farm dams, irrigation. Water quality: Rural settlements, sugar cane.
U80E-05212	Quha	B	n/a
U80F-05258	Mtwalume	B/C	Flow: Irrigation. Water quality: Sugar cane. Non-flow: Subsistence farming, grazing.
U80F-05301	uMngeni	B/C	Non-flow: Forestry, subsistence agriculture, sugar cane.
U80G-05097	Fafa	B/C	Flow: Irrigation (sugar cane). Non-flow: Subsistence farming.
U80H-05109	uMuziwezinto	C/D	Flow: Irrigation. Water quality: Sugar cane. Non-flow: Subsistence farming, grazing, erosion.
U80J-04979	Mpambanyoni	B	n/a
U80J-05043	Ndonyane	B/C	Flow: Irrigation. Water quality: Sugar cane. Non-flow: Subsistence farming, grazing, erosion.
U80K-04952	Mpambanyoni	C	Water quality: Settlements. Non-flow: High density rural settlements, erosion, sedimentation.
U80L-05020	aMahlongwa	B/C	Water quality: Settlements. Non-flow: High density rural settlements, erosion, sedimentation.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.4 U1: uMkhomazi

Table 2.14 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U10A-04115	Lotheni	A/B	n/a
U10A-04202	Nhlathimbe	B	n/a
U10A-04301	Lotheni	B	n/a
U10B-04239	uMkhomazi	B	n/a
U10B-04251	uMkhomazi	A	n/a
U10B-04274	Nhlangeni	A	n/a
U10B-04337	uMkhomazi	B	n/a
U10B-04343	Mqatsheni	B	n/a
U10C-04347	Mkhomazana	B	n/a
U10D-04199	Nzinga	A	n/a
U10D-04222	Rooidraai	B	n/a
U10D-04298	Nzinga	B/C	Non-flow[1]: Sedimentation, riparian zone, erosion.
U10D-04349	uMkhomazi	B/C	Non-flow: Sedimentation, riparian zone, erosion.
U10D-04434	uMkhomazi	B/C	Non-flow: Sedimentation, riparian zone, erosion.
U10E-04380	uMkhomazi	C	Non-flow: Sedimentation, overgrazing, erosion.
U10F-04528	uMkhomazi	B/C	Non-flow: Sedimentation, riparian zone, erosion.
U10F-04560	Luhane	B/C	Non-flow: Sedimentation, riparian zone, erosion.
U10G-04388	Elands	C	Non-flow: Alien vegetation, riparian zone, water quality.
U10G-04405		C	Non-flow: Forestry, irrigation, roads.
U10G-04473	Elands	C	Non-flow: Alien vegetation, riparian zone, water quality.
U10H-04576	Tholeni	B	n/a
U10H-04638	uMkhomazi	B	n/a
U10H-04666	Ngudwini	B/C	Non-flow and Flow[2]: Dam, forestry.
U10H-04675	uMkhomazi	B	
U10H-04708	Ngudwini	B	n/a
U10H-04729	Mzalanyoni	C	Non-flow and Flow: Dam, forestry.
U10J-04679	uMkhomazi	B	n/a
U10J-04713	Mkobeni	C	Non-flow: Forestry, subsistence farming, agricultural lands.
U10J-04721	Pateni	B	n/a
U10J-04799	uMkhomazi	C	Non-flow: Agriculture, erosion.
U10J-04807	uMkhomazi	B	n/a
U10J-04820	Lufafa	B/C	Non-flow: Agriculture, erosion.
U10J-04833	uMkhomazi	B/C	Non-flow: Agriculture, erosion.
U10J-04837		A/B	n/a
U10K-04838	uMkhomazi	B/C	Flow: Irrigation. Non-flow: Agriculture.
U10K-04842	Nhlavini	B	n/a
U10K-04899	Xobho	C/D	Flow: Large dams. Irrigation.
U10K-04946	Nhlavini	B/C	Non-flow: Forestry.
U10M-04746	uMkhomazi	B/C	Flow: Cumulative impact of all upstream abstractions. Non-flow: Subsistence farming.

1: Non-flow refers to Non-Flow related activities.

2: Flow refers to Flow related activities.

2.8.5 U7: Lovu

Table 2.15 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U70A-04599	Serpentine	C	Non-flow[1]: Small town. Flow[2]: Forestry.
U70A-04609	Lovu	B/C	Non-flow: Forestry. Flow: Forestry.
U70A-04618		C	Non-flow: Forestry. Flow: Forestry.
U70A-04685	Lovu	C	Non-flow: Forestry. Flow: Forestry.
U70B-04655	Lovu	C/D	Flow: Forestry, large dam, irrigation-sugar cane, water quality (WWTW, Richmond town, fertilisers, and pesticides). Non-flow: Forestry, township, formal and informal agriculture (sugar cane, subsistence farming, grazing).
U70C-04710	Mgwahumbe	C	Flow: Forestry, small dams, irrigation (formal agriculture (sugar cane)), water quality (agricultural runoff). Non-flow: Afforestation, agriculture, rural settlements, subsistence farming.
U70C-04724		C	Non-flow: Forestry. Flow: Forestry.
U70C-04732		C	Non-flow: Forestry. Flow: Forestry.
U70C-04859	Lovu	B/C	Non-flow: Rural settlements, subsistence agriculture, grazing.
U70D-04800	Nungwane	B/C	Non-flow: Barrier of large dams.
U70E-04942	Umsimbazi	C	Flow: Irrigation, water quality (agricultural runoff, township). Non-flow: Agriculture, rural settlements, high density township, grazing.
U70E-04974	uMgababa	C	Flow: Dam. Non-flow: Rural settlements, grazing.
U70F-04845	aManzimtoti	C	Water quality: Urban runoff). Non-flow: Urban and rural settlements, subsistence farming.
U70F-04893	Little Manzimtoti River	C	Water quality: Urban runoff. Non-flow: Urban and rural settlements.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.6 U6: uMlazi

Table 2.16 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U60A-04533	uMlazi	C	Non flow[1]: Forestry, water quality, agriculture lands. Flow[2]: Instream dams – irrigation.
U60B-04614	Mkuzane	C/D	Non-flow: Barriers, forestry, agricultural lands, alien vegetation. Flow: Irrigation.
U60C-04555	uMlazi	C/D	Non-flow: Water quality, barrier, vegetation removal from agriculture. Flow: Large dam, abstraction.
U60C-04556	Sterkspruit	D	Water quality issues associated with townships.
U60C-04613	Wekeweke	C	Non-flow: Key - alien vegetation. Vegetation removal (sugar). Barrier
U60C-04697	uMlazi	C/D	Water quality. Non-Flow: Vegetation removal from wood harvesting.
U60D-04661	Mbokodweni	B	n/a
U60E-04714	Mbokodweni	C	Non-Flow: Water quality; also vegetation removal from wood harvesting.
U60E-04795	Bivane	B/C	Non-flow: Trampling, sedimentation, vegetation removal.
U60F-04597	Sipingo	D/E	Non-flow: Trampling, sedimentation, vegetation removal.
U60F-04632	Umbilo	D	Non-flow: Trampling, sedimentation, vegetation removal.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.7 U2: uMngeni

Table 2.17 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U20A-04253	uMngeni	B/C	Non-flow[1]: Agriculture, grazing. Flow[2]: Dams, forestry, agriculture. Water quality: Agricultural runoff, livestock farming.
U20B-04074	Ndiza	B/C	Flow: Forestry, small dams.
U20B-04144	Mpofana	C	Flow: Interbasin Transfer (IBT), irrigation, water quality (irrigation return flows, town runoff. Non-flow: Agriculture.
U20B-04173	Lions	C	Flow: Dams, forestry, irrigation. Water quality (agricultural runoff, urban runoff, livestock farming). Non-flow: Agriculture, forestry, livestock farming.
U20B-04185	Lions	B/C	Flow: IBT, forestry. Non-flow: Forestry, commercial farming.
U20C-04190	Lions	B/C	Flow: Forestry, IBT. Non-flow: Forestry, dryland agriculture.
U20C-04275	uMngeni	C	Flow: IBT, irrigation. Non-flow: Agriculture.
U20C-04332	Gqishi	B/C	Flow: Forestry, irrigation. Non-flow: Forestry, agriculture.
U20C-04340	Nguklu	C	Flow: Forestry, water quality (township runoff, organic and bacterial pollution). Non-flow: Forestry and urban areas.
U20D-04029	Yarrow	B/C	Flow: Forestry, irrigation. Non-flow: Forestry, agriculture.
U20D-04032	Karkloof	C	Flow: Forestry, irrigation. Non-flow: Forestry, agriculture.
U20D-04098	Kusane	D	Flow: Dams, irrigation, forestry. Non-flow: Agriculture.
U20D-04151	Karkloof	B/C	Non-flow: Agriculture.
U20E-04136	Nculwane	C	Flow: Forestry. Non-flow: Forestry.
U20E-04170	Karkloof	B/C	Flow: Irrigation, forestry. Non-flow: Forestry, agriculture.
U20E-04221	uMngeni	B/C	Flow: Midmar dam, irrigation. Non-flow: Agriculture.
U20E-04243	uMngeni	C	Flow: Midmar Dam water quality (Howick town).
U20E-04271	Doring Spruit	B/C	Non-flow: Agriculture, forestry.
U20F-04011	Sterkspruit	C/D	Flow: Forestry, dams, agriculture. Non-flow: Forestry, agriculture.
U20F-04095	Mpolweni	C/D	Flow: Forestry, dams, irrigation. Non-flow: Forestry, agriculture.
U20F-04131	Mhlalane	C/D	Flow: Agriculture, sugar cane. Non-flow: Irrigation return flows, urban runoff.
U20F-04204	Sterkspruit	B/C	Flow: Agriculture/sugar cane/irrigation. Non-flow: Agriculture: sugar cane.
U20F-04224	Mpolweni	B/C	Water quality (nutrients). Non-flow:township.
U20G-04194	Mkabela	C/D	Flow: Dams, forestry, irrigation. Non-flow: Forestry, agriculture.
U20G-04215	Cramond Stream	B/C	Water quality (township runoff, agricultural runoff). Non-flow: Township and agriculture.
U20G-04240	uMngeni	B/C	Flow modification: Albert Falls Dam, irrigation. Water quality (agricultural and livestock farming).
U20G-04259	uMngeni	B/C	Flow: Albert Falls Dam, irrigation. Non-flow: Agriculture.
U20G-04385	uMngeni	E	Flow: Nagel dam. Water quality (nutrient load, urban runoff). Non-flow: Rural village.
U20H-04410	Nqabeni	C	Non flow: Agriculture and townships, water quality.
U20H-04449	Msunduzi	C	Non flow: Sedimentation, overgrazing, alien.
U20J-04364	Msunduzi	D/E	Non flow: Water quality, canalisation, inundation, barriers. Urbanisation.
U20J-04391	Msunduzi	C	Non Flow: Water quality from upstream, agriculture, some flow impacts.
U20J-04401	Msunduzi	D	Non-flow: Urban development, clearing of riparian vegetation, water quality.
U20J-04452	Mpushini	B/C	Non-flow: Urbanisation, Ashburton, vegetation removal.
U20J-04459	Msunduzi	C	Non flow: Water quality, informal settlements with agriculture, sand mining.
U20J-04461	Slang Spruit	C/D	Non flow: Water quality, urbanisation.
U20J-04488	Mshwati	B/C	Non flow: Vegetation removal from informal agriculture, wood collection. Water quality.

SQ number	River	River PES (EC)	Key PES Driver
U20K-04181	Mqeku	C	Flow: Forestry, irrigation, small dams. Non-flow: Forestry, formal agriculture (sugar cane), rural areas, grazing.
U20K-04296	Tholeni	C	Flow: Agriculture. Non-flow: Agriculture, grazing.
U20K-04411	Mqeku	B/C	Non-flow: Rural villages, grazing.
U20L-04435	uMngeni	B/C	Flow: Nagel dam, water quality (Msinduzi).
U20M-04396	uMngeni (upstream of Inanda dam)	C	Water quality (nutrients). Non-flow: Rural area, grazing.
U20M-04642	Palmiet	D	Water quality (urban and industrial). Non-flow: Urban/industrial.
U20M-04649	Mbongokazi	C	Non-flow: Residential.
U20M-04653	Palmiet	C/D	Water quality (nutrients). Non-flow: Urban.
U20M-04659	Palmiet	C	Water quality: Urban area.
U20M-04682		C/D	Non-flow: Residential.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.8 U3: uMdloti

Table 2.18 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U30A-04228	uMdloti	B/C	Non-flow[1]: Subsistence farming, limited sugar cane, grazing.
U30A-04360	uMdloti	D	Flow[2]: Dam, irrigation, water quality (nutrients). Non-flow: Rural settlements, grazing, informal agriculture.
U30A-04363	Mwangala	B/C	Non-flow: Subsistence farming, grazing.
U30B-04465	Black Mhlashini	B/C	Water quality (nutrients). Non-flow: Agriculture: sugar cane; informal settlements/rural area, grazing, informal agriculture.
U30C-04227	uThongathi	B/C	Non-flow: Rural settlements, informal farming, grazing.
U30C-04272	Mona	B/C	Non-flow: Dryland agriculture, rural settlements, informal farming, grazing.
U30E-04207	Mhlali	C	Non-flow: Agriculture: sugar cane; settlements.
U30A-04228	uMdloti	B/C	Non-flow: Subsistence farming, limited sugar cane, grazing.
U30A-04360	uMdloti	D	Flow: Dam, irrigation, water quality (nutrients). Non-flow: Rural settlements, grazing, informal agriculture.
U30A-04363	Mwangala	B/C	Non-flow: Subsistence farming, grazing.
U30B-04465	Black Mhlashini	B/C	Water quality (nutrients). Non-flow: Agriculture: sugar cane, informal settlements/rural area, grazing, informal agriculture.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.9 U4: Mvoti

Table 2.19 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U40A-03869	Mvoti	B/C	Non-flow[1]: Forestry, Agriculture (vegetation removal). Flow: Centre pivot, dams in tributaries.
U40B-03708	Intinda	C	Non-flow: Forestry, Agriculture (vegetation removal). Barriers.
U40B-03740	Mvozana	C	Non-flow: Forestry, Agriculture (vegetation removal), barrier, inundation.
U40B-03770	Heinespruit	C	Non-flow: Forestry, Agriculture (vegetation removal). Barrier.
U40B-03832	Mvozana	C/D	Non flow: Agriculture. Barriers, vegetation removal. Water quality. Flow[2]: Abstraction for irrigation.
U40B-03896	Mvoti	C	Non flow: Aquatic alien macrophytes, agriculture (vegetation removal) encroachment.
U40C-03982	Khamanzi	B/C	Non-flow: Forestry, agriculture, and overgrazing.

SQ number	River	River PES (EC)	Key PES Driver
U40D-03867	Mvoti	B/C	Non-flow: Overgrazing, erosion.
U40D-03908	Mtize	B	n/a
U40D-03957	Mvoti	B	n/a
U40E-03967	Mvoti	B/C	Non-flow: Overgrazing, informal agriculture.
U40E-03985	Mvoti	B/C	Non-flow: Overgrazing, sedimentation.
U40E-04079	Faye	B	n/a
U40E-04082	Sikoto	B	n/a
U40E-04137	Sikoto	B	n/a
U40F-03690	Potspruit	C	Non-Flow: Forestry, agriculture, inundation, barrier.
U40F-03694	Hlimbitwa	C	Non-Flow: Vegetation removal (agriculture and forestry), canalisation.
U40F-03730	Cubhu	C	Non-Flow: Forestry, agriculture, overgrazing, barrier impacts.
U40F-03769	Hlimbitwa	C	Flow: Large dam in SQ and upstream. Non-flow: Forestry and agriculture.
U40F-03790	Nseleni	B/C	Non-flow: Forestry and agriculture.
U40F-03806	Hlimbitwa	B	n/a
U40G-03843	Hlimbitwa	B	n/a
U40H-04064	Mvoti	B/C	Non-Flow: Sedimentation, overgrazing, trampling.
U40H-04091	Pambela	B/C	Non-Flow: Sedimentation, overgrazing, trampling.
U40H-04117	Nsuze	B/C	Non-Flow: Sedimentation, overgrazing, trampling.
U40H-04133	Nsuze	B/C	Non-Flow: Sedimentation, overgrazing.
U40J-03998	Mvoti	C	Non-Flow: Sedimentation, overgrazing. Flow: Cumulative dams in tributaries, small abstractions.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities.

2.8.10 U5: Nonoti

Table 2.20 River PES and key drivers resulting in modification from natural

SQ number	River	River PES (EC)	Key PES Driver
U50A-04018	Zinkwazi	B/C	Non-flow[1]: Formal agriculture: sugar. Flow[2]: Dryland agriculture, small dam. Water quality (agricultural runoff).
U50A-04021	Nonoti	B/C	Flow: Dryland agriculture. Water quality (agricultural runoff, WWTW effluent). Non flow: Agriculture, settlements.
U50A-04141	Mdlotane	B/C	Flow: Dryland agriculture. Water quality (agricultural runoff). Non-flow: Formal agriculture: sugar.

2.9 ECOLOGICAL STATUS QUO: ESTUARIES

Data from the desktop EcoClassification study including updated results obtained during the study, are summarised below (Table 2.21). The PES is provided and the pressures/impacts are grouped into flow related, non-flow related and water quality impacts.

Table 2.21 Estuary PES and summary of pressures

Estuary	PES	Flow	Water Quality	Non-Flow
Mtamvuna	B			
Zolwane	B			
Sandlundlu	C			X
Ku-Boboyi	B			
Tongazi	B/C		X	X
Kandandhlovu	B		X	X

Estuary	PES	Flow	Water Quality	Non-Flow
Mpenjati	B/C		X	X
Umhlangankulu	C		X	X
Kaba	C		X	X
Mbizana	B			X
Mvutshini	B/C		X	X
Bilanhlolo	C		X	X
Uvuzana	C		X	X
Kongweni	E	X	X	X
Vungu	B		X	
Mhlangeni	C		X	X
Zotsha	B/C		X	X
Boboyi	B/C		X	X
Mbango	E	X	X	X
Umzimkulu	B			
uMthente	C	X	X	X
Mhlangamkulu	C	X		X
Damba	D	X		X
Koshwana	C/D	X	X	X
Intshambili	C	X	X	X
Mzumbe	C/D		X	X
Mhlabatshane	B/C			X
Mhlungwa	C		X	X
Mfazazana	C		X	X
Kwa-Makosi	B/C		X	X
Mnamfu	C		X	X
Mtwalume	C		X	X
Mvuzi	C		X	X
Fafa	C/D	X	X	X
Mdesingane	D		X	X
Sezela	C		X	X
Mkumbane	C		X	X
uMuziwezinto	C/D	X	X	X
Nkomba	B/C		X	X
Mzimayi	C/D	X	X	X
Mpambanyoni	C		X	X
Mahlongwa	C		X	X
Mahlongwane	C		X	X
uMkhomazi	C		X	X
Ngane	C		X	X
Umgababa	C	X	X	X
Msimbazi	B		X	X
Lovu	C/D	X	X	X
Little Manzimtoti	E	X	X	X
aManzimtoti	D/E	X	X	X
Mbokodweni	E	X	X	X
Sipingo	F	X	X	X
Durban Bay	E	X	X	X
uMngeni	D/E	X	X	X
Mhlanga	D	X	X	X

Estuary	PES	Flow	Water Quality	Non-Flow
uMdloti	D	X	X	X
uThongathi	D	X	X	X
Mhlali	C/D	X	X	X
Bob's Stream	B/C		X	X
Seteni	B/C		X	X
Mvoti	D	X	X	X
Mdlotane	B		X	
Nonoti	C		X	X
Zinkwasi	B/C		X	X

2.10 ECOLOGICAL STATUS QUO: WETLANDS

The scores and comments for each quaternary catchment are provided on the CD including all raw data and supporting documentation for this project. A summary of the key impacts for quaternary catchments selected for PES assessment is provided in Table 2.22.

Table 2.22 Key impacts for quaternary catchments selected for wetland PES assessments

Quat	PES	Key Catchment scale impacts	Key within wetlands impacts
T4 - Mtamvuna			
T40A	D	Non-Flow: Agriculture.	Non-Flow[1]: Canalisation and erosion.
T40B	C/D	Non-Flow: Forestry with poor buffer zones.	Non-Flow: Canalisation and erosion.
T40C	C	Non-Flow: Agriculture.	Non-Flow: Erosion.
T40E	C	Flow: Dams, irrigation and other flow reduction activities. Non-Flow: Urbanization.	Non-Flow: Sugar cane farming.
T5 - Umzimkulu			
T51A	C	Flow: Farm dams.	Non-Flow: Erosion and grazing. Some cropping in wetlands.
T51B	B/C	Flow: Numerous farm dams; some irrigated agriculture.	Non-Flow: Some canalisation.
T51C	C	Non-Flow: Large afforested sections, invasive trees along watercourses. Flow: Some irrigated agriculture, farm dams.	Non-Flow: Some widespread dongas/eroding drains.
T51D	C	Flow: Several large farm dams.	Flow[2]: Several large farm dams are within the wetland areas.
T51E	C	Flow: Several small dams, some irrigation, cropping, forestry.	Non-Flow: Canalisation, erosion, invasive plants, cropping.
T51F	C/D	Flow: Farm dams, irrigated agriculture.	Non-Flow: Agricultural encroachment. Flow: Farm dams, some drains present.
T51G	C	Non-Flow: Afforestation. Flow: Irrigation dams.	Non-Flow: Canalisation, erosion, invasive plants, cropping.
T51H	B/C	Non-Flow: Some afforestation, low density residential areas.	Non-Flow: Limited erosion and invasive plants.
T51J	B	Non-Flow: Lower catchment is peri-urban.	Non-Flow: Erosion dongas (incised channels) are present.
T52A	C	Non-Flow: Some afforestation.	Non-Flow: Some Invasive Alien Plants (IAPs) evident, forestry encroachment. Flow: Few canals.
T52B	C	Non-Flow: Afforestation.	Non-Flow: Erosion.
T52C	C	Non-Flow: Afforestation.	Non-Flow: Erosion.
T52D	C/D	Non-Flow: Afforestation, small urban and peri-urban areas, some agriculture. Flow: Some farm dams, irrigated agriculture.	Non-Flow: Erosion, forestry encroachment, invasive plants.
T52E	B/C	Non-Flow: Afforestation, some small urban and peri-urban areas.	Non-Flow: Forestry encroachment, invasive plants.

Quat	PES	Key Catchment scale impacts	Key within wetlands impacts
T52F	C/D	Non-Flow: Upper catchment afforested, widespread peri-urban areas, numerous settlements.	Non-Flow: Erosion. Flow: Many canals/drains
T52H	C/D	Non-Flow: Numerous settlements.	Non-Flow: Erosion. Flow: Drains in wetlands
T52K	C/D	Non-Flow: Large afforested sections.	Non-Flow: Some forestry and agriculture. Erosion and invasive plants.
U1 - uMkhomazi			
U10C	C	Flow: Many farm dams, irrigated agriculture.	Non-Flow: Agricultural encroachment.
U10D	C	Non-Flow: Limited agriculture.	Non-Flow: Erosion. Flow: Drains, dams in some wetlands.
U10E	B	Non-Flow: Forestry in some areas, but generally wide buffers.	Non-Flow: Erosion and forestry encroachment. Flow: Some drains.
U10F	C	Non-Flow: Forestry in some areas, but generally wide buffers.	Non-Flow: Some forestry encroachment (low). Some dams.
U10G	C	Flow: Widespread irrigation/agriculture in high density wetland areas.	Non-Flow: Agricultural encroachment. Flow: Dams, possibly dykes.
U10H	C/D	Non-Flow: Widespread forestry in high density wetland areas, agriculture, settlements.	Flow: Dams, roads, drains. Non-Flow: Agricultural encroachment, erosion.
U10J	D	Non-Flow: Widespread irrigated and dryland (often within wetland) agriculture. Widespread settlements.	Flow: Dams, roads, drains. Non-Flow: Severe encroachment by agriculture.
U10K	C	Non-Flow: Widespread (often within wetland) agriculture. Forestry in upper catchment.	Non-Flow: Severe encroachment by agriculture.
U2 - uMngeni			
U20A	C	Non-Flow: Some afforestation in the lower catchment, IAPs in some sections. Flow: Several small dams.	Flow: Extensive drains, some dams. Non-Flow: Some cropping encroachment. Incision in some wetlands.
U20B	D	Flow: Several dams, irrigated agriculture.	Non-Flow: Extensive cropping encroachment. Flow: Many dams, some drains.
U20C	C	Non-Flow: Agriculture. Flow: A few small dams, irrigated agriculture.	Non-Flow: Extensive cropping encroachment.
U20D	D	Flow: A few small dams, irrigated agriculture. Non-Flow: Agriculture.	Non-Flow: Forestry and agricultural encroachment.
U20E	C	Non-Flow: Agriculture and settlements. Flow: A few small dams, irrigated agriculture, large dam upstream.	Non-Flow: Forestry and agriculture. Encroachment in some places.
U20F	C/D	Non-Flow: Widespread forestry in high density wetland areas.	Non-Flow: Erosion. Forestry and agriculture. Encroachment in some places. Flow: Some dams in wetlands.
U20H	D	Non-Flow: Widespread urban areas/settlements.	Non-Flow: Erosion.
U20J	D	Non-Flow: Pietermaritzburg - widespread urban areas/settlements.	Non-Flow: Erosion.
U3 - uMdloti			
U30B	C/D	Non-Flow: Widespread urban areas/settlements. Flow: Dams, widespread sugar cane.	Non-Flow: Erosion.
U4 - Mvoti			
U40A	D	Non-Flow: Extensive afforestation. Flow: Afforestation, irrigated agriculture.	Non-Flow: Extensive forestry, although sometimes wide buffers are in place along watercourses, invasive plants.
U40B	C	Non-Flow: Widespread forestry in high density wetland areas.	Non-Flow: Invasive plants.
U40C	C/D	Non-Flow: Dams, irrigated agriculture.	Non-Flow: Agricultural encroachment.
U40F	C/D	Flow: Dams and irrigated agriculture.	Non-Flow: Extensive agricultural encroachment.
U40J	D	Flow: Widespread sugar cane farming. Non-Flow: Stanger in lower reach.	Non-Flow: Extensive agricultural encroachment.
U5 - Nonoti			
U50A	D	Flow: Widespread sugar cane farming.	Non-Flow: Extensive agricultural encroachment. Infestation of IAPs in many wetlands.
U6 - uMlazi			

Quat	PES	Key Catchment scale impacts	Key within wetlands impacts
U60A	D	Non-Flow: Widespread forestry.	Non-Flow: Roads, encroachment from forestry. Widespread erosion.
U60B	C/D	Non-Flow: Intensive agriculture.	Non-Flow: Agricultural encroachment.
U60C	C	Flow: Several farm dams, agriculture.	Non-Flow: Heavy grazing on largest wetland.
U60E	D	Non-Flow: Widespread urban areas.	Non-Flow: Urban and industrial encroachment. Erosion. Flow: High peak flows, wetlands isolated from rivers/other wetlands.
U7 - Lovu			
U70A	C/D	Non-Flow: Extensive forestry, narrow buffers.	Non-Flow: Forestry encroachment.
U70B	D	Non-Flow: Dams and agriculture.	Non-Flow: Forestry and agricultural encroachment. Flow: Numerous dams in wetlands.
U80E	D	Non-Flow: Dams and agriculture. Forestry.	Non-Flow: Forestry and agricultural encroachment. Flow: Numerous dams in wetlands.

1: Non-flow refers to Non-Flow related activities. 2: Flow refers to Flow related activities

3 INTEGRATED UNITS OF ANALYSIS

This chapter is an extract from report:
Department of Water Affairs (DWA), South Africa. 2013a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Status quo assessment, IUA delineation and biophysical node identification. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. July 2013. DWA Report: RDM/WMA11/00/CON/CLA/0113.

3.1 PROCESS TO DETERMINE IUAs

An IUA is a broad scale unit (or catchment area) that contains several biophysical nodes. These nodes define at a detail scale specific attributes which together describe the catchment configuration of the IUA. Scenarios are assessed within the IUA and relevant implications in terms of the Water Resource Classes (commonly referred to as Management Classes) are provided for each IUA. The objective of defining IUAs is therefore to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on ecological conditions at a SQ scale.

3.2 DESCRIPTION OF STATUS QUO PER IUA

The selected IUAs are illustrated in Appendix C. The status quo for all the different components is described for each IUA in the subsections below.

3.2.1 IUA T4: Mtamvuna

Water resources: The storage regulation in this IUA is low with no noticeable dams located in the area. There is no surface water developments planned in the IUA. The land use activities include extensive forestry in the upper reaches and some cultivation in the lower reaches. The IUA is predominantly rural with a large number of scattered rural and informal settlements supplied from regional water abstractions.

According to a desktop investigation conducted as part of this study, insignificant volumes of groundwater are utilised in the water resources IUA and there is a potential for some groundwater development in the upper reaches underlain by Karoo sediments. The lower reaches are underlain by low yielding Dwyka tillites. The locality of the groundwater resources relative to potential users and the viability for development needs to be confirmed.

Economy: Mtamvuna River forms the boundary with the Eastern Cape Province. It is a very popular holiday area with some sub-tropical fruit, mostly banana and sugar cane production with commercial forestry in the inland areas.

EGSA: The upper portion of the IUA consists of plantation and formal commercial farming with the utilisation of EGSA limited to ad hoc consumption by farm workers and recreational usage - not significant. The remainder of the catchment is under communal tenure and made up of former homeland areas (Transkei). Utilisation of EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Some parts of the IUA are characterised by high population densities and development is more typically that associated with the closer settlement that was developed as “betterment planning”. Here the resource base is under considerable stress and as such the production of EGSA is constrained. The lower part of the Mtamvuna Gorge is a popular area with aesthetic appeal.

Ecology (rivers and wetlands): Dominated by B and B/C PES. Quaternary catchment T40A (Mafadobo and Goxe rivers) is subjected to small areas of forestry and low density rural settlements with the primary impacts being non-flow related (sedimentation). T40B has flow and non-flow related impacts, consisting of extensive forestry occurring in the upper reaches, with a timber mill and rural settlements. Subsistence farming, grazing and low density rural settlements occur in T40C. T40D is mostly in a good state which is often due to the protection provided by gorges. Impacts are non-flow related as well as for the rivers further downstream with impacts being primarily non-flow related (rural settlements, subsistence farming, sedimentation and grazing).

IUA rationale: The storage regulation in this IUA is low with no noticeable dams located in the area. There is no surface water developments planned in the IUA. Landuse is mostly forestry (upper areas) and rural. Ecological impacts are similar and in relatively good state. The Mtamvuna catchment therefore forms a logical unit.

3.2.2 IUA T5-1: Upper Umzimkulu Mountain Zone

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and instream dams. There is no surface water developments planned in the IUA.

The upper reach of the IUA is mainly a mountainous area below which the IUA is mainly characterised by agricultural activities including extensive forestry, extensive irrigation, cultivation, dairy, cattle and sheep farming. Some parts of the IUA are rural with some community water use from the scattered rural villages. Subsistence farming is practised in these areas. The towns Underberg and Himeville are also located in the IUA.

According to a desktop investigation conducted as part of this study, some groundwater is utilised in the water resources IUA for rural supply and livestock watering purpose and there is some potential for further groundwater development as the Karoo sediments underlying the region are moderately yielding. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Umzimkulu catchment starts in the Drakensberg area of Underberg, a mixed farming area with large areas under animal pasture production supporting the dairy industry in the area, followed by commercial forestry and large tracts of communal land. In the Himeville and Underberg districts a number of tourist facilities have been developed and the tourism has experienced a healthy growth rate.

EGSA: This is largely the Drakensberg and adjacent foothills. For the most part the population density is very low. There are some patches of commercial farming entities but the bulk of the IUA is given over to conservation. Recreational aspects of EGSA are important.

Ecology (rivers and wetlands): A mountainous zone which contains several headwater streams. Most SQs are an A or B PES, with a single C PES. Low severity impacts that exist are created by small patches of afforestation and other alien vegetation, small dams, tourism, irrigation and rural community use in the form of subsistence farming (grazing and trampling, agricultural lands). A large percentage of the area is protected in various Wilderness areas and the Cobban Nature Reserve (T51D-04404).

The Pholela (T51D-04404) has been noted for low wetland importance (large valley bottom wetlands). Several wetland clusters also occur in the zone, mostly not associated with a SQ.

IUA rationale: Mountainous zone with most of the rivers in a good PES and impacts similar. Low storage capacity and not prospects for future development. Population density is low with some recreation. Outside of this IUA, the uses and level of impacts change due to the different topography, therefore providing the rationale for this IUA.

3.2.3 IUA T5-2: Middle Umzimkulu and Mzimkulwana Tributary

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. A surface water development planned for the area is the Ncwabeni off-channel dam with abstraction from a new weir on the Umzimkulu River for regional water supply, which will have some effect on the flows.

The land use activities in the IUA include extensive forestry concentrated in the upper higher rainfall areas, irrigation in the upper reaches, cultivation, cattle farming and subsistence farming. There are a number of scattered rural villages supplied by regional water supply schemes. The towns Creighton and Umzimkulu are also located in the IUA.

According to a desktop investigation conducted as part of this study, some groundwater is utilised by rural villages in the water resources IUA, with a potential for further groundwater development, however, the lower reaches are underlain by low yielding Dwyka tillites. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: *Commercial forestry is the main economic activity surrounded by large areas of tribal land*. Saw mills operate at Harding and Weza.

EGSA: The upper portion of the IUA consists of plantation and formal commercial farming and EGSA is limited to ad hoc consumption by farm workers and some recreational usage (not significant). The rest of the IUA is under communal tenure and made up of former homeland areas. Utilisation of goods and services (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Some parts of the IUA are characterised by high population densities and development is more typically that associated with the closer settlement that was developed as “betterment planning”. Here the resource base is under considerable stress and the production of EGSA is constrained. Oribi Gorge in the catchment is a popular area with aesthetic appeal.

Ecology (rivers and wetlands): Most of the rivers are in a B/C and C PES. Extensive rural development and associated settlements are the main impacts. Forestry, irrigation, trampling and erosion, dams and IAPs occur. Further downstream, dense human settlements and large townships occur. SQs with a high PES originate in the Ntsikeni Wildlife Reserve and in other areas, are protected by being within steep valleys. The one SQ that is in an E PES is drowned by dams.

The Lubhukwini River (T51H-04846) is noted for high priority wetlands (extensive seeps) which are KZN priority monitoring sites and is also a Ramsar site. Wetland rehabilitation is evident. Very high priority channelled valley bottom wetlands with meandering grasslands have been noted in the Pholelana (T51D-04460) and Pholela (T51E-04478) Rivers. Meandering floodplains in the Pholela are KZN priority monitoring sites. Some wetlands are inundated and grazing and formal agriculture has affected wetland PES.

IUA rationale: Most of the rivers in a similar state due to similar land use and impacts. The upper border of this IUA is due to the change in topography and landuse. It is split from the T5-3 due to the rivers being all in a better state than this SQ, probably due to the protection of steep valleys. Land use also changes.

3.2.4 IUA T5-3: Umzimkulu

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. The upstream development of the Cwabeni off-channel dam with abstraction from a new weir on Umzimkulu for regional water supply will have some effect on the flows.

The land use activities include extensive forestry and sugar cane, Oribi Gorge Nature Reserve, natural areas with grazing, and run of river abstraction or regional water supply to rural villages. The town Harding is also located in the IUA. Industrial activities include limestone mining and the Illovo Umzimkulu sugar mill in the lower reach, which abstracts water directly from the Umzimkulu River just upstream of the estuary.

According to a desktop investigation conducted as part of this study, some groundwater is utilised by rural villages in the water resources IUA, with a potential for further groundwater development in areas underlain by Natal Metamorphic Province and Natal Group rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Commercial forestry is the main economic activity supported by sugar cane production; the commercial area is surrounded by large areas of tribal land.

EGSA: In the upper part the population densities are relatively low as the topography militates against development. Most of this portion of the IUA is under communal tenure and made up of former homeland areas. Although utilisation is low given population density and problems of accessibility the EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) are of high importance to those who do consume them. The bottom part of the IUA is made up of the town of Port Shepstone. Recreational use of the river in this area is of potentially high importance.

Ecology (rivers and wetlands): The SQs are all in a B PES. The good state of especially the main Umzimkulu in this area is attributed to the protection provided by a large gorge section. Impacts in this area is primarily non-flow related, related to small scale subsistence farming, grazing, limited forestry, erosion and sedimentation of instream habitats. A lime stone mining plant is also present in the lower Umzimkulu River reach but does not impact notably on the present status of this zone.

The Bisi (T52H-05178) has been noted for low importance wetlands (isolated pockets of valley bottom wetlands).

Ecology (estuary)***:*** The Umzimkulu Estuary is a B PES. This status has been confirmed through a detailed EWR study recently conducted on the system. Currently it is under moderate flow modification, pollution, habitat loss and medium-high fishing pressure. Artificial mouth-breaching is practised in the system. It is of moderate importance from a biodiversity perspective. The estuary also forms part of the national priority set identified under the National Estuaries Biodiversity Plan, which affirms the REC as a B Category (Turpie *et al*., 2012). This catchment plays an important role in providing nutrients and sediments to the near-shore marine environment.

IUA rationale: The River is mostly protected by gorge section which results in a better state than the upper reaches. It culminates in an estuary which is also in a good state.

3.2.5 IUA U8-1: Mzumbe

Water resources: The storage regulation in this IUA is low with no significant dams present and there is no future surface water developments planned in the IUA.

The IUA is predominantly rural with scattered rural villages located throughout. There is some forestry and cultivation located in the upper reach of the IUA.

According to a desktop investigation conducted as part of this study, small volumes of groundwater are utilised for rural supply in the water resources IUA and there is a potential for limited groundwater development in the area, since it is underlain by low yielding Natal Metamorphic Province rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: It is has a large rural population in the inland area with some mixed farming and commercial forestry and sugar cane production.

EGSA: The very top end of IUA is given over to forestry (low EGSA utilisation). The rest has pockets of forest, is under communal tenure and made up of former homeland areas. EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Some parts of the IUA are characterised by high population densities, particularly the ridges, and development is more typically that associated with the closer settlement.

Ecology (rivers and wetlands): All the SQs that comprise the Mzumbe system have B PES. Impacts in the Mzumbe comprise mainly forestry (U80B-05145), rural settlements and subsistence farming, small dams in the tributaries, and associated non-flow related impacts such as grazing, but all with low severity or extent.

Ecology (estuary): The Mzumbe Estuary is a C/D PES. Currently it is under low flow modification pressure, but moderate pollution and habitat loss pressures. It is of average importance from a biodiversity perspective. The estuary is highly sensitive to modification in base flow as it influences the mouth state.

IUA rationale: There is no reason to break the Mzumbe River catchment in different IUAs as the ecological state is similar, the landuse is predominantly rural and there are no planned developments.

3.2.6 IUA U8-2: Mtwalume

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few instream dams. There is no future surface water developments planned in the IUA.

Land use activities in the water resources IUAs generally include cultivation and some forestry in the middle and upper reaches. Rural villages are also scattered throughout the IUA with semi-urban and urban areas located along the coast.

According to a desktop investigation conducted as part of this study, small volumes of groundwater are utilised for rural supply in the water resources IUA and there is a limited potential for further groundwater development in the area since it is largely underlain by low yielding Natal Metamorphic Province rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: It is has a high rural population percentage in some areas with some mixed commercial farming and commercial forestry and sugar cane production.

EGSA: The very top end of IUA is given over to forestry and formal commercial agriculture. There are pockets of scattered forestry development in other parts of the IUA (EGSA utilisation is low). The bulk of the remainder is under communal tenure and made up of former homeland areas. EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Some parts of the IUA are characterised by high population densities, particularly the ridges, and development is more typically that associated with the closer settlement. Population densities increase closer to the coastal areas.

Ecology (rivers and wetlands): Rivers are mostly in a B, C, B/C and D PES. Both flow and non-flow related impacts dominate the Mtwalume and its tributaries. Notable are instream dams, forestry, subsistence agriculture and encroaching sugar cane fields. No importance has been noted for wetlands.

Ecology (estuary): The Mtwalume Estuary is a C PES. Currently it is under low flow modification pressure, but moderate pollution and habitat loss pressures. It is of average importance from a biodiversity perspective. The estuary is highly sensitive to modification in base flow as it influences the mouth state.

IUA rationale: There is no reason to break the Mtwalume River catchment in different IUAs as the ecological state is very varied, with varied landuse and there are no planned developments.

3.2.7 IUA U1-1: uMkhomazi Mountain Zone

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. The proposed Smithfield Dam site is located at the lower end of the IUA and is likely to be developed in the future. The DWA is currently in the process of conducting a feasibility study for the uMkhomazi River Development Project (Smithfield Dam) and the purpose of the project is to augment the uMngeni River supply area. The construction of Smithfield Dam will have a noticeable effect on the river flows downstream of the dam.

The middle to upper reach of the IUA is mainly a mountainous area, where nature reserves (Lotheni, Vergelegen, Kamberg, Highmore Nature Reserves, and uMkhomazi National Park) and the Sani Pass Tourism area are located. There is some agriculture and community water use. The main activities in the middle to lower end of the IUA underlain by the Middelveld Karoo groundwater region include forestry, cultivation, irrigation, grazing, and community water use from low density rural settlements. Bulwer Town is located in the lower end of the IUA. In general there are few impacts on the river systems and the water quality can be regarded as good.

According to a desktop investigation conducted as part of this study, some groundwater is utilised in the water resources IUA and there is some potential for further groundwater development in the area. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Some commercial cattle farming occurs at the top end of the river, followed by a mixture of commercial plantations and rural tribal land.

EGSA: There is a belt of commercial farming entities but the bulk of the upper part of the IUA is given over to conservation in the Drakensberg. Recreational aspects of EGSA are important. In the DS section, EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Population densities in this part of IUA are high and the regions of Sitofela and Moyeni are particularly dense.

Ecology (rivers and wetlands): The Rivers are mostly in an A, A/B and B PES category. The few impacts that exist are created by small patches of afforestation and other alien vegetation, small dams and trout farms, tourism, and rural community use in the form of subsistence farming (cattle trampling, erosion, roads, and agricultural lands). A large percentage of the area is protected in nature reserves (Lotheni, Vergelegen, and uMkhomazi). The two B/C PES SQs are due to an increase in subsistence farming which leads to an increase in abandoned lands, roads, trampling and erosion.

The Nzinga River (U10D-04199) is noted for low priority wetlands, mainly small pockets of channelled valley bottom wetlands, and several wetland clusters (predominantly seep wetlands and channelled valley bottom wetlands) (Nel *et al.*, 2011).

IUA rationale: Mountainous zone with most of the rivers in a good PES and impacts similar. The proposed Smithfield Dam is the logical break for the IUA.

3.2.8 IUA U1-2 Middle uMkhomazi

Water resources**:** The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. The development of the upstream uMkhomazi River Development Project (Smithfield Dam) will have a significant impact on the uMkhomazi River in the water resource IUA.

The land use activities in the IUA include forestry, cultivation, irrigation, some sugar cane, cattle farming, and community water use from low density rural settlements. The small town Ixopo is also located in the IUA.

According to a desktop investigation conducted as part of this study, some groundwater is utilised for rural supply in the water resources IUA and there is some potential for further groundwater development in the area since it is underlain largely by moderately yielding sediments of the Ecca Group. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Commercial plantations with some well-developed irrigation activities and cattle farming are the main economic activities.

EGSA: The eastern part has well-developed commercial agriculture and forestry (use of EGSA is limited to *ad hoc* consumption by farm workers and some recreational usage). The remainder of the catchment is under communal tenure and made up of former homeland areas of KwaZulu. Some parts, particularly around Machabasini, Impendle and Nkumba, are densely populated. Densities mean that resources are under pressure. Nevertheless the utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance.

Ecology (rivers and wetlands): All SQs are in a C PES. The uMkhomazi and Luhane rivers are dominated by non-flow related impacts (mainly forestry and rural settlements with informal agriculture), while the Elands and its tributaries is dominated by both flow (mainly small dams and some irrigation) and non-flow related (mainly forestry and rural settlements with informal agriculture) impacts.

The zone also contains several National Freshwater Ecosystem Priority Area (NFEPA) wetland clusters, which are not necessarily associated with the river directly.

IUA rationale**:** The upper border of the IUA is delineated by Smithfield Dam. The lower border is due to the change in topography of the uMkhomazi gorge. Ecological impacts all similar due to similar range of land use.

3.2.9 IUA U1-3: uMkhomazi Gorge Zone

Water resources: The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. The development of the upstream uMkhomazi River Development Project (Smithfield Dam) will have a significant impact on the uMkhomazi River in the water resource IUA.

The land use activities are predominantly community water use from low density rural settlements.

According to a desktop investigation conducted as part of this study, minimal volumes of groundwater are utilised in the water resources IUA and there is some potential for further groundwater development in the area. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Very few economic activities occurs other than beef farming and a sprinkling of dairy farms with some tourist facilities present.

EGSA: The upper and western part has well-developed commercial agriculture and forestry (use of EGSA is limited to *ad hoc* consumption by farm workers and some recreational usage). The gorge itself is of aesthetic importance with recreation (rowing) taking place. There are pockets of former homeland areas of KwaZulu including KwaSandanezwe. The utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance but constrained by problematic access.

Ecology (rivers and wetlands): The IUA is dominated by a B PES with one C and one B/C PES SQ. These reaches are impacted by both flow and non-flow related activities, consisting primarily of forestry, subsistence farming and sugar cane agriculture, resulting in instream sedimentation, riparian zone modification and flow alterations.

The Tholeni and Pateni Rivers are impacted by forestry in the upper reaches. The uMkhomazi (U10H-04638, U10H-04675, and U10J-04807), Mkobeni (U10J-04713), Pateni (U10J-04721) and Lufafa (U10J-04820) rivers are all noted for low importance wetlands (mostly small or narrow valley bottom wetlands).

IUA rationale: The topography, i.e. the gorge, resulted in this IUA. This zone is largely inaccessible and dominated by a good PES.

3.2.10 IUA U1-4: Lower uMkhomazi

Water resources: The storage regulation in this IUA is low with no dams located in the IUA. The development of the upstream uMkhomazi River Development Project (Smithfield Dam) will have a significant impact on the uMkhomazi River in the water resource IUA.

The landuse activities are predominantly community water use from low density rural settlements and there is also an abstraction for Sappi Saiccor in the lower end of the IUA.

According to a desktop investigation conducted as part of this study, some groundwater is utilised for rural supply in the water resources IUA and there is limited potential for further groundwater development in the area, since it is underlain by low permeability Dwyka tillites and Natal Metamorphic Province rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: The large Sappi cellulose producing facility, SAICCOR, operates close to the coast. Some holiday facilities also operate in the area.

EGSA: Part of this IUA has well-developed commercial agriculture and forestry including the regionally important centre of Ixopo. The bulk of the main portion of the IUA is former homeland areas of KwaZulu. Some parts, particularly around Mgandleni, KwaNkukhu, KwaMagidigidi, and Kadeda are densely populated. Densities mean that resources are under pressure. Nevertheless the utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. The bottom part of the IUA includes Craigieburn, and the associated Sappi Saiccor development as well as parts of the town of eMkhomazi. This part is heavily developed and other than recreational utilisation of the river (swimming and fishing) above the estuary there is little in the way of utilisation of the EGSA.

Ecology (rivers and wetlands): *The d*ominant PES is C and B/C. The Xobho River is a D PES (main impacts being dams, forestry and agriculture). The uMkhomazi River in U10L and M is a B/C PES with the predominant impacts being overgrazing.

Wetlands have been noted for very high and high importance in the Xobho (large valley bottom wetlands in headwater area) and uMkhomazi (extensive narrow valley bottom wetlands) rivers respectively, while the Nhlavini River was noted for wetlands, but with a low importance.

Ecology (estuary): The uMkhomazi Estuary is a C PES. It is under low flow modification, moderate pollution and habitat loss pressure and under high fishing pressure. It is of moderate importance from a biodiversity perspective. Artificial mouth-breaching is practised in the system. The estuary also forms part of the national priority set identified by the National Estuaries Biodiversity plan (Turpie *et al*., 2012). The national plan also recommends that uMkhomazi Estuary be improved to a B PES. This catchment plays an important role in providing nutrients and sediments to the near-shore marine environment.

IUA rationale**:** This IUA represents the remainder of the uMkhomazi catchment. There are no reasons for a finer delineation.

3.2.11 IUA U7: Lovu

Water resources: The storage regulation in this IUA is low and the only dams include a number of small farm and instream dams. There is no future surface water developments planned in the IUA.

There are extensive forestry and sugar cane plantations located in the middle to upper reach of the IUA with Richmond town and adjacent township also located in the upper reach. The middle to lower reach of the IUA is occupied by scattered rural villages. Discharges from the Richmond and township area enter the river systems affecting both the flow and especially the water quality of the river.

According to a desktop investigation conducted as part of this study, small volumes of groundwater are utilised for rural supply and livestock watering in the water resources IUA and there is a potential for further groundwater development in the area, especially in the lower reaches underlain by faulted Natal Metamorphic Provice and Natal Group rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U7-1 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U70B-4655	Lovu	Serious (4) - around Richmond	WWTW, urban centre; fertilizers and pesticides.
U70D-4905	Lovu	Large (3)	Oil and diesel pollution; sugar mill; elevated nutrients.

Economy: It hosts large timber plantations and sugar cane fields feeding the saw and sugar mills. Vegetable production has also experienced considerable growth as well as leisure tourism on the coastal area.

EGSA: The upper half of the Lovu catchment is home to well-developed commercial agriculture and forestry including the regionally important centre of Richmond. Utilisation of EGSA is limited to ad hoc consumption by farm workers and some recreational usage (not significant). The remainder of the catchment is under communal tenure and made up of former homeland areas. The population density given the proximity to the metropolitan areas of Durban is high. Densities mean that resources are under pressure. The utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance. The formal town of Illovo Beach is at the bottom of the IUA. Recreational utilisation of the river above the estuary, mostly swimming and fishing, is an important part of EGSA.

Ecology (rivers and wetlands): The upper Lovu catchment (U70A) is situated in areas mainly covered with plantation forestry (C and B/C PES). Further downstream there are large areas of forestry. Sugar cane, rural development (towns/townships), and dams, have increased impacts on these rivers, especially the water quality (C/D PES). The deeper valleys of the Lovu and Nungwane prevent the people from impacting too much on the rivers but water quality impacts prevail.

The Lovu at U70C-04859 has been noted for low priority, isolated, small and narrow channelled valley bottom wetland patches associated with the main channel.

Ecology (estuary): The Lovu Estuary is a C PES. Currently it is under moderate flow modification, pollution and habitat loss pressure. Artificial mouth-breaching is practised in the system. While the estuary is of average importance from a biodiversity perspective, it does form part of the national priority set identified by the National Estuaries Biodiversity Plan (Turpie *et al*., 2012). The estuary is highly sensitive to modification in baseflow as it influences the mouth state.

IUA rationale: There is no reason to break the Lovu River catchment in different IUAs as the ecological state and land use is similar and there are no planned developments. Water quality problems are an issue.

3.2.12 IUA U6-1: Upper uMlazi

Water resources: The IUA is regulated by the Shongweni Dam located at the lower end of the IUA and there are also a number of small farm and instream dams. There is no future surface water developments planned in the IUA.

The main landuse activities include cultivation (dryland sugar cane, maize), irrigation and forestry located in the upper half of the IUA. There are some low density settlements as well as semi-urban and urban areas with industries located in the lower half of the IUA. Discharges from the Hopewell and Hammersdale (industrial area) WWTWs into the rivers affect both the flow and especially the water quality of the river.

According to a desktop investigation conducted as part of this study, small volumes of groundwater are utilised for rural supply and livestock watering in the water resources IUA and there is a potential for further groundwater development in the area, especially in the lower reaches underlain by faulted Natal Group sandstones. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U6-1 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U60C-4555	uMlazi	Large (3)	Urban and industrial effluents, so high nutrient and salt load.
U60C-4556	Sterkspruit	Serious (4)	Elevated salts, nutrients, and toxicants. Identified by eThekwini MM as a hotspot.
U60C-4613	Wekeweke	Large (3)	Elevated nutrients and fertilizers.
U60C-4697	Sterkspruit	Large (3)	Urban and industrial effluents.

Economy: It hosts some timber and sugar cane plantations in the upper half of the river feeding the saw and sugar mills. Irrigation agriculture has experienced considerable growth the previous number of years producing vegetables and grazing for dairy farming.

EGSA: The upper half has well-developed commercial agriculture and forestry including the Baynesfield farming area (limited EGSA use). The lower part of the IUA has peri- urban and urban settlement, including Mpumalanga. The population density given the proximity to the metropolitan areas of Durban is high. Densities mean that resources are under pressure. Utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance. Parts of the riverine system are difficult to access and this further inhibits utilisation.

Ecology (rivers and wetlands): The IUA is dominated by C/D and D PES rivers. Upstream of the Shongweni Dam predominant impacts are both flow (instream dams and irrigation) and non-flow related (forestry, agricultural activities, IAPs, and water quality especially in U60C-04556). The uMlazi at SQs U60A-04533 and U60C-04555 is noted for wetlands of moderate and low importance respectively. Most wetlands consist of isolated patches of valley bottom wetlands that have a C or D PES. Many of the wetlands are inundated or reduced in extent by forestry and agricultural activities. The Sterkspruit (U60C-04556) is noted for wetlands of moderate importance.

Overall wetland PES is low (D or worse mainly due to agricultural encroachment and overgrazing).

IUA rationale: The land use in the IUA result in both flow (instream dams and irrigation) and non-flow related (forestry, agricultural activities, IAPs, and water quality especially in U60C-04556) ecological impacts. The Shongweni Dam is located at the end of the IUA which is a logical break for the IUA.

3.2.13 IUA U6-2: Lower uMlazi

Water resources: The IUA is regulated by the upstream Shongweni Dam and there is no future surface water developments planned in the IUA.

The middle to upper reach of the IUA is occupied by scattered rural villages and the middle to lower reach by semi-urban and urban areas. Discharges from numerous WWTWs enter the river system affecting both flow and especially the water quality of the river. There is also a hazardous landfill site in the upper reaches of the tributaries which also affect the water quality of the uMlazi River, which is regarded as very poor. The lower end of the uMlazi River has been canalised and hence there is no estuary.

According to a desktop investigation conducted as part of this study there are insignificant volumes of groundwater utilised in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Natal Group rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U6-2 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U60D-4661	uMlazi	Critical (5)	Elevated salts, nutrients, toxicants; Identified by eThekwini MM as a hotspot.

Economy: It is surrounded by the eThekwini expanding urban areas and the farming area is shrinking.

EGSA: This includes the informal and formal urban developments of uMlazi township that forms part of the Durban metropolis. This part is heavily developed and other than recreational utilisation of some of the rivers (swimming and fishing) above the estuary there is little in the way of utilisation of the EGSA.

Ecology (rivers and wetlands): The River is in a D PES and impacts are degraded water quality and riparian vegetation removal (wood harvesting and grazing).

Ecology (estuary): The uMlazi Estuary has been canalised and is not considered a functional estuary any more (Van Niekerk and Turpie, 2012).

IUA rationale**:** The upper border of the IUA is delineated by Shongweni Dam. The ecological impacts are all similar due to the similar range of land use and water quality problems are an issue in the IUA.

3.2.14 IUA U6-3: Mbokodweni

Water resources: The storage regulation in this IUA is low and there are no major dams present. There is no future surface water developments planned in the IUA.

There is some sugar cane (dryland) located in the upper reaches of the IUA. The middle to upper reach of the IUA is occupied by scattered rural villages and the middle to lower reach by semi-urban areas, urban areas (uMlazi, Isipingo) as well as industrial areas close to the coast (Prospecton Industrial area). Discharges from numerous WWTWs enter the river system affecting both flow and especially the water quality of the river.

According to a desktop investigation conducted as part of this study there are insignificant volumes of groundwater utilised in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Natal Group rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U6-3 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U60E-4792	Mbokodweni	Serious (4) – especially Isipingo River	High organic and nutrient load. Isipingo River identified by eThekwini MM as a hotspot.

Economy: It is surrounded by the eThekwini expanding urban areas and the farming area is shrinking with sugar cane and vegetable production in the interior.

EGSA: This includes the informal and formal urban developments associated with the outskirts of the Durban metropolis. The upper part consists of informal semi-rural closer settlements. Although it is rural the population density given the proximity to the metropolitan areas of Durban is high. Densities mean that resources are under pressure. The lower part is heavily developed and includes Adams Mission, Folweni and parts of the extended uMlazi Township. Other than recreational utilisation of some of the rivers (swimming and fishing) above the estuary, there is little in the way of utilisation of the EGSA.

Ecology (rivers and wetlands): The upper Mbokodweni (U60E-04714) is a B PES and the remainder of the IUA a C PES. Impacts are non-flow related including water quality, vegetation removal (wood harvesting) and sugar cane plantations (in the upper reach). Similarly, the main impacts on the Bivane River is also non-flow related (trampling, sedimentation, vegetation removal).

Ecology (estuary): The Mbokodweni and Isipingo estuaries are in an E and F PES respectively. The Mbokodweni PES status has been confirmed through an EWR study. The Mbokodweni is under moderate flow modification, and high pollution and habitat loss pressures. Artificial mouth breaching is also practised in the system. The Isipingo Estuary is under high flow modification (most of its catchment has been diverted), pollution and habitat loss pressure. Both systems are of average importance from a biodiversity perspective. The Mbokodweni Estuary is highly sensitive to modification in baseflow as it influences the mouth state.

IUA rationale: There was no reason for delineation of the Mbokodweni River catchment into separate IUAs as the ecological state and land use is similar.

3.2.15 IUA U2-1: uMngeni: Upstream of Midmar Dam

Water resources: The IUA is regulated by the Midmar Dam located at the lower end of the IUA and there are also a number of small farm and instream dams. The interbasin Mooi-uMngeni Transfer Scheme (MMTS) transfers water from the Mooi River System (Mearns Weir) to the Midmar Dam catchment (Mpofana River, a tributary of the Lions River that flows into Midmar Dam). This has resulted in increased flows in the effected rivers. The second phase of the MMTS is in the process of being constructed i.e. Spring Grove Dam in the Mooi River catchment, which will transfer additional volumes of water into the Midmar Dam catchment. Water is abstracted from Midmar Dam to supply uMnsunduze (Pietermaritzburg) and surrounding areas.

The main land use activities in the IUA include forestry, cultivation and irrigation. The Mpophomeni semi-urban is located in the IUA, almost adjacent to the Midmar Dam.

According to a desktop investigation conducted as part of this study, minimal volumes of groundwater are utilised in the water resources IUA and there is some potential for groundwater development in the area since it is underlain by moderately yielding argillaceous rocks of the Adelaide Sub group and Volksrust Formations. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U2-1 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U20C-04340	Nguklu	Large (3)	Elevated nutrient loads.

Economy: It is mostly commercial mixed farming area with some commercial forestry plantations and a number of rural tribal areas.

EGSA: The upper half of this IUA is home to well-developed commercial agriculture and forestry including the regionally important centre of Nottingham Road. In this area the utilisation of EGSA is limited to ad hoc consumption by farm workers and some recreational usage. Potentially the most important use is probably that associated with fly-fishing.

Ecology (rivers and wetlands): The IUA is mostly in a C and B/C PES. Forestry is not restricted to the higher altitudes, patches occur throughout the area. In between these patches are well-organised commercial farms comprising of irrigation and dry land agriculture. Flow impacts stem from damming and water transfers (Mpofana River), while water quality impacts are associated with irrigation return flows, urban runoff and effluent from different sources (towns, farming, trout dams). A large section of the main stem is also inundated by the Midmar Dam.

This zone contains several wetlands clusters (Nel *et al.*, 2011) and is noted for uMngeni vlei (a KZN priority monitoring site). The upper portion of the U20A quaternary has a high density of seep wetlands (mostly not associated with the main channel), and some channelled valley bottom wetlands farther down. Impacts on the wetlands in U20A (C PES) comprise mainly of inundation, agricultural encroachment and grazing. The Kusane and uMngeni have moderate priority wetlands noted. Instream dams, forestry, road crossings, irrigation and cultivation result in wetlands ranging from D to E PES.

IUA rationale: The land use in IUA is can be characterised by agricultural actives and the Mooi-uMngeni Transfer Scheme which transfers water from the Mooi River System (Mearns Weir) into the Mpofana River (a tributary of the Lions River that flows into Midmar Dam) results in increased flows in the affected rivers. Midmar Dam is located at the end of the IUA which is a logical break for the IUA.

3.2.16 IUA U2-2: uMngeni: Midmar Dam to Albert Falls Dam

Water resources: The IUA is regulated by the upstream Midmar Dam, Albert Falls Dam located at the lower end of the IUA and also a number of small farm and instream dams. The IUA is regarded as highly regulated. There is no surface water development options planned directly in the IUA but the implementation of Mooi-Mgeni Transfer Scheme Phase 2 (MMTS2) will have an impact on the water resources.

Howick town and industrial area are located in the IUA, just downstream of Midmar Dam. Return flows from the Howick WWTW enter the uMngeni River affecting both the flow and the water quality.

The main land use activities in the IUA include extensive forestry, cultivation (sugar cane and other cash crops) and irrigation.

According to a desktop investigation conducted as part of this study, minimal volumes of groundwater are utilised in the water resources IUA and there is some potential for groundwater development in the area since it is underlain by moderately yielding sediments of the Ecca Group. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U2-2 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U20E-04243	uMngeni	Large (3)	Elevated nutrient loads; urban run-off.

Economy: The main town is Howick followed by the well-known Karkloof leisure and nature area. The farming activities are mixed with some dairy and vegetable production.

EGSA: The upper half of the this IUA is home to well-developed commercial agriculture and forestry including the regionally important centre of the Karkloof In this area the utilisation of EGSA is limited to ad hoc consumption by farm workers and some recreational usage. The Karkloof Nature Reserve as well as a number of smaller private reserve areas means that recreational aspects are of high importance.

Ecology (rivers and wetlands): The IUA SQs are in a C and B/C PES, except the Kusane River which is a D due to a combination of forestry, dams and irrigation impacts. The main stem of the uMngeni River becomes very regulated as 0.9 m^3/s is released constantly from Midmar Dam. All the tributaries between the two dams are also heavily impacted due to forestry, irrigation and dry land agriculture (formal), weirs and dams, and removal of riparian vegetation.

***IUA rationale*:** The upper border of the IUA is delineated by Midmar Dam and Albert Falls Dam is located at the end of the IUA which is a logical break for the IUA.

3.2.17 IUA U2-3: uMngeni Downstream of Albert Falls Dam to uMnsunduze Confluence

Water resources: The IUA is regulated by the upstream Midmar Dam and Albert Falls Dams as well as Nagle Dam located at the lower end of the IUA from where water is abstracted for the eThekwini supply area. Nagle Dam is supported from the upstream dam and the IUA is regarded as highly regulated. There are also a number of small farm and instream dams located in the IUA. There is no surface water development options planned directly in the IUA but the implementation of MMTS2 will have an impact of the water resources.

Small towns such as New Hannover and Wartburg as well as other scattered rural and informal settlements are located in the IUA. The main land use activities in the IUA include extensive forestry and dry land sugar cane.

According to a desktop investigation conducted as part of this study, some volumes of groundwater are utilised in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Natal Group sandstones. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U2-3 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U20F-04224	Mpolweni	Large (3)	High nutrient load.
U20G-04194	Mkabela	Large (3)	High nutrient load; toxics may be present.
U20G-04215	Cramond Stream	Large (3)	High nutrient load; toxics may be present.
U20G-04240	uMngeni	Large (3)	High nutrient load.
U20G-04385	uMngeni	Large (3)	High nutrient load; urban impacts.

Economy: Some commercial cattle farms occur in the area, but the area is mostly rural tribal land.

EGSA: The upper half, which includes Wartburg, has well-developed commercial agriculture and forestry. The utilisation of EGSA is limited to ad hoc consumption by farm workers and some recreational usage. The lower part has relatively high density rural closer settlements. Densities mean that resources are under pressure – particularly just upstream of Nagle Dam. Nevertheless the utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance.

Ecology (rivers and wetlands): The northern tributaries of the uMngeni have a PES of C/D and three tributaries are in a B/C PES. Impacts are primarily flow (consistent high base flows from Albert Falls Dam) and non-flow related with extensive forestry and formal agriculture (sugar cane) present in this area. Some rural areas and townships with associated non-flow (grazing, subsistence farming) and water quality (runoff) related impacts are also present. The main uMngeni is in a B/C due to protection of steep river valleys. The main impacts are dense rural settlements on higher plateaus and on gentle river slopes as well as impacts due to deforestation, agriculture (erosion, sedimentation etc.). The reach in which Nagle Dam is, is in an E PES due to the presence of the dam and the flow related impacts DS of the dam. There are no releases from Nagle Dam.

Low priority wetlands have been noted in the Mpolweni River (U20F-04224) and are mostly valley bottom wetlands.

***IUA rationale*:** The upper border of the IUA is delineated by Albert Falls Dam and the confluence of the uMngeni and uMnsunduze River, just downstream of Nagle Dam is located at the end of the IUA, which is a logical break for the IUA.

3.2.18 IUA U2-4: uMnsunduze

Water resources: The storage regulation in this IUA is low. Henley Dam is located in the upper reaches of the IUA, which is a relatively small dam when compared to the dams located in the uMngeni System, and there are also a number of small farm and instream dams.

A large portion of the IUA is occupied by the greater Pietermaritzburg urban area and there are also a large number of semi-urban and rural settlements. Discharges from the Darvill WWTW (Pietermaritzburg area) enter the uMnsunduze River and affect the flow and especially the water quality of the river. uMngeni Water is currently investigating the potential of re-using effluent from the Darvill WWTW, which could have a future impact on the uMnsunduze River. The possibility of implementing such a project at this stage is uncertain.

The main land use activities in the IUA include extensive forestry and dry land sugar cane.

According to a desktop investigation conducted as part of this study, some volumes of groundwater are utilised for rural supply in the water resources IUA and there is a potential for further groundwater development in the area in the upper reaches underlain by Ecca Group sediments. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U2-4 are shown below.

SQ reach	River name	Water quality impact (rating)	Water quality issues
U20J-04364	uMnsunduze	Serious (4)	Industrial discharges; elevated nutrients and salts.
U20J-04391	uMnsunduze	Critical (5)	WWTW; industrial discharges; elevated nutrients and salts.

SQ reach	River name	Water quality impact (rating)	Water quality issues
U20J-04401	uMnsunduze	Critical (5)	Industrial discharges; elevated nutrients and salts.
U20J-04461	Slang Spruit	Critical (5)	Urban and industrial discharges.
U20J-04488	Mshwati	Large (3)	Urban impacts; nutrient elevations.

Economy: It hosts large timber and sugar cane plantations feeding the saw and sugar mills and includes the urban centre of Pietermaritzburg.

EGSA: This IUA is associated with greater Pietermaritzburg. The upper two thirds are either formal urban or peri-urban, Other than recreational utilisation of some of the rivers (swimming and fishing) there is little in the way of utilisation of the EGSA. The bottom third of the IUA is less densely populated for the first part of the river course but then becomes very densely populated around the Mkhambathini area. The utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance. The Duzi Canoe Marathon (from Pietermaritzburg downstream) also results in high importance for recreation.

Ecology (river and wetlands): Upstream of Henley Dam the PES is a C, with non-flow related impacts (poor water quality, rural settlements, sedimentation, overgrazing, agriculture and alien vegetation). Downstream of Henley Dam through Pietermaritzburg the PES ranges from C to D to E. The E PES is due to poor water quality, canalisation, inundation, instream barriers and high intensity urbanisation. Downstream of the E, the river is impacted by poor water quality, rural settlements, informal agriculture, clearing of vegetation, overgrazing and some erosion.

Valley bottom wetlands have been noted for the following SQs: U20H-04449, U20J-04364, U20J-04452 and U20J-04461. Several wetland clusters, not necessarily associated with the main stream are noted in this zone.

IUA rationale: A large portion of the IUA is occupied by the greater Pietermaritzburg urban area and semi-urban and rural settlements with WWTW discharges. The ecological impacts are similar resulting in rivers being in relatively poor state. The confluence of the uMngeni and uMnsunduze River is located at the end of the IUA, which is a logical break for the IUA.

3.2.19 IUA U2-5: uMngeni downstream of the uMnsunduze Confluence to Inanda Dam

Water resources: The IUA is regulated by the upstream Midmar Dam and Albert Falls Dams, Nagle Dam as well as Inanda Dam located at the lower end of the IUA and is regarded as highly regulated. Abstractions are made from Inanda Dam for supplying water to the eThekwini area and the dam is supported by the upstream dams. The water quality of the uMngeni River reduces after the confluence with the uMnsunduze River. There is no surface water development options planned directly in the IUA but the implementation of MMTS2 will have an impact on the water resources as well as the potential implementation of the Darvill re-use project.

A large portion of the IUA is rural, with scattered rural villages and subsistence farming activities. There are a large number of rural settlements located around the Inanda Dam area.

Areas in the upper reaches of the IUA are covered by extensive cultivation (dryland sugar cane) and forestry.

According to a desktop investigation conducted as part of this study, some volumes of groundwater are utilised for rural supply in the water resources IUA and there is a potential for small scale further groundwater development in the area underlain by the Natal Metamorphic Province. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U2-5 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U20L-04435	uMngeni	Large (3)	Urban impacts; nutrient elevations.

Economy: Mostly rural tribal land.

EGSA: The middle third of the IUA is less densely populated for the first and last parts of the river course in the IUA. Settlement is associated with the former KwaZulu homeland and is mostly communal. The utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance.

Ecology (rivers and wetlands**)*****:*** The SQ reaches in the IUA are in a C and B/C PES. Impacts are flow related (no releases from Nagle Dam) and water quality from the uMnsunduze River. Tributaries are influenced by forestry, dams and agriculture.

Several wetland clusters occur in this zone. Moderate and low priority valley bottom wetlands are noted in the Mqeku (U20k-04411) and uMngeni (U20M-04396) Rivers respectively.

IUA rationale: The land use in the IUA is similar throughout the IUA. The upper border of the IUA is delineated by the confluence of the uMngeni and uMnsunduze River and Inanda Dam is located at the end of the IUA, which is a logical break for the IUA.

3.2.20 IUA U2-6: Downstream of Inanda Dam to Estuary

Water resources: The IUA is regulated by the upstream Midmar, Albert Falls Dams, Nagle and Inanda Dam and is regarded as highly regulated. Inanda Dam is supported by the upstream dams in the uMngeni River and compensation releases are also made from Inanda Dam for environmental purposes. The eThekwini Municipality has conducted a feasibility study for the re-use of treated effluent in the eThekwini metropolitan area. The implementation of the investigated re-use schemes will have an impact on the WWTW return flows entering the river system in the future. The implementation of the upstream MMTS2 as well as the potential implementation of the Darvill re-use project will have an impact on the water resources in the IUA.

A large portion of the IUA is semi urban area and urban in the lower reaches (eThekwini municipal area). There are a number of discharges form WWTW within the eThekwini municipal areas that enter the uMngeni River in the IUA that affect both the flow and the water quality of the river.

According to a desktop investigation conducted as part of this study there is no groundwater use in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Karoo and Natal Group sediments. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: On the high lying areas sugar cane production occurs, interspaced with the expanding urban areas of the eThekwini municipality.

EGSA: This part of the IUA is in the Durban metropolis. This first part is in the uMngeni Gorge and although surrounded by high density peri-urban settlement is relatively protected as it is very inaccessible. The last part is more accessible but given the nature of development (formal urban) the utilisation of EGSA is low. Some fishing in the upper part of the estuary takes place.

Water quality: Water quality hotspots for U2-6 are shown below.

SQ reach	River name	Water quality impact (rating)	Water quality issues
U20M-04396	uMngeni	Serious (4)	Urban impacts; nutrient elevations; aquatic plants in upstream dam so low DO levels; treated effluent coming in from the Piesang in the north (below Inanda). Note the input of the Mhlangane River, which is a hotspot identified by eThekwini MM.
U20M-04639	Palmiet	Large (3)	Elevated nutrients.
U20M-04642	Palmiet	Serious (4)	Elevated nutrients and industrial discharges.
U20M-04653	Palmiet	Large (3)	Elevated nutrients.

Ecology (rivers and wetlands): This IUA includes the uMngeni River downstream of Inanda Dam, as well as the Palmiet River (U20M). The lower uMngeni River is especially in a poor state (E PES) due to the flow regulation by Inanda dam, coupled with extensive urban and industrial areas. The Palmiet River reaches a range between a PES of C and D and the alterations are primarily non-flow and water quality related due to the extensively developed catchment (urban/residential and industrial areas).

Ecology (estuary): The uMngeni Estuary is an E PES. This status has been confirmed through a rapid EWR study recently conducted on the system. Currently it is under moderate flow modification, high pollution, high habitat loss and low fishing pressure. Artificial mouth breaching is also practised in the system.

IUA rationale: This is the remaining portion of the uMngeni River catchment and the upper border of the IUA is delineated by the Inanda Dam. A large portion of the IUA is semi urban area and urban in the lower reaches (eThekwini municipal area) with WWTW discharges which *culminates in an estuary which is in a poor state.*

3.2.21 IUA U3-1: uMdloti upstream of Hazelmere Dam

Water resources: This zone includes all the rivers falling within quaternary catchments U30A (upper uMdloti), U30B (lower uMdloti), U30C (upper uThongathi and Mona Rivers) and U30D (lower uThongathi).

The IUA is regulated by the Hazelmere Dam located at the lower end of the IUA. The raising of Hazelmere Dam has been approved, which will take place in the near future and will have a further impact on river flows downstream of the dam.

There is some dryland sugar cane located in the upper reaches of the IUA. There are a large amount of low density settlements and rural settlements spread throughout the IUA.

According to a desktop investigation conducted as part of this study, minimal volumes of groundwater are utilised for rural supply in the water resources IUA and there is a potential for further groundwater development in the area since is significantly faulted. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U3-1 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U30A-04360	uMdloti	Large (3)	Elevated nutrients and high sediment loads.

Economy: It is an important sugar producing area complimented by commercial forestry and mixed farming.

EGSA: Other than the very top of this IUA, the area consists of land under communal tenure. Population densities are moderate in the upper parts of the IUA but increase in the lower parts of the IUA particularly in the Oakford Priory/Ogunjini area. Utilisation of goods and services (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance.

Ecology (rivers and wetlands): The SQs in the IUA are in a B/C and D PES. The impacts are non-flow related activities (informal settlements with related subsistence agriculture and grazing).

IUA rationale: The land use is similar in the IUA resulting in similar ecological impacts. Hazelmere Dam is located at the end of the IUA which is a logical break for the IUA.

3.2.22 IUA U3-2: uMdloti downstream of Hazelmere

Water resources: The IUA is regulated by the upstream Hazelmere Dam. The raising of Hazelmere Dam has been approved, which will take place in the near future and will have a further impact on river flows in the IUA.

A large portion of the IUA is occupied by urban areas (Verulam) and numerous WWTW discharges enter the Mvoti River from various WWTWs (Phoenix, Umhlanga, temporary WWTW from the King Shaka Airport) affecting both flow and water quality of the river. The eThekwini Municipality has conducted a feasibility study for the re-use of treated effluent in the eThekwini metropolitan area. The implementation of the investigated re-use schemes will have an impact on the WWTW return flows entering the river system in the future. A significant portion of the IUA is also covered by sugar cane (dryland and irrigated). There are also a large amount of low density rural settlements spread throughout the IUA.

According to a desktop investigation conducted as part of this study there is no groundwater use in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Karoo and Natal Group sediments. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U3-2 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U30B-04465	Black Mhlashini	Large (3)	Elevated nutrients.
U30B-04475	uMdloti	Critical (5)	Elevated nutrients and blue-green algae; WWTW. Identified by eThekwini MM as a hotspot.
U30B-04498	Ohlanga	Critical (5)	Elevated nutrients; WWTW.

Economy: It is an important sugar producing area complimented by commercial forestry and mixed farming. Two sugar mills operate in the catchment. It is also an important tourism destination.

EGSA: This IUA is dominated by the formal urban development associated with Verulam and surrounds. There is a belt of commercial farming development downstream of Verulam but upstream of the coastal town on uuMdloti. Other than recreational utilisation of some of the river, swimming and fishing in particular, above the estuaries there is little in the way of utilisation of the EGSA in this part of the IUA

Ecology (rivers and wetlands): The River downstream of Hazelmere Dam is in a D PES. The tributary is in a B/C PES. Non-flow related activities (informal settlements with related subsistence agriculture and grazing).

High priority wetlands have been noted for both the uMdloti (U30B-04475) and Ohlanga (U30B-04498) Rivers. These are mainly floodplain and channelled valley bottom wetlands with coastal estuaries and are generally in a C PES (excludes estuaries). The Black Mhlashini (U30B-04465) has been noted for low priority wetlands.

Ecology (estuary): Both the uMdloti and the Mhlanga estuaries are in a D PES. This status has been confirmed through more detailed EWR studies. The uMdloti is under low flow modification and high pollution and habitat loss pressure. The Mhlanga Estuary is under moderate flow modification, high pollution and moderate habitat loss pressure. Unofficially, artificial mouth-breaching may be practised in these systems.

IUA rationale: This is the remaining portion of the uMdloti River catchment. The land use is in the IUA is similar i.e. predominantly urban with WWTW discharges. The upper border of the IUA is delineated by the Hazelmere Dam. The IUA ends with the uMdloti and Mhlanga estuaries, which are both in a poor state.

3.2.23 IUA U3-3: uThongathi

Water resources: The IUA is regulated by the Dudley Pringle Dam. There is no surface water resource developments planned in the IUA area.

There are a large amount of low density settlements and rural settlements spread throughout the IUA. The uThongathi town and industries are located in the IUA area discharges from the uThongathi WWTW enter the uThongathi River affecting both flow and water quality of the river. The area is predominantly a sugar cane farming area with most of the IUA covered with dry land sugar cane plantations.

According to a desktop investigation conducted as part of this study, minimal volumes of groundwater are utilised and there is some potential for groundwater development since it is largely underlain by faulted Natal Group sediments. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U3-3 are shown below.

SQ reach	River name	Water quality impact (rating)	Water quality issues
U30D-04315	uThongathi	Large (3)	Elevated nutrients and fertilizers; industrial discharges.

Economy: The main economic activities consist of the production of the primary sector, which includes dryland sugar cane and forestry plantations.

EGSA: The bulk is given over to land under communal tenure. Population densities are moderate in the upper parts of the IUA but increase in the lower parts of the IUA particularly in the area around the town of uThongathi. The profile of the population in this small part of the IUA is such that utilisation of goods and services (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. The town of uThongathi and surrounds is in the lower third of the IUA. There is a belt of commercial farming between uThongathi and the coast. Recreational utilisation of some of the river (swimming and fishing) above the estuaries is of importance

Ecology (rivers and wetlands): The SQ in the IUA is in a B/C PES. Only the two upper SQs were evaluated as the lower uThongathi is represented by the estuary (E PES). The impacts in the two SQs related to non-flow related activities (informal settlements with related subsistence agriculture and grazing).

The uThongathi (U30D-04315) SQ has been noted for low priority wetlands.

Ecology (estuary): The uThongathi Estuary is an E PES. This status has been confirmed through an Intermediate EWR study recently conducted on the system. It is under flow modification, high pollution and habitat loss pressure. Unofficially, artificial mouth-breaching may be practised in this system. It is of moderate importance from a biodiversity perspective. The uThongathi Estuary is highly sensitive to modification in baseflow as it influences the mouth state.

IUA rationale: There was no reason for delineation of the uThongathi River catchment into separate IUAs as the ecological state and land use is similar. Water quality problems are an issue in the IUA.

3.2.24 IUA U4-1: Mvoti Upper Reaches

Water resources: The main river is the Mvoti and the Heinespruit, Intinda, Mvozana and Khamanzi Rivers form its tributaries.

The storage regulation in this IUA is low and the only dams in the area include a number of small farm and instream dams. The dams are of such nature that no releases are made for downstream users. The Greytown town is located in the upper reaches of the IUA and the discharges from the towns WWTW enter the river system, affecting both the flow and water quality of the river system. The Mvoti Poort Dam site is located at the lower end of the IUA. There is however a more favourable dam site lower down in the Mvoti River System (IsiThunda Dam Site), which is likely to be developed first.

The main land use activities in the IUA include extensive forestry and a significant amount sugar cane plantations and irrigation (sugar cane, maize etc.) also occur. There are also a few low density settlements and rural settlements located in the lower reaches.

According to a desktop investigation conducted as part of this study there are insignificant volumes of groundwater utilised in the water resources IUA and there is a potential for further groundwater development in the area in areas underlain by faulted Natal Group sandstones, and limited potential in the Pietermaritzburg shales. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U4-1 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U40B-03770	Heinespruit	Serious (4)	Pesticides and nutrients; WWTW.
U40B-03832	Mvozana	Large (3)	Elevated nutrients and salts.

Economy: It is an important sugar producing area complimented by commercial forestry and mixed farming with the town Greytown in this area. Two sugar mills operate in the area and a wattle bark processing plant.

EGSA: This is almost exclusively forestry and commercial farming. The utilisation of EGSA is limited to ad hoc consumption by farm workers and some recreational usage. The town of Greytown is included.

Ecology (rivers and wetlands): Most SQs are in a C and B/C PES, with only the Mvozana a C/D PES. Impacts are predominantly non-flow related such as forestry, agriculture (vegetation and wetland removal), overgrazing, erosion, aquatic alien macrophytes and dams. The Heinespruit passes close to Greytown which influences the water quality. Some irrigation and centre pivots are also prevalent.

The Mvoti River (U40A-03869) has high priority wetlands, notably the Mvoti Vlei (within the Mvoti Vlei Nature Reserve), but several other channelled valley bottom wetlands, seeps and meandering floodplains (with oxbows) occur. These wetlands are degraded by agriculture or floodplain manipulation (PES C). The Khamanzi (U40C-03982) is noted for low priority wetlands, mainly valley bottom wetlands in the tributaries which have an average PES of C.

IUA rationale: A similar range of land use activities in the IUA result in similar ecological impacts. The lower border is due to the change in land use and in the topography.

3.2.25 IUA U4-2: Mvoti Middle Reaches

Water resources: This zone includes the Mvoti River from U40D-03957 down to U40E-03985 and includes the Mtize, Faye, Sikoto and Hlimbitwa (including its headwater tributaries) Rivers. The confluence of the Mvoti and Hlimbitwa Rivers is the site of the proposed IsiThunda Dam.

The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. The dams are of such nature that no releases are made for downstream users. The IsiThunda Dam site is located at the lower end of the IUA, which is the most favourable dam site for development in the Mvoti River catchment, with a high likelihood of is being developed in the short to medium term. The main land use in the IUA is extensive forestry and sugar cane (dryland and irrigated).

According to a desktop investigation conducted as part of this study, some groundwater is utilised by rural villages in the water resources IUA and there is a limited potential for further groundwater development in the area as it is underlain by faulted Natal Group Sandstones and Natal Metamorphic Province rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Economy: Some sugar cane production with a number of rural tribal areas.

EGSA: Almost the entire IUA is given over to the former homeland. The EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Population densities in this part of IUA are generally lower and much of the area is sparse rural and steeply incised valleys making the river and its resources difficult to access

Ecology (rivers and wetlands): The SQ reaches are in a B or B/C PES. Much of the Mvoti flows through a gorge and is highly confined. Predominant impacts are non-flow related: Mostly overgrazing, informal agriculture and some erosion. The Hlimbitwa and tributaries upstream of U40G-03843 are mostly C PES with the main impacts being forestry, overgrazing and instream dams.

No priority wetlands were noted in the zone, although many seeps occur in the U40F.

IUA rationale: The change in land use and topography resulted in this IUA. The lower border of the IUA is delineated by the proposed IsiThunda Dam site. A similar range of land use activities in the IUA result in similar ecological impacts. The change in land use and topography, i.e. start of the gorge zone resulted in this IUA.

3.2.26 IUA U4-3: Mvoti Lower Reaches

Water resources: This zone includes the Mvoti from U40H-04064 to the coast and includes the Nsuze and Pambela tributaries.

The storage regulation in this IUA is low but could however be impacted by future surface water resource developments planned upstream in the catchment i.e. the development of IsiThunda Dam. The town KwaDukuza (Stanger) is located in the lower end of the IUA and water is abstracted directly from the Mvoti River (run of river abstraction) for supplying the town, which affects the downstream river flow.

There is some dryland sugar cane and subsistence farming occurring in the area and there are a vast amount of low density and rural settlements located throughout the IUA.

According to a desktop investigation conducted as part of this study, some groundwater is utilised by rural villages in the water resources IUA and there is a potential for further groundwater development in the area, especially in the faulted sediments in the lower reaches. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for U4-3 are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U40H-04064	Mvoti	Large (3)	Discharge from agriculture, urban and industrial areas.
U40J-03998	Mvoti	Large (3), esp. around KwaDukuzu	Sugar (Illovo) and paper mill effluents; WWTW so elevated nutrients; high turbidity levels; urban impacts (Stanger).

Economy: There is mostly sugar cane production with one sugar mill operating in the area which constitutes the main economic activity.

EGSA: The bulk of this IUA consists of the former KwaZulu homeland. Utilisation of EGSA (fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing) is of high importance. Population densities in this part of IUA increase with proximity to the coast. There are pockets of very high density development in and around the town of Stanger and KwaDukuza. Commercial farming, mostly sugar cane is found in the coastal belts. The utilisation of EGSA here is limited to ad hoc consumption by farm workers and some recreational usage.

Ecology (rivers and wetlands): The SQs are in a B/C and C PES. Main impacts are non-flow related, especially sedimentation, overgrazing, trampling and vegetation removal. The last section of the Mvoti (U40J-03998) consists mainly of subsistence farming, dryland sugar cane, road crossings, sand mining and residential in the lower reach until the estuary.

Several narrow channelled valley bottom wetlands were noted as very high priority.

Ecology (estuary): The Mvoti Estuary is a B PES. Currently it is under moderate flow modification, high pollution and moderate habitat loss pressure. Artificial mouth-breaching is practised in the system. It is of average importance from a biodiversity perspective. The estuary also forms part of the national priority set identified under the National Estuaries Biodiversity Plan (Turpie *et al*., 2012). The estuary shows sensitivity to a reduction in baseflow. This catchment plays an important role in providing nutrients and sediments to the near-shore marine environment.

IUA rationale: The upper border of the proposed IsiThunda Dam site and the IUA represents the remainder of the Mvoti River catchment and there were no reasons for a finer delineation.

3.2.27 IUA SC: Southern Coastal

It was deemed appropriate to subdivide the Southern Coastal Cluster further into two IUAs, north and south of the Umzimkulu River (see SC1 and SC 2 in Error! Reference source not found.). The motivation for this subdivision was to distinguish between the southern estuaries (SC 2) where there are lower intensity development while the northern part (SC 1) that is generally more developed as it is close to the highly developed Central Cluster (eThekwini Metropolitan Area). Table 3.1 provides the SC 1 and SC 2 estuaries. The estuaries shown in red text is affected by wastewater discharges.

Table 3.1 Estuaries and IUAs

No:	Estuary Name	Estuary Area (ha)	No:	Estuary Name	Estuary Area (ha)
Estuaries falling within SC 1					
1	Mtamvuma	54.1	11	Mvuthsini	0.6
2	Zolwane	0.4	12	Bilanhlolo	2.0
3	Sandhlunlu	4.7	13	Uvuzana	0.4
4	Ku-Boyoyi	0.7	14	Kongweni	1.5
5	Tongazi	0.7	15	Vungu	0.3
6	Kandanhlovu	1.3	16	Mhlangeni	5.9
7	Mpenjati	14.9	17	Zotsha	8.5
8	Umhlangankulu	5.6	18	Boboyi	1.8
9	Kaba	2.4	19	Mbango	0.4
10	Mbizana	13.4	20	Umzimkulu	107
Estuaries falling within SC 2					
21	uMthente	7.8	32	Mtwalume	5
22	Mhlangamkulu	2.8	33	Mvuzi	0.9
23	Damba	3.6	34	Fafa	14.3
24	Koshwana	1	35	Mdesingane	0.2
25	Intshambili	0.7	36	Sezela	6.6
26	Mzumbe	6.7	37	Mkumbane	1.1
27	Mhlabatshane	3.0	38	uMuziwezinto	5.8
28	Mhlungwa	5.9	39	Nkomba	0.1
29	Mfazazana	1.1	40	Mzimayi	0.5
30	Kwa-Makozi	2.5	41	Mpambanyoni	2.9
31	Mnamfu	1.3			

The status quo for all the different components are described for the Southern Cluster IUA as a whole and no distinction has been made between SC 1 and SC 2.

Water resources: These include the coastal strips and immediate hinterland associated with Port Edward, Leisure Crest, Palm Beach, Southbroom, Ramsgate, Margate, Shelly Beach Oslo Beach, South Port, Pumula, Hibberdene, Bazeley Beach, Pennington, Park Rynie, and Palmcliffe. The storage regulation in this IUA is low and the only dams in the area include a number of small farm dams in tributaries and a few Instream dams. There is no surface water developments planned in the IUA.

Landuse activities in the water resources IUAs generally include cultivation (mostly sugar cane with some orchards) and some forestry plantations slightly inland. Rural settlements are usually located more inland with semi-urban and urban areas towards the coast. Return flows from a number of WWTW enter river systems affecting both the flow and quality of the river system.

According to a desktop investigation conducted as part of this study, groundwater is utilised for rural supply in the water resources IUA and there is a limited potential for further groundwater development in the area since it is largely underlain by low permeability Dwyka tillites and Natal Metamorphic Province rocks. An exception may be the karstic rocks of the Mzimkulu Formation of the Natal Metamorphic Province in the vicinity of Umzimkulu. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for SC are shown below.

SQ reach	River name	Water quality impact (rating)	Water quality issues
U80H-5109	uMuziwezinto	Serious (4)	Elevated nutrients; possible impact of WWTW.
U80H-5120	Mzimayi	Large (3)	Possible impact of WWTW in Umzinto; low confidence.
U80L-5056	Mahlongwana	Large (3)	Elevated nutrients.

Economy: Port Shepstone is the largest coastal town on the South Coast with a sugar cane mill, forestry production and a beverage producing facility. The surrounding coastal area is also a very popular holiday area with a number of holiday resorts.

EGSA: The coastal stretch is heavily developed and other than recreational utilisation of the river (swimming and fishing) above the estuary there is little in the way of utilisation of the EGSA. Also included in this section are scattered pockets of commercial farming enterprises (low EGSA). The coastal and hinterland areas associated with the old KwaZulu homeland are densely populated and EGSA utilisation is high. Densities mean that resources are under pressure. Nevertheless the utilisation of fish, wood for fuel, building and handicrafts, medicinal plants, and riparian grazing is of high importance.

Ecology (rivers and wetlands*)*: The uMuziwezinto River is in a D PES. Extensive sugar cane farming, in addition to other developments in the catchment is present. The Mpambanyoni system (U80J and U80K) is in a B, B/C and C PES. Impacts are forestry on the upper catchments, with rural developments and associated cultivation, as well as in-stream weirs downstream. The Fafa River system (U80G) is in a C PES mainly due to rural developments, plantations and an in-stream weir. Low priority wetlands have been noted on the Fafa (U80G-05097), uMuziwezinto (U80H-05109) and Mpambanyoni (U80K-04952) Rivers. These consist of small to narrow patches of both channelled and unchannelled valley bottom wetlands.

The lower density in human settlement in the Mbizana (T4) River has resulted in a B PES. The higher density of rural settlements, sugar cane farming, an in-stream dam, WWTW and quarries close to the river, places the Vungu (T4) River in a B/C PES. No wetlands of any importance were noted.

Ecology (estuary): The remaining thirty seven estuaries form this cluster of which the majority is in a B to C/D PES with two D and one D/E and one E PES. Most of the systems are subject to low flow modification pressure but under moderate to high pollution and habitat loss pressures. Artificial mouth breaching is also practised in some of the systems. All temporarily open/closed estuaries are highly sensitive to modification in baseflow as it influences their mouth state.

IUA rationale: This IUA consists of a range of short coastal rivers. The impacts on especially the estuaries are very similar and these estuaries and rivers form a logical grouping in an IUA.

3.2.28 IUA CC: Coastal Cluster

Water resources: The storage regulation in this IUA is low and the only dams in the area include one or two small Instream dams. There is no surface water developments planned in the IUA.

The area is predominantly urban with some semi-urban and rural settlements. Return flows from a number of WWTW enter river systems affecting both the flow and quality of the river system.

According to a desktop investigation conducted as part of this study, small volumes of groundwater are utilised for rural supply in the water resources IUA and there is a potential for further groundwater development in the area since it is underlain by faulted Natal Group rocks. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for CC are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U60F-4597	Mhlatuzana	Critical (5)	Urban and industrial effluents, so high nutrient and salt load.
U60F-4632	Umbilo	Critical (5)	Urban and industrial effluents, so high nutrient and salt load.

Economy: eThekwini metropolitan covers most of the area with holiday accommodation along the coast. On the southern areas sugar cane plantations and commercial forestry is also present.

EGSA: This includes the informal and formal urban developments of Umgababa, Winkelspuit, Kingsborough, Manzimtoti, and the greater Durban metropolis. This part is heavily developed and other than recreational utilisation of some of the rivers (swimming and fishing) above the estuary there is little in the way of utilisation of the EGSA. There may be some grazing of riverine grasses but overall, given the state of the rivers, would be marginal.

Ecology (Rivers and Wetlands): Four coastal rivers in the U7 (Lovu) were evaluated and are in a C PES. The impacts are rural settlement with extensive high density townships, with associated activities (informal agriculture and some sugar cane).

The Mhlatuzana and Umbilo Rivers in U60F upstream of Durban harbour are highly developed with many residential, rural and industrial areas. Main impacts are non-flow related with poor water quality, trampling, sedimentation, alien vegetation and vegetation removal resulting in a PES of D and D/E for the Umbilo and Mhlatuzana respectively.

Ecology (estuary): Sixteen estuaries form the Central Coastal cluster of which one is in a B PES (Msimbazi), five are in a C PES (Amahlongwa, Mahlangwana, uMkhomazi, Ngane, Umgababa), one in a C/D (Lovu), three in a D PES (Umhlanga, uMdloti, uThongathi), and the rest of the estuaries falling below a D EC (Little Manzimtoti, Manzimtoti, Mbokodweni, Sipingo, Durban Bay and uMngeni). Sipingo and Durban Bay are impacted by significant structural changes as well as water quality issues. Pressures in the other estuaries relate to water quality issues, which can be either storm water related (from upstream catchment) and / or discharges from WWTW. Other issues are non flow-related and often relates to degradation of estuarine habitat.

IUA rationale: This IUA consists of a range of short coastal rivers originating within the coastal quaternary with similar land use (predominantly urban and semi-urban). The impacts on especially the estuaries are very similar and these estuaries and rivers form a logical grouping in an IUA.

3.2.29 IUA NCC: Northern Coastal Cluster

Water resources: The storage regulation in this IUA is low and the only dams in the area include one or two small Instream dams.

The area is predominantly a sugar cane farming area with most of the IUA covered with dry land sugar cane plantations. There are a few small coastal towns, some slightly inland and a few rural villages. Return flows from WWTW enter river systems in one or two cases.

According to a desktop investigation conducted as part of this study, some groundwater is utilised by a municipality and rural villages in the water resources IUA and there is a potential for further groundwater development in the faulted Karoo sediments. The locality of the groundwater resources relative to potential users and the viability for development however needs to be confirmed.

Water quality: Water quality hotspots for NCC are shown below.

SQ reach	River	Water quality impact (rating)	Water quality issues
U30E-04207	Mhlali	Large (3)	Elevated nutrients; WWTW discharges.

Economy: On the coastal side there are large sugar production estates and well as forestry production and a number of holiday resorts.

EGSA: The southern part of this IUA is the Mhlali River. The very upper part of the IUA is given over to the former KwaZulu Homeland. The profile of the population in this small part of the IUA is such that utilisation of goods and services (fish, wood for fuel, building and handicrafts, medicinal plants) is of high importance.

Ecology (rivers and wetlands): This ecological zone includes all the coastal rivers falling in secondary catchment U5 (U50A, B/C PES) as well as sub-quaternary reach U30E-4207 (C PES). The three U5 rivers (Zinkwazi, Nonoti and Mdlotane) and the U3E (uMhlali) are all subjected to similar land use activities of which the dominant activity is dry land formal agriculture (sugar cane). The impacts are therefore flow related, non-flow related (agriculture and settlements) as well as water quality related (agricultural and township runoff, WWTW effluents).

Low priority wetlands (mainly unchannelled valley bottom wetlands) are noted in the Nonoti River but are reduced in extent by sugar cane fields (D PES).

Ecology (estuary): Seven estuaries form this cluster, of which one is in a B (Mdlotane); two in a B/C (Bobs Stream, Seteni); one in a C PES (Nonoti); one in a C/D (uMhlali) and the Mvoti Estuary which is in a D Category. The majority of the systems are under low to moderate flow, pollution and habitat loss pressure. Unofficially, artificial mouth breaching is also practised in some of these systems.

IUA rationale: This IUA consists of a range of short coastal rivers originating within the coastal quaternary with similar land use (predominantly sugar cane farming with small coastal towns and WWTW discharges in some cases*)*. The impacts on especially the estuaries are very similar and these estuaries and rivers form a logical grouping in an IUA.

4 HOTSPOT IDENTIFICATION

This chapter is an extract from the following reports:
Department of Water Affairs (DWA), South Africa. 2013a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Status quo assessment, IUA delineation and biophysical node identification. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. July 2013. DWA Report: RDM/WMA11/00/CON/CLA/0113.

Department of Water Affairs (DWA), South Africa. 2013b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Desktop Estuary EcoClassification and Ecological Water Requirement. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. June 2013. DWA Report: RDM/WMA11/00/CON/CLA/0313.

4.1 BACKGROUND

The hotspot represents a river reach with a high Integrated Environmental Importance which could be under threat due to its importance for water resource use. The hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future (Louw and Huggins, 2007; Louw *et al.,* 2010).

Hotspots are areas with high Integrated Environmental Importance (IEI) and high Water Resource Use Importance (WRUI). IEI considers PES, Ecological Importance and Sensitivity (EIS), Freshwater Ecosystem Priority Area (FEPAs) (Table 4.1) and Socio-Cultural Importance (SCI).

4.2 IMPORTANCE

4.2.1 NFEPAs

The SQs with associated NFEPAs (Nel, *et al*., 2011), specifically FEPAs are listed and verified in Table 4.1.

Table 4.1 FEPA verification based on PES data and fish information

IUA	SQ	River	PES	EI	Veri-fication	FEPA comment
T4-1	T40C-05510	Mtamvuna	B/C	2.8	×	FEPA fish spp. listed is *Barbus anoplus* (BANO): Based on PESEIS (2012) and Frequency of Occurrence (FROC) (2007), this spp. Is absent in SQ.
T4-1	T40C-05520	Mtamvuna	B/C	2.9	×	
T4-1	T40C-05530	Mtamvuna	B	2.7	×	
T4-1	T40C-05566	Ludeke	B	2.7	×	
T4-1	T40D-05537	Mtamvuna	B	2.8	×	
T4-1	T40D-05584	Mtamvuna	B	2.9	×	
T4-1	T40D-05615	Tungwana	B	2.9	×	
T4-1	T40D-05643	Gwala	B	3	×	
T4-1	T40D-05707	Mtamvuna	C	2.8	×	In a C PES, therefore does not qualify.
T4-1	T40D-05719	Londobezi	B	2.9	✓?	Qualifies for FEPA based on B PES.
T4-1	T40E-05601	Mtamvuna	B/C	3.7	✓?	Marginally qualifies for FEPA - B/C PES.
T4-1	T40E-05767	Hlolweni	B/C	3.5	✓?	Marginally qualifies for FEPA - B/C PES.
T5-1	T51A-04431	Umzimkulu	B	3.4	×	In a B PES, but fish reasoning based on common fish.
T5-1	T51A-04522	Mzimude	B	3.5	×	In a B PES, but fish reasoning based on common fish.

IUA	SQ	River	PES	EI	Veri-fication	FEPA comment
T5-1	T51A-04608		B	3.5	✗	In a B PES, but fish reasoning based on common fish.
T5-1	T51A-04551	Mzimude	B/C	3.2	✗	In a B/C PES, but fish reasoning based on common fish.
T5-1	T51F-04566	Boesmans	A	3.4	✗	In an A PES, but fish reasoning based on common fish.
T5-1	T51F-04674		C	3.5	✗	In a C PES, therefore does not qualify.
T5-1	T51G-04722	Ndawana	C	3.2	✗	In a C PES, therefore does not qualify.
T5-2	T51F-04611	Ngwangwane	A	3.5	✗	In an A PES, but fish reasoning based on common fish.
T5-2	T51F-04605	Ngwangwane	B/C	3.5	✗	In a B/C PES, but fish reasoning based on common fish.
T5-2	T51F-04621	Ngwangwane	B/C	2.9	✗	In a B/C PES, but fish reasoning based on common fish.
T5-2	T51G-04751		B	2.9	✓?	Uncertain about FEPA classification although river condition in B, no important fish spp. indicated and uncertain about FEPA rationale.
T5-2	T51J-04747	Ngwangwane	C	3.3	✗	In a C PES, therefore does not qualify.
T5-2	T52A-04690	Umzimkulu	C	3.6	✗	In a C PES, therefore does not qualify.
T5-2	T52C-04880		C	3.2	✗	In a C PES, therefore does not qualify.
T5-2	T52C-04960	Umzimkulu	B	3.3	✗	In a B PES, but fish reasoning is based on common fish.
T5-2	T52E-05053	Upper Bisi	B/C	3.5	✗	In a B/C PES, but fish reasoning is based on common fish.
T5-2	T52K-05353	Mzimkhulwana	C	3.3	✗	In a C PES, therefore does not qualify.
T5-3	T52D-05155	Umzimkulu	B	3.7	✓?	Uncertain about FEPA classification although river condition in B , no important fish spp. indicated and uncertain about FEPA rationale.
T5-3	T52H-05189	Bisi	B	3.5	✓?	Uncertain about FEPA classification although river condition in B, no important fish spp. indicated and uncertain about FEPA rationale.
T5-3	T52J-05276	Umzimkulu	B	4.5	✓?	Uncertain about FEPA classification although river condition in B, no important fish spp. indicated and uncertain about FEPA rationale.
U8-2	U80E-05028	Mtwalume	C	3.6	✗	In a C PES, therefore does not qualify
U1-2	U10A-04115	Lotheni	A/B	3.3	✗	A/B PES, but fish reasoning based on common sp.
U1-2	U10A-04202	Nhlathimbe	B	3.0	✗	B PES, but fish reasoning based on common sp.
U1-2	U10A-04301	Lotheni	B	3.0	✗	B PES, but fish reasoning based on common sp.
U1-2	U10B-04239	uMkhomazi	B	3.1	✗	B PES, but fish reasoning based on common sp.
U1-2	U10B-04337	uMkhomazi	B	3.0	✗	B PES, but fish reasoning based on common sp.
U1-2	U10B-04343	Mqatsheni	B	2.9	✗	B PES, but fish reasoning based on common sp.
U1-2	U10C-04347	Mkhomazana	B	3.6	✗	B PES, but fish reasoning based on common sp.
U1-2	U10D-04298	Nzinga	B/C	3.5	✗	B/C PES, but fish reasoning based on common sp.
U1-2	U10D-04349	uMkhomazi	B/C	3.5	✗	B/C PES, but fish reasoning based on common sp.
U1-2	U10D-04434	uMkhomazi	B/C	3.5	✗	B/C PES, but fish reasoning based on common sp.
U1-2	U10E-04380	uMkhomazi	C	3.5	✗	In a C PES, therefore does not qualify.
U1-2	U10F-04528	uMkhomazi	B/C	3.5	✗	B/C PES, but fish reasoning based on common sp.
U1-3	U10J-04679	uMkhomazi	B	3.8	✗	B/C PES, but fish reasoning based on common sp.
U1-4	U10J-04799	uMkhomazi	C	3.5	✗	In a C PES, therefore does not qualify.
U1-4	U10J-04833	uMkhomazi	B/C	3.5	✓?	Agree on FEPA based on river condition B/C - however no important fish spp. indicated and uncertain about FEPA rationale.
U1-4	U10J-04837		A/B	3.7	✓?	Agree on FEPA based on river condition A/B - however no important fish spp. indicated and uncertain about FEPA rationale.
U1-4	U10K-04838	uMkhomazi	B/C	3.0	✓?	Agree on FEPA based on river condition B/C - however no important fish spp. indicated and uncertain about FEPA rationale.
CC	U70E-04974	uMgababa	C	3.6	✗	In a C PES, therefore does not qualify.
U6-1	U60C-04613	Wekeweke	C	3.3	✗	In a C PES, therefore does not qualify.
U2-1	U20A-04253	uMngeni	B/C	3.7	✗	B/C PES, but fish reasoning based on common sp.

IUA	SQ	River	PES	EI	Veri-fication	FEPA comment
U2-1	U20B-04074	Ndiza	B/C	3.5	×	B/C PES, but fish reasoning based on common sp.
U2-1	U20B-04144	Mpofana	C	3.3	×	In a C PES, therefore does not qualify.
U2-1	U20B-04173	Lions	C	3.7	×	In a C PES, therefore does not qualify.
U2-1	U20B-04185	Lions	B/C	3.5	×	B/C PES, but fish reasoning based on common sp.
U2-1	U20C-04332	Gqishi	B/C	3.5	✓?	Agree on FEPA based on river condition B/C - however no important fish spp. indicated and uncertain about FEPA rationale.
U2-2	U20D-04029	Yarrow	B/C	3.5	×	In a B/C, but fish reasoning is based on common fish.
U2-2	U20D-04032	Karkloof	C	3.2	×	Disagree with FEPA classification, C/D - river condition
U2-2	U20D-04151	Karkloof	B/C	3.5	×	B/C PES, but fish reasoning based on common sp.
U2-3	U20F-04095	Mpolweni	C/D	3.2	×	In a C/D PES, therefore does not qualify.
U2-3	U20G-04194	Mkabela	C/D	3.2	×	In a C/D PES, therefore does not qualify.
U2-5	U20K-04181	Mqeku	C	3.1	×	In a C PES, therefore does not qualify.
U2-5	U20K-04296	Tholeni	C	3.6	×	In a C PES, therefore does not qualify
U3-1	U30A-04360	uMdloti	D	3.2	×	In a D PES, therefore does not qualify.
U3-1	U30A-04363	Mwangala	B/C	3.8	✓?	Agree on FEPA based on river condition B/C - however no important fish spp. indicated and uncertain about FEPA rationale.
U4-1	U40A-03869	Mvoti	B/C	3.8	×	B/C PES, but fish reasoning based on common sp.
U4-1	U40B-03832	Mvozana	C/D	2.9	×	In a C/D PES, therefore does not qualify.
U4-1	U40D-03867	Mvoti	B/C	3.5	✓?	Agree on FEPA based on river condition B/C - however no important fish spp. indicated and uncertain about FEPA rationale.
U4-2	U40D-03908	Mtize	B	3.4	✓?	Agree on FEPA based on river condition B - no important fish spp. indicated and uncertain about FEPA rationale.
U4-2	U40D-03957	Mvoti	B	3.4	✓?	Agree on FEPA based on river condition B - no important fish spp. indicated and uncertain about FEPA rationale.
U4-2	U40F-03690	Potspruit	C	2.8	×	In a C PES, therefore does not qualify.

4.2.2 River Ecological Importance and Sensitivity results

The results are available from the PESEIS study (DWS, 2014a). No review or adjustments have been made to these results during this study and they have been taken as is. The number of HIGH or VERY HIGH (≥ 3.5) Ecological Important areas is provided per IUA (Table 4.2). The pink shading shows any IUA with 70% or higher HIGH EI SQs

Table 4.2 Number of High scoring SQs for Ecological Importance per IUA

IUA	Number of SQs	Number of HIGH (≥3.5) SQs	% of HIGH (≥3.5) SQs
T4-1	20	4	20
T5-1	10	1	10
T5-2	39	9	23
T5-3	5	3	60
U8-1	4	4	100
U8-2	4	3	75
SC	10	7	70
U1-1	14	4	29
U1-2	6	4	67
U1-3	9	8	89
U1-4	10	6	60
U7-1	10	1	10
U6-1	6	1	17
U6-2	1	0	0

IUA	Number of SQs	Number of HIGH (≥3.5) SQs	% of HIGH (≥3.5) SQs
U6-3	2	2	100
CC	2	1	50
U2-1	9	6	67
U2-2	10	3	30
U2-3	9	1	11
U2-4	9	4	44
U2-5	4	3	75
U2-6	8	0	0
NC	4	4	100
U3-1	3	2	67
U3-2	1	0	0
U3-3	2	1	50
U4-1	8	3	38
U4-2	14	5	36
U4-3	5	4	80

4.2.3 Estuary importance results

The importance of estuaries for various importance criteria is listed in Table 4.3. Estuaries with an overall importance of 4 and 5 are listed below.

Table 4.3 The Recommended Ecological Category (REC) for the estuaries of Mvoti to Umzimkulu WMA

Estuary	National Importance		Regional Importance			Overall importance
	Biodiversity	Conservation	Macro-phytes	Fish	Birds	
Mtamvuna	4	5	3	4	2	5
Mpenjati	3	5	1	3	1	5
Zotsha	3	5		3		5
Umzimkulu	4	5	5	3	1	5
Mhlangamkulu	1	1	4	3		4
Damba	2	5	3	3		5
Koshwana	2	5		3		5
Intshambili	2	5	1	3	1	5
Mhlabatshane	2	5	3	3		5
Mfazazana	3	5		3		5
Kwa-Makosi	3	5	1	3		5
Fafa	4	1	3	4	1	4
Mahlongwa	2	5		3		5
Mahlongwana	3	5	4	3		5
uMkhomazi	4	5	5	4	3	5
Umgababa	3	5	4	4		5
Msimbazi	3	5	1	3	2	5
Lovu	3	5		3	1	5
Sipingo	3	1	5	3	1	5
Durban Bay	5	5	5	4	5	5
uMngeni	4	5	5	4	4	5
Mhlanga	4	5	1	4	2	5
uMdloti	4	1	3	4	2	4
uThongathi	4	1		3	2	4

Estuary	National Importance		Regional Importance			Overall importance
	Biodiversity	Conservation	Macro-phytes	Fish	Birds	
Mhlali	4	5	2	4	3	5
Mvoti	3	5		3	3	5
Mdlotane	4	5	5	4	1	5
Zinkwasi	4	5	5	3	2	5

4.2.4 SCI results

The following river SQs, as set out in Table 4.4 below, scored “High”. There were no scores in the “Very High” range. The bulk of those scoring HIGH did so either because of the recreation and aesthetic value associated with the Drakensberg or the high dependence on resources associated with poor and vulnerable communities located within the SQ.

Table 4.4 HIGH scoring SCI SQs

SQ	River	SCI score
U10C-04347	Mkhomazana	3.5
U20K-04296	Tholeni	3.6
U20M-04396	uMngeni	3.4
U30A-04228	uMdloti	3.1
U30A-04363	Mwangala	3.1
U30C-04227	uThongathi	3.1
U30C-04272	Mona	3.6
U60E-4795	Bivane	3.0
U70D-4905	Lovu	3.5
U70E-4942	Lovu	3.5
T51C-04582	Umzimkulu	3.2
T51E-04536	Polela	3.0
T51F-04566	Boesmans	3.0
T51F-04611	Ngwangwane	3.0
T51H-04808	Gungununu	3.4
T52K-05467	Mzimkhulwana	3.1

Table 4.5 provides the estuaries that scored High.

Table 4.5 Overall SCI scores for the Mvoti to Umzimkulu WMA estuaries

Name	Ritual Use (0 - 5)	Aesthetic (0 - 5)	Resource Dependence (0 - 5)	Recreational Use (0 - 5)	Historical/ Cultural (0 - 5)	Ecosystem Services Score
Kongweni	3	4	3	5	3	**3.42**
Mhlabatshane	3	4	3	4	3	**3.25**
Mhlungwa	4	2	2	4	4	**3.16**
Mfazazana	4	2	2	4	4	**3.16**
Kwa-Makosi	4	2	2	4	4	**3.16**
Mnamfu	4	2	2	4	4	**3.16**
uMngeni	4	4	3	5	4	**3.82**
Mhlanga	3	4	3	4	3	**3.25**

4.2.5 Integrated Environmental Importance results

These results are similar to the Ecological Importance results provided in the tables above.

4.3 WATER RESOURCE USE IMPORTANCE

The WRUI was assessed by assigning a qualitative score to a river reach for four variables that represent the status of the in-stream flow. The detailed Excel spreadsheet will be made available on the CD with all data provided with the main report. The HIGH importance evaluation and the associated metric resulting in the evaluation are provided in Table 4.6.

Table 4.6 High Importance WRUI SQs

SQ	River	Comment
U40E-03985	Mvoti	Future Development.
U40H-04064	Mvoti	Future Development.
U40H-04064	Mvoti	Future Development.
U40J-03998	Mvoti	Future Development.
U30A-04360	uMdloti	Operational implications - river used for Hazelmere Dam releases.
U30B-04475	uMdloti	Operational implications - river used for Hazelmere Dam releases.
U30B-04498	Ohlanga	Current water balance.
U30D-04315	uThongathi	Current water balance.
U20B-04144	Mpofana	IBT from Mooi Catchment.
U20B-04185	Lions	IBT from Mooi Catchment.
U20C-04190	Lions	IBT from Mooi Catchment.
U20C-04275	uMngeni	IBT from Mooi Catchment.
U20E-04221	uMngeni	Operational implications - river used for dam releases from Midmar and Albert Falls Dams.
U20E-04243	uMngeni	Operational implications - river used for dam releases from Midmar Dam.
U20G-04240	uMngeni	Operational implications - river used for dam releases from Midmar and Albert Falls Dams.
U20G-04259	uMngeni	Operational implications - river used for dam releases from Midmar and Albert Falls Dams.
U20G-04385	uMngeni	Operational implications - river used for dam releases from Midmar and Albert Falls and Nagle Dams.
U20J-04364	uMnsunduze	Return flows from Darvill WWTW.
U20J-04391	uMnsunduze	Return flows from Darvill WWTW.
U20J-04401	uMnsunduze	Return flows from Darvill WWTW.
U20J-04459	uMnsunduze	Return flows from Darvill WWTW.
U20J-04461	Slang Spruit	Water quality score - Edendale, urban, industries.
U20L-04435	uMngeni	Water quality issues.
U20M-04396	uMngeni	Water quality issues.
U60C-4556	Sterkspruit	Water quality - Hammarsdale Industrial WWTW return flows.
U60D-4661	uMlazi	Water quality – WWTW.
U60F-4597	Mhlatuzana	Water quality.
U60F-4632	Umbilo	Water quality.
U10F-04528	uMkhomazi	Future development.
U10H-04638	uMkhomazi	Future development.
U10H-04675	uMkhomazi	Future development.
U10J-04679	uMkhomazi	Future development.
U10J-04799	uMkhomazi	Future development.

SQ	River	Comment
U10J-04807	uMkhomazi	Future development.
U10J-04833	uMkhomazi	Future development.
U10K-04838	uMkhomazi	Future development.
U10M-04746	uMkhomazi	Future development.
T51D-04460	Pholelana	Current water balance.
Kandandhlovu	Estuary	Water use
Kaba	Estuary	Water Use
Vungu	Estuary	Water quality
Zotsha	Estuary	Water quality
Mbango	Estuary	Water quality
Mvuzi	Estuary	Operational
Sezela	Estuary	Water use, operational
Mkumbane	Estuary	Water use, operational
uMuziwezinto	Estuary	Water use, operational, water quality
uMkhomazi	Estuary	Future development
Ngane	Estuary	Water quality
Umgababa	Estuary	Operational
Mbokodweni	Estuary	Water quality
Sipingo	Estuary	Water quality
Durban Bay	Estuary	Use, operational, Water quality
uMngeni	Estuary	Use, operational, Water quality, future development
Mhlanga	Estuary	Use, Water quality
uMdloti	Estuary	Use, operational, Water quality, future development
uThongathi	Estuary	Use, Water quality

4.4 PRIORITY AREAS – HOTSPOTS

The identified hotspots are illustrated in Table 4.7. Only hotspots with the maximum evaluation, i.e. a 4 scoring, has been provided.

Table 4.7 Hotspot results

SQ	River	IEI (0 - 5)	WRUI (0 - 4)	Hotspot
T40G-05616	Vungu	4	3	**4**
T51F-04621	Ngwangwane	4	3	**4**
T52K-05467	Mzimkhulwana	4	3	**4**
U10F-04528	uMkhomazi	4	4	**4**
U10H-04638	uMkhomazi	5	4	**4**
U10H-04675	uMkhomazi	5	4	**4**
U10J-04679	uMkhomazi	5	4	**4**
U10J-04799	uMkhomazi	3	4	**4**
U10J-04807	uMkhomazi	5	4	**4**
U10J-04833	uMkhomazi	4	4	**4**
U10K-04838	uMkhomazi	3	4	**4**
U10M-04746	uMkhomazi	4	4	**4**
U60C-04556	Sterkspruit	3	4	**4**
U60F-04597	Mhlatuzana	3	4	**4**
U60F-04632	Umbilo	3	4	**4**
U20B-04144	Mpofana	3	4	**4**

SQ	River	IEI (0 - 5)	WRUI (0 - 4)	Hotspot
U20B-04185	Lions	4	4	**4**
U20C-04190	Lions	4	4	**4**
U20C-04275	uMngeni	3	4	**4**
U20C-04332	Gqishi	4	3	**4**
U20E-04221	uMngeni	3	4	**4**
U20E-04243	uMngeni	3	4	**4**
U20G-04240	uMngeni	3	4	**4**
U20G-04259	uMngeni	4	4	**4**
U20J-04391	uMnsunduze	3	4	**4**
U20J-04459	uMnsunduze	3	4	**4**
U20L-04435	uMngeni	4	4	**4**
U20M-04396	uMngeni (upstream of Inanda Dam)	3	4	**4**
U40A-03869	Mvoti	4	3	**4**
U40D-03867	Mvoti	4	3	**4**
U40D-03957	Mvoti	5	3	**4**
U40E-03985	Mvoti	4	4	**4**
U40F-03806	Hlimbitwa	4	3	**4**
U40H-04064	Mvoti	4	4	**4**
U40J-03998	Mvoti	3	4	**4**
ESTUARIES				
Zolwane	Estuary	4	4	**4**
Tongazi	Estuary	4	4	**4**
Kandandhlovu	Estuary	4	3	**4**
Mpenjati	Estuary	5	4	**4**
Vungu	Estuary	4	4	**4**
Zotsha	Estuary	5	3	**4**
Boboyi	Estuary	4	3	**4**
Koshwana	Estuary	4	4	**4**
Sezela	Estuary	3	4	**4**
uMkhomazi	Estuary	4	4	**4**
Umgababa	Estuary	4	3	**4**
Sipingo	Estuary	5	3	**4**
Durban Bay	Estuary	3	4	**4**
uMngeni	Estuary	3	4	**4**
Mhlanga	Estuary	3	4	**4**
uMdloti	Estuary	3	4	**4**
uThongathi	Estuary	3	4	**4**
Mhlali	Estuary	4	4	**4**
Mvoti	Estuary	3	4	**4**

The rivers where hotspots dominate are:

- Mvoti and uMkhomazi due to the potential for large dam development in the near future.
- uMngeni due to its WRUI importance and existing dam developments.
- uMnsunduze due to its water quality issues.

The estuaries where hotspots dominate are:

- Mvoti and uMkhomazi due to the potential for large dam development in the near future.
- uMngeni and Umgababa due to its existing dam developments.

- Zolwane, Tongazi, Kandandhlovu, Mpenjati, Vungu, Zotsha, Boboyi, Koshwana, Sezela, Mhlanga uMdloti, uThongathi and Mhlali due to water quality and current/future waste water discharges issues.
- Sipingo and Durban Bay due to severe catchment and/or habitat transformation pressure.

5 RIVER ECOLOGICAL WATER REQUIREMENTS

This chapter is an extract from the following reports:
Department of Water Affairs (DWA), South Africa. 2013c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Resource Units and EWR sites. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. July 2013. DWA Report: RDM/WMA11/00/CON/CLA/0213.

Department of Water Affairs (DWA), South Africa. 2014a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 1: EWR estimates of the River Desktop Biophysical Nodes. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Birkhead AL, Louw MD. March, 2014. DWA Report: RDM/WMA11/00/CON/CLA/0114.

Department of Water Affairs (DWA), South Africa. 2014b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 2: EcoClassification and EWR assessment on the Mtamvuna, Lovu, uMngeni, Karkloof and uMnsunduze Rivers. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. May 2014. DWA Report: RDM/WMA11/00/CON/CLA/0214.

Department of Water Affairs (DWA), South Africa. 2014c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 3: EcoClassification and EWR assessment on the uMkhomazi, uMngeni, and Mvoti Rivers. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. July 2014. DWA Report: RDM/WMA11/00/CON/CLA/0314.

5.1 BACKGROUND

Within Table 5.1, reference is made to the delineation of RUs. EWR sites are situated in RU and the EWR sites selected are also provided.

Within the integrated water resource management process outlined in Table 5.1, integrated step 3 refers to: Quantify EWRs and changes in non-WQ ecosystem services. The main aspect of this Chapter is the EcoClassification and EWR determination at various biophysical nodes in the study area. This Chapter summarises the EcoClassification and EWR results.

Table 5.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	**Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.**
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

5.2 RESOURCE UNITS

RUs are required as it may not be appropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches. Different 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. The approach adopted was to consider both Natural Resource Units (NRU) and Management Resource Units (MRU) and to take account of the following aspects:

- EcoRegion classification of the river system.
- Geomorphological zonation in which channel gradient has been found to be a dominant factor.
- Land cover.
- Management and operation of the river system.
- Water quality considerations.
- Local knowledge.
- PES.

The MRUs selected are summarised in Table 5.2.

Table 5.2 MRU summary table

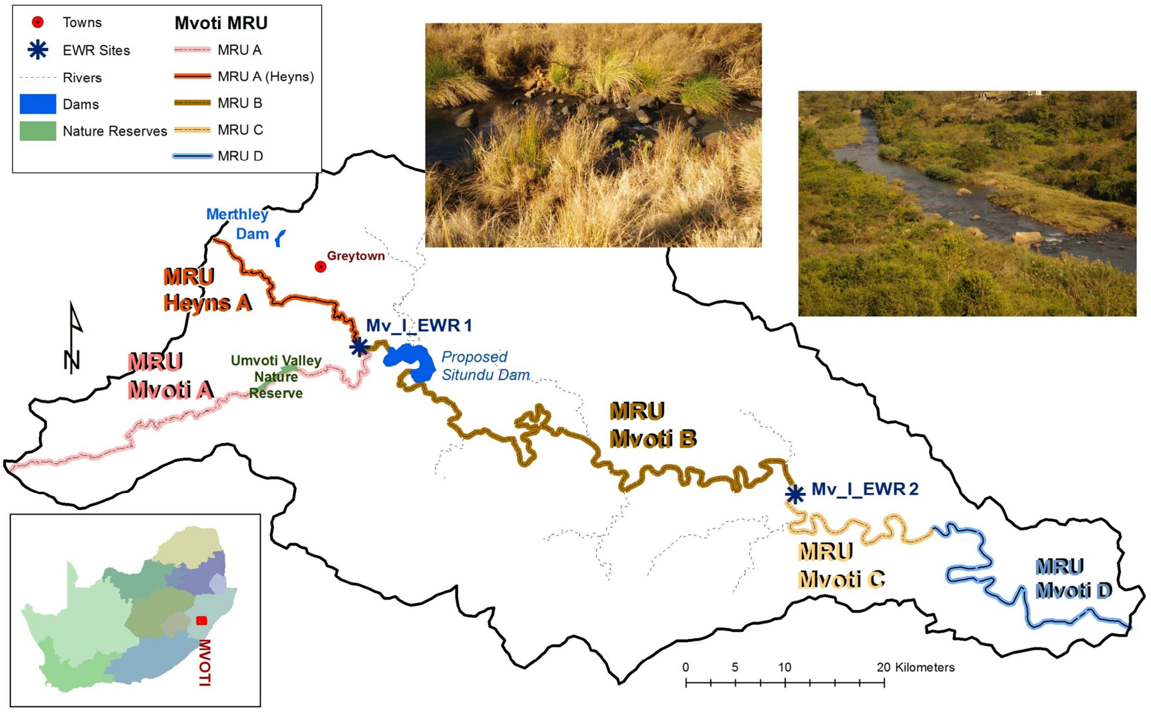
MRU	Rationale
Mtamvuna River	
MRU Mtamvuna A	Coincides with area dominated by farming, grazing and low density settlements.
MRU Mtamvuna B	Area with improved PES and river with gorge nature.
MRU Mtamvuna C	Subsistence farming, grazing, rural settlements, sedimentation.
uMkhomazi River	
MRU uMkhomazi A	The MRU coincides with land use (largely natural with forestry and a mostly B PES.
MRU uMkhomazi B	This area has more land use with a slightly lower PES (C and B/C). The logical break is the next MRU where a steep and inaccessible gorge with a better PES starts.
MRU uMkhomazi C	A gorge area in good ecological condition with limited access.
MRU uMhkomazi D	Downstream of the gorge the PES changes with concurrent landuse changes such as irrigation and mostly settlements with grazing. This warrants an MRU which is different from the gorge.
Lovu River	
MRU Lovu A	This land use is dominated by forestry and the logical end of the MRU is the Richmond Dam and Richmond town.
MRU Lovu B	Downstream of the town there is extensive sugar cane with some forestry. The PES is similar for this whole stretch (C/D).
MRU Lovu C	The MRU is distinct from the upstream stretch as the intensive forestry is replaced by rural settlements with associated subsistence and agriculture.
MRU Lovu D	This area is different from upstream due to the change in topography and the resulting limited use of the river compared to upstream. The PES also improves in this section.
uMngeni River	
MRU uMngeni A	Upstream of Midmar Dam. Formal agriculture and forestry with no major water resource operation of infrastructure.
MRU uMngeni B	Operation from Midmar Dam with quality impacts of Howick results in this being a logical MRU.
MRU uMngeni C	Operation from Albert Falls Dam with a consistent release results in this MRU.
MRU uMngeni D	Nagle Dam is small, spills often, and the flow is more diverse that the consistent flow upstream. This therefore forms a separate MRU.
Karkloof River	

MRU Karkloof A	The land use is used to delineate the NRU A into two MRUs. This MRU is dominated by forestry.
MRU Karkloof B	Upstream of the waterfall with landuse dominated by agriculture.
MRU Karkloof C	The waterfall and break between the two NRUs also forms a definitive break in terms of landuse (private nature reserve) and warrants an MRU.
uMnsunduze	
MRU uMnsunduze A	Impacts upstream of Pietermaritzburg are different than those associated with the urban areas where water quality problems become severe. This area is therefore an MRU on its own, ends at a dam, is of the same PES and coincides virtually with NRU A.
MRU uMnsunduze B	Pietermaritzburg area requires an MRU on its own due to very specific impacts associated with urbanisation.
MRU uMnsunduze C	The section downstream of PMB is in some way protected by the river falling within a gorge. The water quality issues from upstream however are still prevalent. The landuse is different (forestry and some formal agriculture).
MRU uMnsunduze D	Landuse changes to high density rural settlements. The water quality improves somewhat with the dilution that tributary inflows contribute. This section therefore forms its own MRU.
Mvoti River and Heinespruit	
MRU Heine A	The Heinespruit is too short to warrant more than one MRU.
MRU Mvoti A	The area is dominated by forestry, irrigation and a large section of the river is a wetland. The logical break is the confluence of the Heinespruit as it forms a separate MRU.
MRU Mvoti B	This MRU is based on a change in land cover and the changed nature of the river within a gorge.
MRU Mvoti C	This section of the river again illustrates changed landuse and ends at the point where sand mining dominates the river.
MRU Mvoti D	This MRU is dominated by sand mining and is separate from the upstream river as it would require intensive non-flow related mitigation measures.

5.3 EWR SITES

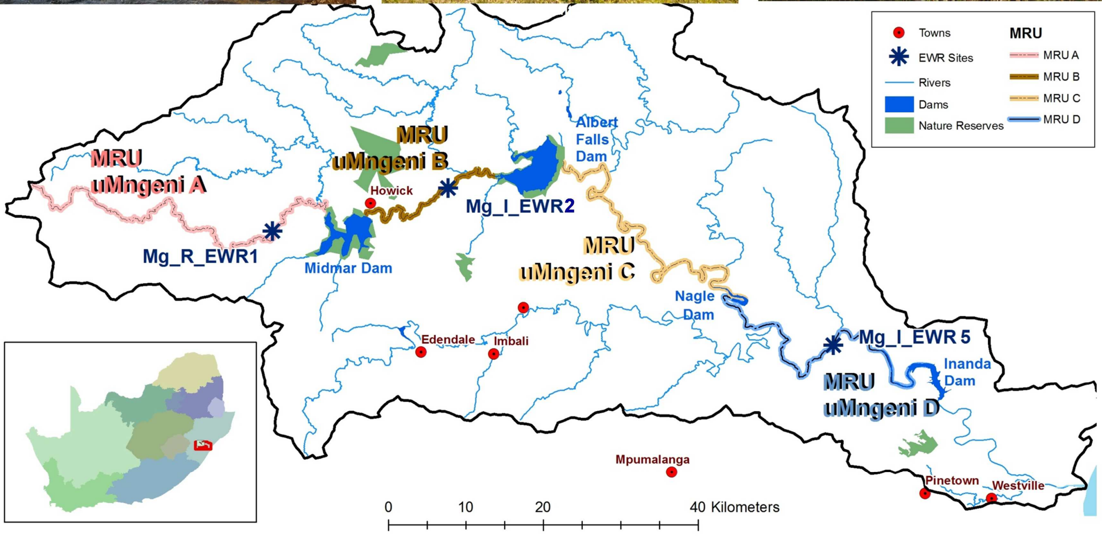
Well established criteria and processes (Louw *et al*., 1999) were adopted to select EWR sites for further analysis. The locality and general description of the selected EWR sites are provided in Table 5.3 to Table 5.9.

Table 5.3 Locality and characteristics of Mv_I_EWR1 and Mv_I_EWR2 located in the Mvoti River (U4: Mvoti)



EWR and River name	**Mv_I_EWR1, Heinespruit**
Co-ordinates	S -29.13054; E 30.640024
EcoRegion (Level II)	16.02
Geomorphic Zone	E Lower Foothills
Altitude (m)	929
RU	MRU Heine A
SQ	U40B-03770
Hydrological gauge	None
Assessment Level	Intermediate
EWR and River name	**Mv_I_EWR2, Mvoti**
Co-ordinates	S -29.26398; E 31.03513
EcoRegion (Level II)	17.03
Geomorphic Zone	Lower Foothills
Altitude (m)	203
RU	MRU Mvoti C
SQ	U40H-04064
Hydrological gauge	U4H005, U4H007
Assessment Level	Intermediate
Rationale	The Heinespruit required a Rapid III EWR site to address water quality and quantity issues from the upstream sewage inflows from Greytown. Mv_I_EWR1 was therefore selected downstream of Greytown. Based on the hotspot identification, it was decided to select Mv_I_EWR2 on the Mvoti River to accommodate the proposed dam (IsiThunda).

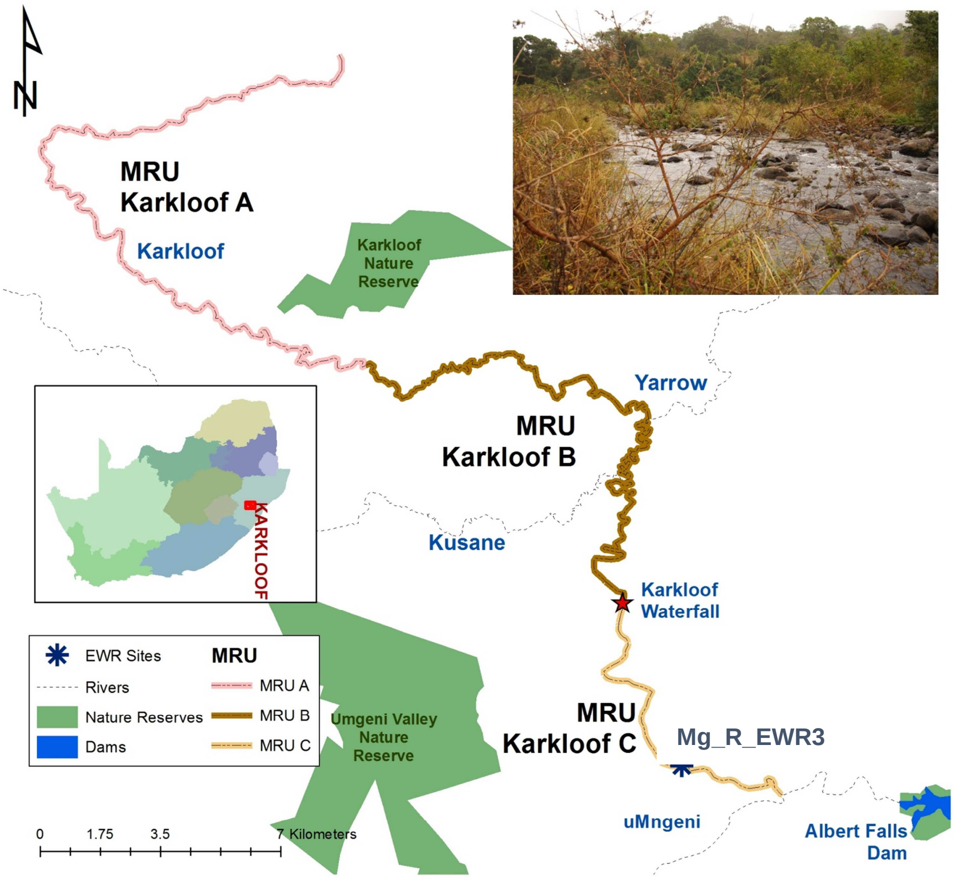
Table 5.4 Locality and characteristics of Mg_I_EWR2, Mg_I_EWR5 and Mg_R_EWR1 located in the uMngeni River (U2: uMngeni)



EWR and River name	**Mg_I_EWR2, uMngeni**
Co-ordinates	S -29.46184; E 30.29832
EcoRegion (Level II)	16.03
Geomorphic Zone	Upper Foothills
Altitude (m)	725
RU	MRU uMngeni B
SQ	U20E-04243
Hydrological gauge	U2H001
Assessment Level	Intermediate
EWR and River name	**Mg_I_EWR5, uMngeni**
Co-ordinates	S -29.64521; E 30.74556
EcoRegion (Level II)	17.03
Geomorphic Zone	Upper Foothills
Altitude (m)	177
RU	MRU uMngeni D
SQ	U20L-04435
Hydrological gauge	U2H002, U2H015
Assessment Level	Intermediate
EWR and River name	**Mg_R_EWR1, uMngeni**
Co-ordinates	S -29.5125; E 30.09417
EcoRegion (Level II)	16.01
Geomorphic Zone	Lower Foothills
Altitude (m)	1081
RU	MRU uMngeni A
SQ	U20A-04253
Hydrological gauge	U2H013
Assessment Level	Rapid

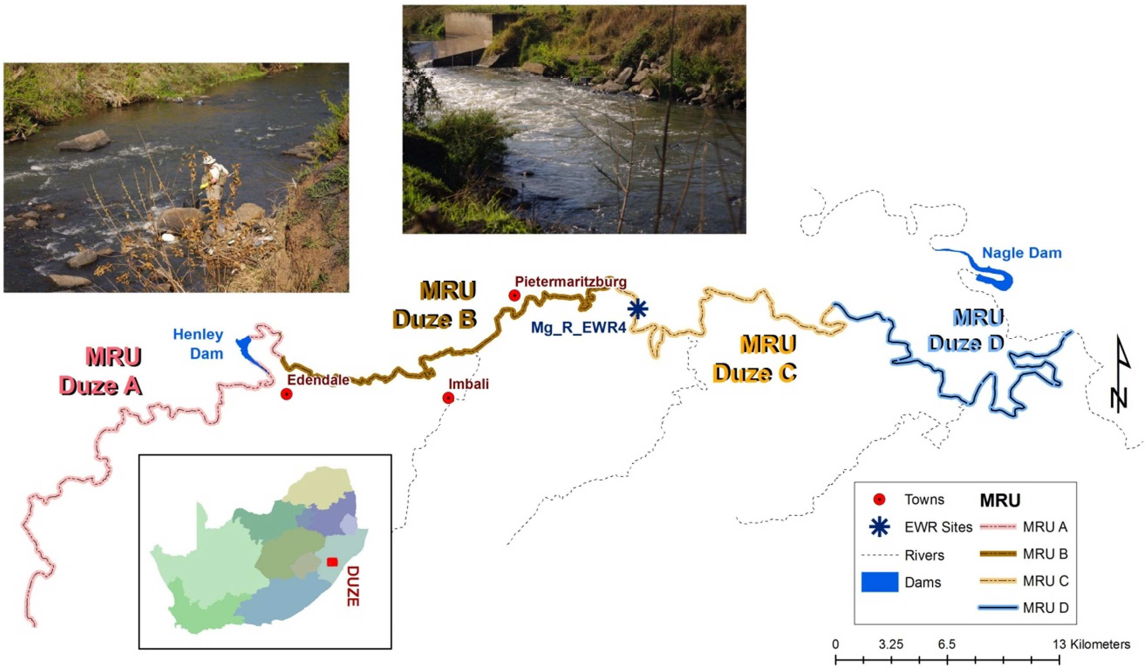
Rationale	An EWR site was located in each of the MRUs apart from the MRU uMngeni C (downstream of Albert Falls Dam). The indications were that the socio-economic consequences would be high if the consistent flow from Albert Falls Dam had to change to accommodate a more seasonal distribution. This would be required for the EWR releases. It was therefore decided to focus on the other MRUs for the selection of EWR sites. Over and above the normal site selection criteria (Louw *et al.,* 1999), the following were key in selecting the EWR sites. ▪ **MRU uMngeni A:** Mg_R_EWR1 used for a Rapid EWR assessment was used due to the information available for this site. ▪ **MRU uMngeni B:** Access was a major problem as well as many instream small dams resulting in inundation. An area on Karkloof SPA was selected (Mg_I_EWR2) as the river is locally in a reasonable condition given that the area is within a private nature reserve. ▪ **MRU uMngeni D:** Access was a major problem in this reach and the site selection, Mg_I_EWR5 was governed by access combined suitable instream habitat.

Table 5.5 Locality and characteristics of Mg_R_EWR3, located in the Karkloof River (U2: uMngeni)



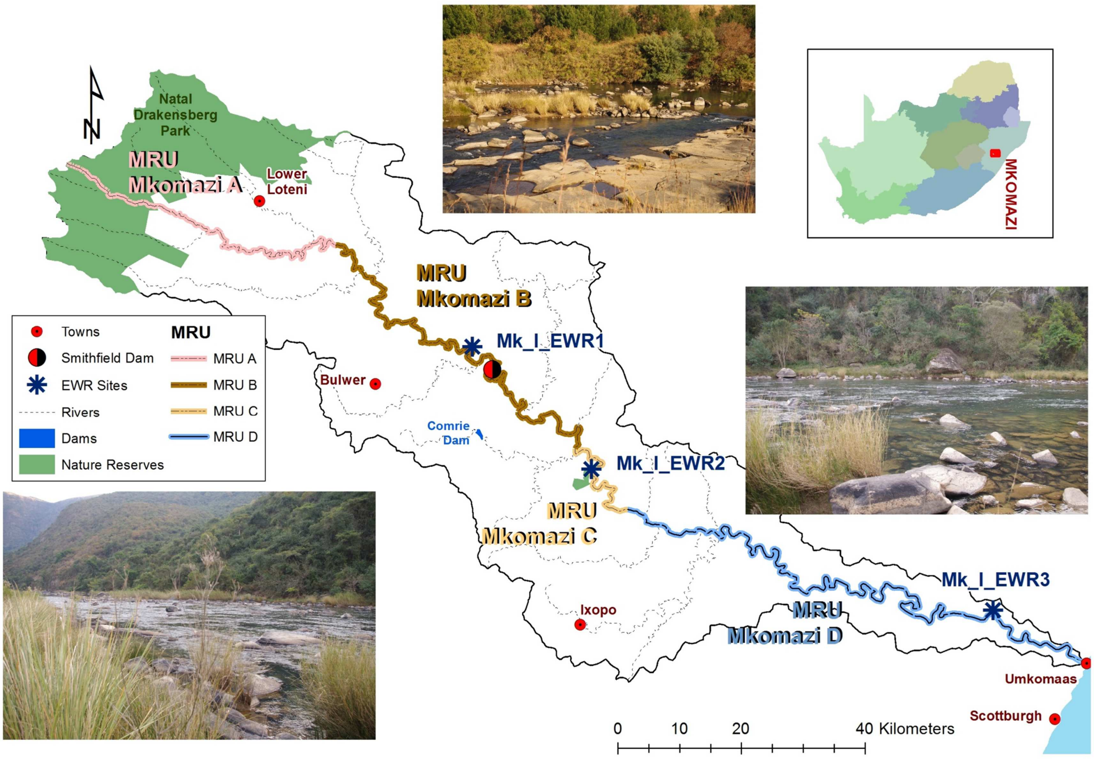
EWR and River name	**Mg_R_EWR3, Karkloof**
Co-ordinates	S -29.4385; E 30.29522
EcoRegion (Level II)	16.03
Geomorphic Zone	Upper Foothills
Altitude (m)	738
RU	MRU Karkloof C
SQ	U20E-04170
Hydrological gauge	None
Assessment Level	Rapid
Rationale	An EWR site should have been placed in the B/C section and downstream of the waterfall. However, the waterfall formed a natural barrier and the flow requirements upstream of the barrier might not have been relevant for the section lower down. A site was therefore selected in MRU Karkloof C.

Table 5.6 Locality and characteristics of Mg_R_EWR4, located in the uMnsunduze River (U2: uMngeni)



EWR and River name	**Mg_R_EWR4, uMnsunduze**
Co-ordinates	S -29.60801; E 30.450406
EcoRegion (Level II)	16.03
Geomorphic Zone	Lower Foothills
Altitude (m)	602
RU	MRU Duze C
SQ	U20J-04364
Hydrological gauge	U2H041
Assessment Level	Rapid
Rationale	Ideally, the EWR site should have been situated far downstream of the system in the C PES section as representing the best condition site and excluding the major water quality impacts. However, access was problematic. It was therefore decided to select the site just downstream of Pietermaritzburg at an existing river health site.

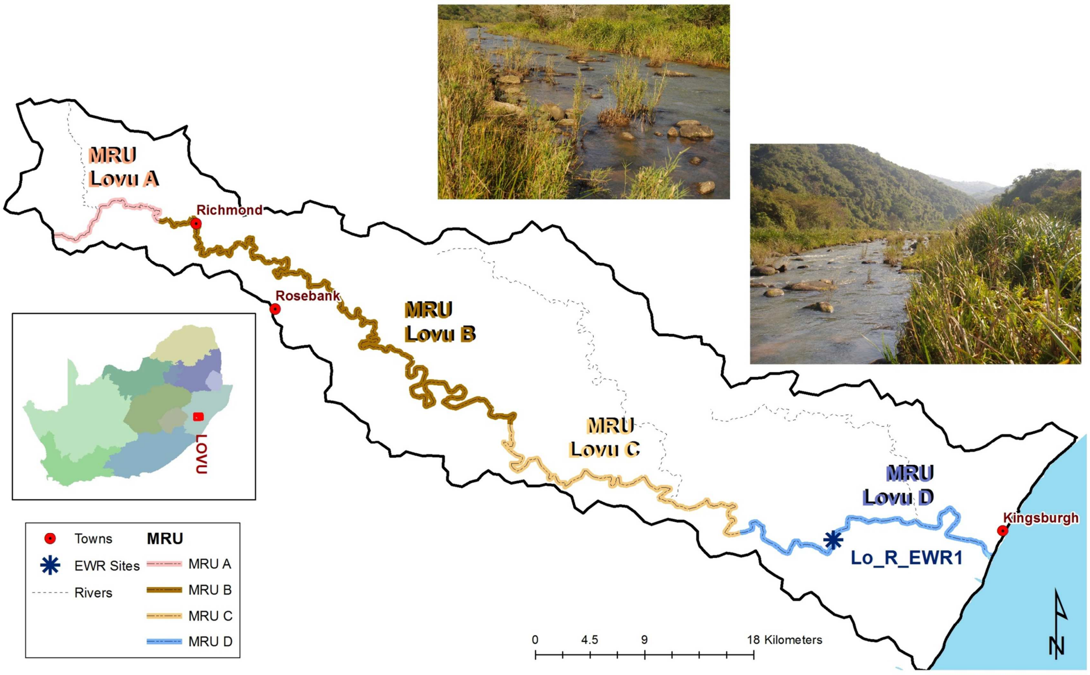
Table 5.7 Locality and characteristics of Mk_I_EWR1, Mk_I_EWR2 and Mk_I_EWR3 located in the Mkomazi River (U2: uMngeni and U1: uMkhomazi)



EWR and River name	**Mk_I_EWR1, uMkhomazi**
Co-ordinates	S -29.921; E 30.08448
EcoRegion (Level II)	16.03
Geomorphic Zone	Lower Foothills
Altitude (m)	916
RU	MRU uMkhomazi B
SQ	U10E-04380
Hydrological gauge	U1H005
Assessment Level	Intermediate
EWR and River name	**Mk_I_EWR2, uMkhomazi**
Co-ordinates	S -29.921; E 30.08448
EcoRegion (Level II)	16.02
Geomorphic Zone	Upper Foothills
Altitude (m)	537
RU	MRU uMkhomazi C
SQ	U20J-4679
Hydrological gauge	U1H002
Assessment Level	Intermediate
EWR and River name	**Mk_I_EWR3, uMkhomazi**
Co-ordinates	S -30.132; E 30.66245
EcoRegion (Level II)	17.01
Geomorphic Zone	Lower Foothills
Altitude (m)	50
RU	MRU uMkhomazi D
SQ	U20M-04746
Hydrological gauge	U1H009
Assessment Level	Intermediate
Rationale	These EWR sites were selected during 1998 and due to the valuable information available

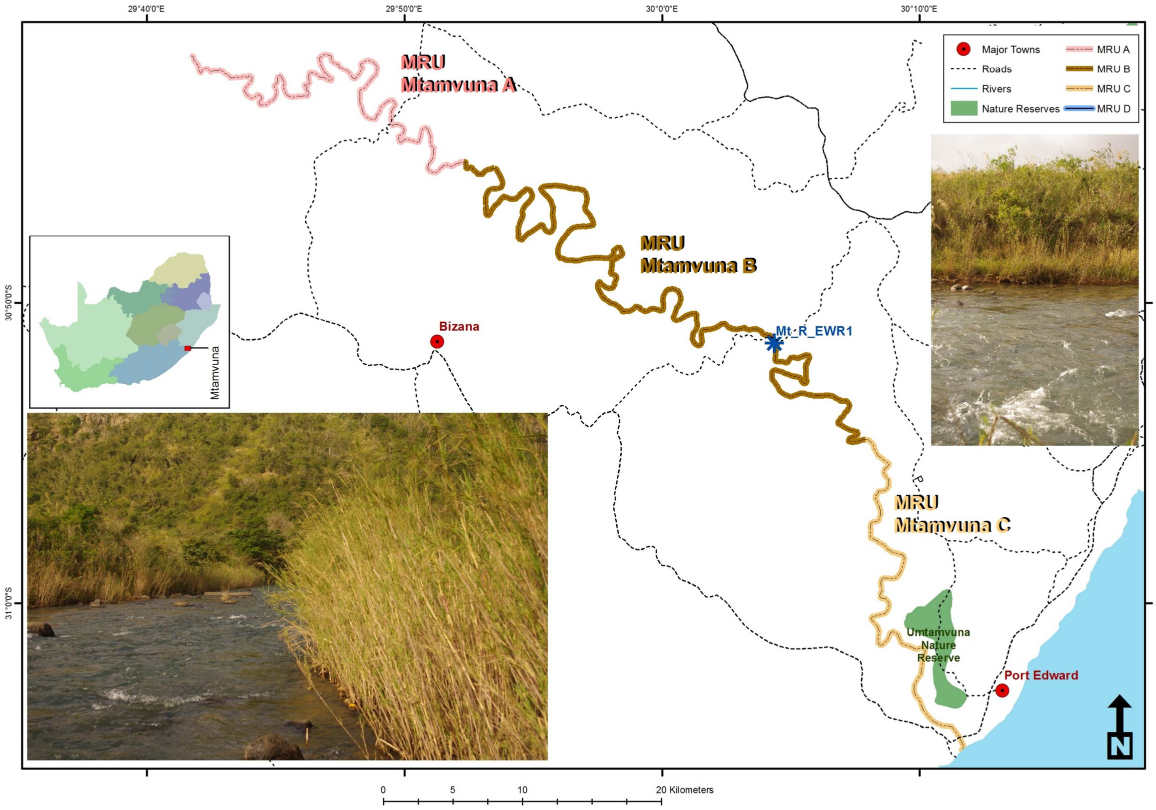
	at the sites, these were maintained as EWR sites during this EWR study. The site selection criteria (Louw *et al.,* 1999) were in place and these sites would conform to the requirements. Mk_I_EWR1 was located in MRU uMkhomazi B where the PES improved from a C to a B/C. Mk_I_EWR2 is located at the start of the gorge section which was in a good ecological state (PES - B). Mk_I_EWR3 represented the downstream area and was located in the long section which was in a B/C PES.

Table 5.8 Locality and characteristics of Lo_R_EWR1, located in the Lovu River (U7: Lovu)



EWR and River name	**Lo_R_EWR1, Lovu**
Co-ordinates	S -30.09997; E 30.73603
EcoRegion (Level II)	17.01
Geomorphic Zone	Lower Foothills
Altitude (m)	44
RU	MRU Lovu D
SQ	U70C-04859
Hydrological gauge	None
Assessment Level	Rapid
Rationale	To be useful for estuary EWR assessment, and EWR site should have been selected as far downstream as possible. The logical place would be to select the site within the downstream area where the river improved to a PES of a B/C and Lo_R_EWR1 was therefore selected in this reach.

Table 5.9 Locality and characteristics of Mt_R_EWR1, located in the Mtamvuna River (T4: Mtamvuna)



EWR and River name	**Mt_R_EWR1, Mtamvuna**
Co-ordinates	S -30.85608; E 30.07268
EcoRegion (Level II)	17.0
Geomorphic Zone	Lower Foothills
Altitude (m)	277
RU	MRU Mtam B
SQ	T40E-5601
Hydrological gauge	None
Assessment Level	Rapid
Rationale	Considering the criteria for site selection, the most suitable position for an EWR section was in the B PES section in the gorge. As this section was in the best condition, it would provide good indicators for EWR determination. However, the gorge was inaccessible and the next best option was in the B/C section further downstream.

5.4 ECOCLASSIFICATION RESULTS (LEVEL IV)

The EcoClassification results are summarised in Table 5.10.

Table 5.10 Summary of EcoClassification results

Mv_I_EWR1: Heinespruit

EIS: MODERATE
Unique fish occur (*B. natalensis* – regional endemic) and instream habitat sensitive to flow changes. Rare and endangered riparian species are present and are intolerant.

PES: C

- Decreased base flows impact to some extent on habitat availability and abundance.
- Deteriorated water quality due to releases from the WWTW resulting in high nutrient levels as well as the presence of toxics.
- High occurrence of alien vegetation species and the presence of three predatory alien fish species.
- General loss of connectivity and bank modification.

REC: C
The EIS was Moderate and therefore the REC was set to maintain the PES.

Alternative Ecological Category (AEC) down: D

- The scenario included further decreased baseflows and floods:
- Increased sedimentation of riffles and fine accumulation in pools.
- Vegetation species composition change with a higher occurrence of grasses and shrubs, and a decrease in sedges.
- Increased nutrients.

Component	PES & REC	AEC↓
IHI Hydrology	C	
Physico chemical	C	D
Geomorphology	B	C
Fish	C	D
Invertebrates	C	D
Instream	C	D
Riparian vegetation	B/C	C/D
EcoStatus	C	C/D
Instream IHI	C	
Riparian IHI	C	
EIS	MODERATE	

Mv_I_EWR2 Mvoti River

EIS: MODERATE
Unique instream fish biota occur (regional freshwater endemics and estuarine fish). There is a diversity of habitat types and the reach is an important migration route for eels. Rare and endangered riparian species are present.

PES: C

- Decreased base flows have impacted to some extent on habitat availability and abundance.
- Deteriorated water quality.
- Catchment erosion.
- Two predatory alien fish species.
- Alien invasive vegetation in the riparian zones along with wood harvesting and clearance has led to a general loss of connectivity and bank modification.

REC: B
The EIS is Moderate, however the instream component of the EIS is High, and improvement can be achieved by non-flow related measures. The REC will therefore indicate the improvement, but an EWR for improved flows will not be set.

AEC down: D
The scenario is based on the impacts of a possible upstream dam which will result in:

- Increased sedimentation of riffles and fines accumulation in pools.
- Vegetation species composition change with a higher occurrence of grasses and shrubs, and a decrease in sedges.
- Increased nutrients.

Component	PES	REC	AEC↓
IHI Hydrology	B/C		
Physico chemical	C	C	D
Geomorphology	C	C	D
Fish	B/C	B	C
Invertebrates	B/C	B	C/D
Instream	B/C	B	C/D
Riparian vegetation	C/D	C/D	D
EcoStatus	C	B	C/D
Instream IHI	C		
Riparian IHI	C		
EIS	MODERATE		

Mg_I_EWR2: uMngeni River

EIS: MODERATE
Highest scoring metrics were diversity of habitat types and migration route. Rare and endangered riparian species occur and intolerant vegetation species are present.

PES: C/D

- Decreased base flows and floods due to Midmar Dam resulting in a loss of flow diversity.
- Alien invasive vegetation, grazing pressure and species composition change in the riparian zone has led to a general loss of connectivity and resulted in bank modification.
- The decrease in baseflows has impacted on habitat availability and abundance.
- Deteriorated water quality impacts (Howick and sediment dam releases has seriously impacted on the fish frequency of occurrence.

REC: C/D
The EIS was moderate and the REC is set to maintain the PES. The fish component is in an unacceptable condition and has to improve to a D EC. This improvement will not require changes in flow.

Component	PES & REC
IHI Hydrology	C/D
Physico chemical	C/D
Geomorphology	D
Fish	E* (D)
Invertebrates	C
Instream	D
Riparian vegetation	C
EcoStatus	C
Instream IHI	D
Riparian IHI	C
EIS	**MODERATE**
*** Fish to improve**	

Mg_I_EWR5: uMngeni River

- **EIS: MODERATE**
- Highest scoring metrics were diversity of habitat types and features, taxon richness and rare and endangered riparian species.

- **PES: D**
- Decreased baseflows and floods due to upstream dams and general landuse in the upper catchment.
- Reduced habitat abundance.
- Deteriorated water quality (uMnsunduze inflows etc. and increased sedimentation).
- Alien invasive vegetation species, vegetation removal and sand mining leading to a general loss of connectivity and bank modification.
- Presence of two predatory alien fish species in the reach.

- **REC: D**

EIS was Moderate and the REC was therefore set to maintain the PES.

Component	PES & REC
IHI Hydrology	C/D
Physico chemical	C/D
Geomorphology	C/D
Fish	D
Invertebrates	C/D
Instream	C/D
Riparian vegetation	D
EcoStatus	D
Instream IHI	D
Riparian IHI	D
EIS	**MODERATE**

Mg_R_EWR1: uMngeni River

EIS: LOW

Highest scoring metrics were diversity of habitat types and features as well as the presence of rare and endangered riparian species.

PES: C/D

- The presence of aggressive alien fish species and exotic vegetation species.
- Some decrease in base flows due to abstractions for agriculture.

REC: C/D

- As the EIS was LOW no improvement was required. The C/D EcoStatus PES mainly due to non-flow related impacts and not representative of flow related problems in the reach. It was decided to exclude alien fish species from the assessment resulting in a PES of a C EC for fish and an instream PES of a C EC for which flow requirements were set.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B
Fish	D (C)
Invertebrates	C
Instream	C/D (C)
Riparian vegetation	C/D
EcoStatus	C/D
Instream IHI	C
Riparian IHI	C
EIS	LOW

Mg_R_EWR3: Karkloof River

EIS: HIGH

The reach falls within a private nature reserve and serves as critical instream refuge from uMngeni which is impacted by bottom releases from Midmar Dam at times. Rare and endangered riparian species occur and therefore this reach is important in terms of refugia and critical riparian habitat.

PES: B

- Reduced baseflows due to upstream irrigation activities.
- Localised impacts of roads, small farm dams, crossings and water quality problems from upstream irrigation.

REC: B

Although the EIS was HIGH, the instream components were all in a B EC and therefore no improvement was required. The REC was therefore set to maintain the PES.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B
Fish	B/C
Invertebrates	B
Instream	B
Riparian vegetation	B
EcoStatus	B
Instream IHI	C
Riparian IHI	B
EIS	HIGH

Mg_R_EWR4: uMnsunduze River

EIS: LOW

Highest scoring metrics were diversity of habitat types and features as well as the presence of rare and endangered riparian species

PES: D/E

- Increased floods and baseflows that exceed thresholds are important flow related impacts in the reach.
- Water quality is the major impact which drives the deteriorated ecological condition and is exacerbated by poor sewer infrastructure and industrial pollution leading to low oxygenation rates, high faecal coliform counts and excessive nutrient loading within the system.
- Intense alien vegetation infestation also impacts the reach severely.

REC: D

As the EIS was LOW no improvement was required. All components were in an unsustainable EC (lower than a D EC), and therefore the REC had to be set at a D. As the water quality issues are the primary problem, these need to be addressed at source first prior to any attention being given to addressing the flow issues. Therefore, no flow requirement was set for this EWR site.

Component	PES	REC
IHI Hydrology	E/F	N/A
Physico chemical	E/F	D
Fish	E	D
Invertebrates	E	D
Instream	E	D
Riparian vegetation	D/E	D
EcoStatus	D/E	D
Instream IHI	E/F	D
Riparian IHI	D/E	D
EIS	LOW	LOW

Mk_I_EWR1: uMkhomazi River

EIS: MODERATE
Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types and features and rare and endangered riparian species.

PES: C

- Overgrazing and alien invasive vegetation in the riparian zones have led to substrate exposure and increased erosion.
- Increased sedimentation has resulted in higher turbidity.
- Migration barriers and alien fish species.

REC: C

- EIS was Moderate and the REC was therefore to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR was set for the instream EC of a B/C.

AEC down: D

- The scenario is based on the impacts of a possible upstream dam which will result in:
- Decreased base flows and floods from a dam.
- Some change in water temperature.
- Erosion of the marginal zone due to scour.
- Decreased fines within the system.

Increased alien vegetation due to decreased floods.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B/C
Geomorphology	A/B	C
Fish	B/C	C
Invertebrates	B/C	C/D
Instream	B/C	C/D
Riparian vegetation	C	C/D
EcoStatus	C	C/D
Instream IHI	B	
Riparian IHI	C	
EIS	MODERATE	

Mk_I_EWR2: uMkhomazi River

EIS: HIGH
Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types, migration route, rare and endangered riparian species, riparian species intolerant to flow and migration corridor for birds.

PES: B

- Increased catchment erosion and alien invasive vegetation in the upper riparian zone leading to substrate exposure.
- Alien predatory fish species.

REC: B
The EIS was High and although an improvement is normally required most components are already in a B EC except for fish which is impacted by alien species. The REC was therefore set to maintain the PES.

AEC down: C
The scenario is based on the impacts of a possible upstream dam which will result in:

- Decreased base flows and floods.
- Some change in water temperature and decreased turbidity.
- Encroachment of non-woody vegetation and more reeds in the marginal zone.
- Reduced scour resulting in increased sedimentation.
- Less mobile beds.

Increased alien vegetation due to decreased floods.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B
Geomorphology	B	C
Fish	B	C
Invertebrates	B	C
Instream	B	C
Riparian vegetation	B	C
EcoStatus	B	C
Instream IHI	B	
Riparian IHI	B/C	
EIS	HIGH	

Mk_I_EWR3: uMkhomazi River

EIS: MODERATE

- Highest scoring metrics were unique instream biota, species intolerant to flow, diversity of habitat types and features and rare and endangered riparian species.

PES: C

- Overgrazing, trampling and alien invasive vegetation impact the riparian zone and has resulted in substrate exposure and increased erosion.
- The structural changes in vegetation impact on longitudinal and lateral connectivity

REC: C

- The EIS was Moderate and the REC was therefore set to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR was set for the instream EC of a B.

AEC down: D

- The scenario is based on the impacts of a possible upstream dam which will result in:
- Decreased base flows and large floods.
- More islands, fewer secondary channels and less quality instream habitats.
- Increased woody vegetation on islands.
- Loss of non-woody vegetation as it will be out-shaded by the increased woody vegetation.

Increased marginal vegetation encroachment.

Component	PES & REC	AEC↓
IHI Hydrology	A/B	
Physico chemical	A/B	B
Geomorphology	B	B/C
Fish	B	C
Invertebrates	B	C
Instream	B	C
Riparian vegetation	D	D
EcoStatus	C	C
Instream IHI	C	
Riparian IHI	C	
EIS	MODERATE	

Lo_R_EWR1: Lovu River

EIS: MODERATE

Highest scoring metrics were diversity of habitat types and features, the reach is important for the migration of eel species and macroinvertebrates in the system and rare and endangered riparian species are present.

PES: B/C

- Reduced base flows due to dams and general landuse in the upper catchment.
- Deteriorated water quality and increased sedimentation due to livestock farming, WWTW, sand mining and sugarcane farming.
- Alien invasive vegetation and wood removal in the riparian zones.

REC: B/C

EIS was MODERATE and the REC was therefore to maintain the PES.

Component	PES & REC
IHI Hydrology	B
Physico chemical	B/C
Fish	B/C
Invertebrates	B/C
Instream	B/C
Riparian vegetation	B/C
EcoStatus	B/C
Instream IHI	B/C
Riparian IHI	B/C
EIS	MODERATE

Mt_R_EWR1: Mtamvuna River

EIS: MODERATE
Highest scoring metrics were migration route for eel species in the system. Rare and endangered riparian species occur and therefore this reach is important in terms of refugia and critical riparian habitat.

PES: C

- General loss of connectivity and bank modification due to overgrazing, trampling, alien invasive vegetation and wood removal in the riparian zones.
- Increased nutrients due to deteriorated water quality.

REC: C
As the EIS was MODERATE no improvement was required. The REC was therefore set to maintain the PES. Due to non-flow related impacts on riparian vegetation, the EWR were set for the instream EC of a B.

Component	PES & REC
IHI Hydrology	A/B
Physico chemical	A/B
Fish	B/C
Invertebrates	B
Instream	B
Riparian vegetation	C/D
EcoStatus	C
Instream IHI	B/C
Riparian IHI	C
EIS	MODERATE

5.5 EWR RESULTS AT EWR SITES (KEY BIOPHYSICAL NODES)

EWR results are summarised in Table 5.11.

Table 5.11 EWR summary expressed as a % of nMAR

				Long term mean					
EWR site	**EC**	**nMAR[1] (MCM)[2]**	**pMAR[3] (MCM)**	**Low flows (MCM)**	**Low flows (%nMAR)**	**High flows (MCM)**	**High flows (%nMAR)**	**Total flows (MCM)**	**TOTAL (%nMAR)**
Mv_I_EWR1	PES/REC: C	17.36	7.08	3.16	18.2	1.69	9.7	4.85	27.9
	AEC: D			2.26	13	1.6	9.2	3.85	22.2
Mv_I_EWR2	PES/REC instream: B/C	273.96	168.84	48.3	17.6	19.4	7.1	67.7	24.7
	AEC instream: C/D			33.4	12.2	17.6	6.4	51	18.6
Mg_I_EWR2	PES/REC: C/D (RDRM C)	228.19	105.4	33.5	14.7	12.1	5.3	45.6	20
Mg_I_EWR5	PES/REC instream: C/D	583.7	245.3	133.57	22.9	17.03	2.9	150.6	25.8
Mg_R_EWR1	Instream: C	79.22	60.46	10.88	13.70	9.86	12.50	20.74	26.20
Mg_R_EWR3	PES/REC: B	70.11	56.50	19.11	27.30	11.38	16.20	30.49	43.50
Mk_I_EWR1	PES/REC instream: B/C	683.17	660.72	171.78	25.1	67.31	9.9	239.09	35
	AEC: C/D			88.96	13	57.57	8.4	146.53	21.4
Mk_I_EWR2	PES/REC: B	890.91	838.35	220.59	24.8	94.44	10.6	315.03	35.4
	AEC: C			166.69	18.7	81.6	9.2	248.29	27.9
Mk_I_EWR3	PES/REC instream: B	1068.6	983.23	223.42	20.9	104.6	9.8	328.02	30.7
	AEC: C			151.2	14.2	90.35	8.4	241.55	22.6
Lo_R_EWR1	B/C	87.76	73.42	20.04	22.80	13.19	15.10	33.23	37.90
Mt_R_EWR1	Instream: B	233.15	200.69	60.99	26.20	35.08	15.00	96.07	41.20

1 Natural Mean Annual Runoff 2 Million Cubic Metres 3 Present Day Mean Annual Runoff

5.6 CONFIDENCE

A summary of the confidence in the EcoClassification and EWR scenario determination is provided below. The confidence score is based on a scale of 0 – 5 and colour coded where:

0 – 1.9: Low 2 – 3.4: Moderate 3.5 – 5: High

Table 5.12 Summary of confidence in EcoClassification and EWR scenario determination at the EWR sites

EWR site	Data availability	Eco-Classification	Low flow EWR (biotic responses)	High flow EWR (biophysical responses	Hydrology	Hydraulics (low)	Hydraulics (high)	Overall low flow EWR confidence	Overall high flow EWR confidence
Mv_I_EWR1	3	3.3	3	2.5	2	3	3	3	3
Mv_I_EWR2	2.8	3.1	4	2.75	1.5	2	3	2	2.8
Mg_I_EWR2	3	3	3.3	3.5	3	2	4	2	3.5
Mg_I_EWR5	3	3.1	5	2.8	3	4	5	4	3
Mg_R_EWR1	3	3	3	3	4	1	1	2.7	2
Mg_R_EWR3	2.5	2.5	2	3	4	2	2	2.7	2.5
Mg_R_EWR4	3	3.1							
Mk_I_EWR1	3	3	4.3	3.5	3	3	4	3	3.5
Mk_I_EWR2	3	3	4.3	3.8	3	3	5	3	3.88
Mk_I_EWR3	3	3	4	2.3	3	4	5	4	2.3
Lo_R_EWR1	2.5	2.5	3.5	4	1.5	3	2.5	2.5	3.3
Mt_R_EWR1	2.5	2.8	3.5	3	1.5	3	3	2.7	3

5.7 ECOCLASSIFICATION RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The PESEIS project (DWS, 2014a) results were used to derive the REC (Table 5.13 to Table 5.20) at the desktop biophysical nodes (DBNs). In cases where the Integrated IEI is high or very high, an improved REC is recommended. The estimated EWR from the Revised Desktop Reserve Model (RDRM) (Hughes *et al*., 2011) is linked to the REC and these results are provided in the following section. It must however be noted that if the REC is not based on an improved flow regime, the EWR for the PES is used. Information is also supplied on what will be required to achieve the REC and if this is attainable.

Table 5.13 summarises the results for the DBNs (DWS, 2014a) and forms the basis for the EWR estimation. Note that biophysical nodes which represent rivers with its source and 'end' in protected areas are not included for EWR estimation and are excluded from the tables below. If information is required on any of these nodes, please refer to DWA (2013a).

5.8 EWR RESULTS AT THE DESKTOP BIOPHYSICAL NODES

The RDRM (Hughes *et al*., 2012) was used to estimate EWRs at all DBNs, excluding those that fall in its totality in conservation areas. The results are summarised in the table below.

A summary of low and high flow EWR requirements, including the naturalised and Present Day (PD) Mean Annual Runoff (MAR) is provided in Table 5.13. The RDRM is run for an EC which is either the PES or the REC. In all cases where the REC is an improvement of the PES, but increased flow is not required to achieve this, the EWR estimate will be undertaken for maintaining the PES. The column referred to as RDRM EC indicates the EC for which the RDRM is run.

Table 5.13 Summary of Desktop EWRs for the biophysical nodes in the Mvoti to Umzimkulu study area

IUA	SQ node	River name	MAR (10^6 m^3)		RDRM EC	Comments	REC	Long-term requirements				Desktop method
								Low flows		Total flows		
			Natural	PD				10^6 m^3	MAR	10^6 m^3	MAR	
IUA T4: Mtamvuna												
T4	T40A-05450	Mafadobo	27.58	26.23	B/C		B	6.22	22.5%	8.79	31.9%	RDRM
T4	T40A-05487	Goxe	30.01	28.42	B/C	Catchment management of informal agriculture and overgrazing will be required. Unlikely to be attainable.	B	6.39	21.3%	9.19	30.6%	RDRM
T4	T40B-05337	Weza	74.47	52.56	C		C	13.94	18.7%	20.37	27.4%	RDRM
T4	T40C-05566	Ludeke	28.72	28.14	B		B	7.56	26.3%	10.41	36.2%	RDRM
T4	T40C-05589	KuNtlamvukazi	12.22	11.94	B		B	3.55	29.1%	4.78	39.1%	RDRM
T4	T40C-05600	Ludeke	14.10	13.64	B		B	4.18	29.7%	5.57	39.5%	RDRM
T4	T40D-05615	Tungwana	2.23	2.04	B		B	0.65	29.3%	0.90	40.4%	RDRM
T4	T40D-05643	Gwala	5.62	5.29	B		B	1.55	27.7%	2.17	38.7%	RDRM
T4	T40D-05683	Ntelekweni	8.91	8.55	B/C		B/C	2.04	22.9%	2.94	33.0%	RDRM
T4	T40D-05707	Mtamvuna	213.74	182.12	C		C	40.16	18.8%	58.61	27.4%	RDRM
T4	T40D-05719	Londobezi	4.62	4.48	B		B	1.23	26.7%	1.75	37.9%	RDRM
T4	T40E-05767	Hlolweni	22.55	22.25	B/C	Catchment management of informal agriculture and overgrazing will be required. Unlikely to be attainable. Alien vegetation can be removed.	B	4.38	19.4%	6.99	31.0%	RDRM
T4	T40F-05666	Mbizana	34.99	34.26	B		B	6.43	18.4%	11.06	31.6%	RDRM
T4	T40G-05616	Vungu	23.15	23.13	B/C	Water quality (WQ) improvement of Uvongo needs to change ratings from a 3 to a 2 which will improve instream continuity.	B	4.52	19.5%	7.18	31.0%	RDRM
IUA T5: Umzimkulu												
T5-1	T51A-04522	Mzimude	43.18	40.76	B		B	6.09	14.1%	11.20	25.9%	RDRM
T5-1	T51A-04551	Mzimude	58.78	54.27	B	Flow modification needs to improve from a 1.5 to a 1.	B	10.08	17.1%	17.07	29.0%	RDRM
T5-1	T51A-04608[1]		1.57	1.55	B		B	0.24	15.5%	0.41	26.0%	DRM
T5-1	T51B-04421	Mzimkulu	246.19	224.32	B		B	37.34	15.2%	65.33	26.5%	RDRM
T5-1	T51G-04751		2.99	2.46	B		B	0.48	15.9%	0.80	26.6%	DRM
T5-2	T51C-04606		3.77	2.45	C		C	0.36	9.6%	0.68	18.0%	DRM
T5-2	T51D-04460	Pholelana	3.03	2.88	B	Lower 50% of catchment dammed. Upper section in a better state. Without removing dams, no improvement possible.	D	0.58	19.2%	0.87	28.8%	DRM

IUA	SQ node	River name	MAR (10^6 m^3)		RDRM EC	Comments	REC	Long-term requirements				Desktop method
			Natural	PD				Low flows		Total flows		
								10^6 m^3	MAR	10^6 m^3	MAR	
T5-2	T51E-04536		8.65	6.85	C		C	1.31	15.1%	1.98	22.9%	RDRM
T5-2	T51F-04674		2.84	1.69	C		C	0.23	8.1%	0.49	17.1%	DRM
T5-2	T51G-04722	Ndawana	91.05	81.32	C		C	11.27	12.4%	20.66	22.7%	RDRM
T5-2	T51H-04913	Nonginqa	16.70	13.33	B/C		B/C	2.44	14.6%	4.06	24.3%	RDRM
T5-2	T51H-04923	Malenge	27.16	24.27	B/C	Riparian buffer reinstatement.	B	3.13	11.5%	5.72	21.1%	RDRM
T5-2	T52C-04880		12.65	6.97	C		C	1.46	11.5%	2.65	20.9%	RDRM
T5-2	T52D-05024	Ncalu	4.45	2.66	C	Reduce sedimentation and establish buffer zone (forestry area)	B	0.45	10.0%	0.97	21.8%	RDRM
T5-2	T52D-05061	Mgodi	5.41	3.39	C	Reduce sedimentation and establish buffer zone (forestry area).	B	0.51	9.3%	1.14	21.0%	RDRM
T5-2	T52E-05053	Upper Bisi	55.53	43.71	B/C	Buffer zone reinstatement in forestry and other areas and alien veg removal.	B	11.11	20.0%	16.35	29.4%	RDRM
T5-2	T52F-05104	Little Bisi	34.29	22.80	C		C	5.41	15.8%	8.46	24.7%	RDRM
T5-2	T52F-05139	Little Bisi	96.08	71.82	B		B	21.98	22.9%	31.72	33.0%	RDRM
T5-2	T52F-05190	Mbumba	47.30	35.24	B/C		B/C	9.38	19.8%	13.90	29.4%	RDRM
T5-2	T52G-05171	Bisi	171.17	131.38	B		B	36.47	21.3%	53.63	31.3%	RDRM
T5-2	T52G-05226	uMbumbane	19.21	16.92	B/C		B/C	3.32	17.3%	5.16	26.9%	RDRM
T5-2	T52H-05244	Mahobe	9.42	8.89	B/C		B/C	1.05	11.2%	2.17	23.0%	RDRM
T5-2	T52K-05475	Nkondwana	6.51	4.21	B/C		B/C	0.90	13.8%	1.46	22.4%	RDRM
T5-3	T52H-05295	Magogo	5.85	4.79	B		B	0.95	16.2%	1.56	26.7%	RDRM
IUA U1: uMkhomazi												
U1-1	U10A-04202	Nhlathimbe	43.52	43.62	B		B	8.33	19.1%	12.73	29.3%	RDRM
U1-1	U10A-04301	Lotheni	208.88	208.16	B		B	41.22	19.7%	62.34	29.8%	RDRM
U1-1	U10B-04343	Mqatsheni	37.30	36.35	B		B	7.57	20.3%	11.34	30.4%	RDRM
U1-1	U10C-04347	Mkhomazana	96.05	91.71	B		B	18.79	19.6%	28.51	29.7%	RDRM
U1-1	U10D-04222	Rooidraai	13.35	12.93	B		B	2.70	20.2%	4.05	30.4%	RDRM
U1-1	U10D-04298	Nzinga	82.42	80.42	B/C	Catchment management - sedimentation. Reinstate buffer zone. Erosion control. This will improve instream habitat.	B	12.58	15.3%	20.34	24.7%	RDRM
U1-2	U10F-04560	Luhane	36.30	33.08	B/C		B/C	5.84	16.1%	9.54	26.3%	RDRM
U1-2	U10G-04388	Elands	18.87	16.63	B/C	Target improvement especially in the lower reach. Buffer zone, alien removal, water quality practices.	B	3.38	17.9%	5.29	28.0%	RDRM
U1-2	U10G-04405		8.66	6.94	C		C	1.52	17.5%	2.32	26.8%	RDRM

IUA	SQ node	River name	MAR (10^6 m^3)		RDRM EC	Comments	REC	Long-term requirements				Desktop method
			Natural	PD				Low flows		Total flows		
								10^6 m^3	MAR	10^6 m^3	MAR	
U1-2	U10G-04473	Elands	67.14	59.47	B	Target improvement especially in the upper reach. Buffer zone, alien removal, water quality practices. Also flow improvements.	B	12.88	19.2%	20.51	30.5%	DRM
U1-3	U10H-04576	Tholeni	14.07	10.69	B		B	2.57	18.3%	4.15	29.5%	DRM
U1-3	U10H-04666	Ngudwini	20.35	13.15	B/C	Address erosion to reduce sedimentation (overgrazing, forestry, informal agriculture).	B	2.48	12.2%	4.57	22.5%	DRM
U1-3	U10H-04708	Ngudwini	47.21	35.64	B		B	7.02	14.9%	12.40	26.3%	DRM
U1-3	U10H-04729	Mzalanyoni	22.98	19.63	B		B	4.40	19.1%	7.01	30.5%	DRM
U1-3	U10J-04721	Pateni	6.23	4.01	B		B	1.43	22.9%	2.13	34.3%	RDRM
U1-4	U10J-04713	Mkobeni	13.90	11.70	C	Riparian buffer zone in forestry and agricultural areas. Also alien removal.	B	2.00	14.4%	3.30	23.8%	RDRM
U1-4	U10J-04820	Lufafa	26.09	21.53	B/C	Erosion control, riparian buffer.	B	4.26	16.3%	6.94	26.6%	DRM
U1-4	U10J-04837		0.39	0.32	A/B		A/B	0.06	16.1%	0.10	26.6%	DRM
U1-4	U10K-04842	Nhlavini	40.18	28.98	B		B	6.19	15.4%	10.48	26.1%	RDRM
U1-4	U10K-04899	Xobho	19.09	11.81	C/D		C/D	2.05	10.7%	3.61	18.9%	RDRM
U1-4	U10K-04946	Nhlavini	6.65	4.49	B/C		B/C	0.99	14.8%	1.65	24.8%	RDRM
IUA U2: uMngeni												
U2-1	U20B-04074	Ndiza	12.27	10.86	B/C	Reinstate riparian zone in forestry.	B	2.73	22.2%	3.89	31.7%	RDRM
U2-1	U20B-04173	Lions	39.85	34.29	C	Reinstate riparian zone in forestry and wetland buffers. Address irrigation return flows (water quality) and town runoff.	B	6.64	16.6%	10.11	25.4%	RDRM
U2-1	U20C-04332	Gqishi	15.90	12.94	B/C	Riparian zone buffer to be improved.	B	3.48	21.9%	4.91	30.9%	RDRM
U2-1	U20C-04340	Nguklu	7.02	5.88	C		C	1.35	19.3%	1.94	27.7%	RDRM
U2-2	U20D-04029	Yarrow	11.56	7.81	B/C	Agricultural area - wetland buffers.	B	2.02	17.5%	3.18	27.5%	RDRM
U2-2	U20D-04098	Kusane	16.85	12.50	D		D	2.28	13.5%	3.48	20.7%	RDRM
U2-2	U20E-04136	Nculwane	14.19	10.73	C		C	1.88	13.3%	3.19	22.5%	RDRM
U2-2	U20E-04271	Doring Spruit	8.12	6.53	B/C		B/C	1.60	19.7%	2.36	29.1%	RDRM
U2-2	U20F-04011	Sterkspruit	30.34	13.44	C/D		C/D	3.33	11.0%	5.61	18.5%	RDRM
U2-3	U20F-04095	Mpolweni	17.59	7.76	C/D		C/D	1.44	8.2%	2.83	16.1%	RDRM
U2-3	U20F-04131	Mhlalane	14.48	6.31	C/D		C/D	1.52	10.5%	2.59	17.9%	RDRM
U2-3	U20F-04204	Sterkspruit	48.79	22.41	B/C		B/C	5.67	11.6%	9.61	19.7%	RDRM
U2-3	U20F-04224	Mpolweni	70.74	33.64	B/C		B/C	9.85	13.9%	15.43	21.8%	RDRM
U2-3	U20G-04194	Mkabela	19.91	16.79	C/D		C/D	1.60	8.0%	3.40	17.1%	RDRM

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								Low flows		Total flows		
			Natural	PD				10^6 m^3	MAR	10^6 m^3	MAR	
U2-3	U20G-04215	Cramond Stream	0.82	0.69	B/C		B/C	0.09	11.2%	0.17	21.0%	DRM
U2-4	U20H-04410	Nqabeni	5.54	5.54	C		C	0.93	16.8%	1.39	25.1%	RDRM
U2-4	U20H-04449	uMnsunduze	32.22	32.22	C		C	4.85	15.0%	7.51	23.3%	RDRM
U2-4	U20J-04391	uMnsunduze	85.31	101.52	C	Water quality issues to be addresses. Unlikely to achieve required B.	C	14.78	17.3%	22.52	26.4%	RDRM
U2-4	U20J-04401	uMnsunduze	48.70	48.41	D		D	5.27	10.8%	8.91	18.3%	RDRM
U2-4	U20J-04452	Mpushini	6.76	5.40	B/C	Water quality from Ashburton town and other aspects.	B	1.43	21.2%	2.08	30.7%	RDRM
U2-4	U20J-04459	uMnsunduze	94.72	109.39	C	Water quality issues to be addresses. Unlikely to achieve required B.	C	16.51	17.4%	25.26	26.7%	RDRM
U2-4	U20J-04461	Slang Spruit	3.98	3.85	C/D		C/D	0.58	14.5%	0.91	22.8%	RDRM
U2-4	U20J-04488	Mshwati	7.25	5.90	B/C	Lower section in worse state. Reinstate riparian zone, address erosion.	B	1.58	21.8%	2.27	31.3%	RDRM
U2-5	U20K-04181	Mqeku	19.52	17.67	C		C	4.03	20.7%	5.76	29.5%	RDRM
U2-5	U20K-04296	Tholeni	4.14	3.76	C	Riparian zone buffer to be improved.	B/C	0.59	14.1%	0.93	22.4%	DRM
U2-5	U20K-04411	Mqeku	26.24	23.76	B/C	Riparian zone buffer to be improved.	B	5.29	20.1%	7.78	29.6%	RDRM
U2-6	U20M-04642	Palmiet	1.60	1.60	D		D	0.24	15.1%	0.39	24.2%	RDRM
U2-6	U20M-04649	Mbongokazi	0.78	0.78	C		C	0.08	10.5%	0.15	19.5%	DRM
U2-6	U20M-04653	Palmiet	3.87	3.87	C/D		C/D	0.49	12.8%	0.87	22.4%	RDRM
U2-6	U20M-04659	Palmiet	2.92	2.92	C	Urban area. Difficult to address.	C	0.57	19.6%	0.88	30.1%	RDRM
IUA U3: uMdloti												
U3-1	U30A-04228	uMdloti	29.78	29.00	B/C	Improve riparian buffer zone, erosion control.	B	4.97	16.7%	8.42	28.3%	RDRM
U3-1	U30A-04360	uMdloti	73.88	61.40	D		D	6.40	8.7%	12.66	17.1%	RDRM
U3-1	U30A-04363	Mwangala	10.61	10.32	B/C	Improve riparian buffer zone, erosion control.	B	1.87	17.6%	3.10	29.2%	RDRM
U3-2	U30B-04465	Black Mhlashini	5.48	5.39	B/C	Extensive agriculture and urban area. Not possible to improve.	B/C	1.01	18.5%	1.63	29.7%	RDRM
U3-3	U30C-04227	Tongati	23.77	23.34	B/C		B/C	2.72	11.4%	5.36	22.6%	RDRM
U3-3	U30C-04272	Mona	17.14	16.82	B/C	Riparian buffer zone improvement.	B	1.95	11.4%	3.88	22.6%	RDRM
U3-NC	U30E-04207	Mhlali	33.23	31.95	C	Improvement very difficult due to extensive agriculture.	C	4.58	13.8%	8.52	25.6%	RDRM
IUA U4: Mvoti												
U4-1	U40A-03869	Mvoti	52.13	26.65	B/C	Improve riparian buffer in forestry and agriculture areas.	B	10.06	19.3%	13.75	26.4%	RDRM
U4-1	U40B-03708	Intinda	8.18	2.34	C		C	0.54	6.6%	1.24	15.2%	RDRM

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			Natural	PD				Low flows		Total flows		
								10^6 m^3	MAR	10^6 m^3	MAR	
U4-1	U40B-03740	Mvozana	4.67	1.24	C		C	0.27	5.8%	0.68	14.5%	RDRM
U4-1	U40B-03832	Mvozana	22.36	6.12	C/D		C/D	1.74	7.8%	2.62	11.7%	RDRM
U4-1	U40B-03896	Mvoti	70.94	34.75	C		C	9.42	13.3%	14.86	21.0%	RDRM
U4-1	U40C-03982	Khamanzi	31.97	15.52	B/C	Improve riparian buffer in forestry and agriculture areas.	B	5.02	15.7%	7.59	23.7%	RDRM
U4-1	U40D-03867	Mvoti	31.97	15.52	B/C	Erosion control, overgrazing, difficult.	B	15.03	15.6%	21.54	22.3%	RDRM
U4-2	U40D-03908	Mtize	7.64	7.34	B		B	1.57	20.5%	2.46	32.2%	RDRM
U4-2	U40D-03957	Mvoti	146.04	72.67	B		B	28.38	19.4%	39.67	27.2%	RDRM
U4-2	U40E-04079	Faye	13.35	10.73	B		B	2.25	16.9%	3.81	28.5%	RDRM
U4-2	U40E-04082	Sikoto	32.17	25.86	B		B	5.84	18.2%	9.57	29.8%	RDRM
U4-2	U40E-04137	Sikoto	15.38	12.36	B		B	2.89	18.8%	4.66	30.3%	RDRM
U4-2	U40F-03690	Potspruit	4.65	1.52	C		C	0.85	18.3%	1.04	22.3%	RDRM
U4-2	U40F-03694	Hlimbitwa	5.14	1.72	C		C	0.75	14.5%	0.99	19.2%	RDRM
U4-2	U40F-03730	Cubhu	4.88	1.60	C		C	0.70	14.3%	0.95	19.5%	RDRM
U4-2	U40F-03769	Hlimbitwa	11.00	3.88	C		C	1.82	16.6%	2.41	21.9%	RDRM
U4-2	U40F-03790	Nseleni	1.27	0.67	B/C		B/C	0.21	16.8%	0.33	25.7%	DRM
U4-2	U40F-03806	Hlimbitwa	17.89	6.55	B		B	3.71	20.7%	4.44	24.8%	RDRM
U4-2	U40G-03843	Hlimbitwa	64.60	51.33	B		B	13.30	20.6%	20.34	31.5%	RDRM
U4-3	U40H-04091	Pambela	13.18	13.19	B/C	Reinstate riparian zone.	B	2.05	15.6%	3.43	26.0%	RDRM
U4-3	U40H-04117	Nsuze	29.78	29.78	B/C	Reinstate riparian zone.	B	5.04	16.9%	8.22	27.6%	RDRM
U4-3	U40H-04133	Nsuze	15.70	15.69	B/C	Reinstate riparian zone, erosion control.	B	2.66	17.0%	4.34	27.6%	RDRM
IUA U5: NCC												
U5	U50A-04018	Zinkwazi	10.99	10.74	B/C	Extensive development catchment, sugarcane, will require removal etc. Have to reinstate about 13 km of riparian zone.	B/C	2.62	23.8%	3.95	35.9%	RDRM
U5	U50A-04021	Nonoti	30.19	25.95	B/C	Extensive development catchment, sugarcane, will require removal etc. Have to reinstate about 46 km of riparian zone.	B/C	3.66	12.0%	7.31	23.9%	RDRM
IUA U6: uMlazi												
U6-1	U60A-04533	uMlazi	33.14	19.16	C		C	5.44	16.4%	7.95	23.9%	RDRM
U6-1	U60B-04614	Mkuzane	8.41	3.05	C/D		C/D	1.54	18.1%	1.86	21.9%	RDRM
U6-1	U60C-04555	uMlazi	76.13	38.76	C/D		C/D	12.29	16.2%	17.32	22.8%	RDRM
U6-1	U60C-04556	Sterkspruit	9.54	8.72	D	Due to presence of townships, not possible to	D	1.50	16.1%	2.25	24.2%	RDRM

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			Natural	PD				Low flows		Total flows		
								10^6 m^3	MAR	10^6 m^3	MAR	
						improve.						
U6-1	U60C-04613	Wekeweke	1.83	1.05	C		C	0.20	11.1%	0.38	21.1%	RDRM
U6-2	U60D-04661	uMlazi	102.21	65.23	C/D		C/D	17.19	16.9%	25.13	24.7%	RDRM
U6-3	U60E-04714	Mbokodweni	16.83	15.67	B/C		B	2.97	17.6%	4.81	28.6%	RDRM
U6-3	U60E-04792	Mbokodweni	26.15	24.32	C		B	4.40	16.8%	7.04	26.9%	RDRM
U6-3	U60E-04795	Bivane	6.56	6.08	B/C		B	1.17	17.8%	1.89	28.8%	RDRM
U6-3	U60F-04632	Umbilo	12.68	19.43	D		D	1.82	14.4%	2.90	22.9%	RDRM
IUA U7: Lovu												
U7-1	U70A-04599	Serpentine	10.43	6.04	C		C	1.68	16.1%	2.57	24.6%	RDRM
U7-1	U70A-04618		3.46	2.16	C		C	0.59	17.1%	0.89	25.8%	RDRM
U7-1	U70C-04710	Mgwahumbe	22.20	20.19	C		C	5.28	23.8%	7.35	33.1%	RDRM
U7-1	U70D-04800	Nungwane	15.16	9.32	B/C		B/C	3.28	21.6%	4.34	28.6%	RDRM
U7-SC	U70E-04942	Umsimbazi	7.88	7.73	C		C	1.38	17.5%	2.10	26.7%	RDRM
U7-SC	U70E-04974	uMgababa	4.98	4.86	C	Reduce overgrazing, reinstate riparian buffer, erosion measure.	C	1.03	20.7%	1.49	29.9%	RDRM
U7-SC	U70F-04845	aManzimtoti	4.74	4.62	C		C	0.69	14.5%	1.20	25.3%	RDRM
U7-SC	U70F-04893	Little Manzimtoti River	1.44	2.37	C		C	0.16	11.3%	0.29	20.5%	DRM
IUA U8: Mzumbe and Mtwalume												
U8-1	U80B-05145	Mzumbe	7.85	6.42	B		B	1.86	23.6%	2.74	34.9%	RDRM
U8-1	U80B-05161	Mhlabatshane	8.78	8.08	B		B	2.12	24.1%	3.11	35.4%	RDRM
U8-1	U80C-05231	Mzumbe	47.86	44.68	B		B	10.70	22.4%	16.59	34.7%	RDRM
U8-1	U80C-05329	Kwa-Malukaka	9.40	9.10	B		B	2.19	23.3%	3.33	35.4%	RDRM
U8-2	U80E-05028	Mtwalume	27.83	18.10	C	14 dams in first 12 km. Without removal of dams, not possible to improve.	C	3.91	14.1%	6.08	21.9%	RDRM
U8-2	U80E-05212	Quha	11.19	10.64	B		B	3.01	26.9%	4.30	38.4%	RDRM
U8-2	U80F-05258	Mtwalume	42.59	32.21	B/C	Improve water quality of return flows.	B	5.88	13.8%	10.27	24.1%	RDRM
U8-2	U80F-05301	uMngeni	7.24	7.14	B/C	Improve water quality of return flows. Reinstate buffer zone.	B	1.40	19.3%	2.20	30.4%	RDRM
U8-SC	U80G-05097	Fafa	46.44	38.58	B	Reinstate riparian zone. Improve flow (optimise irrigation methods) and agricultural return flows – water quality.	B	8.76	18.9%	14.02	30.2%	RDRM
U8-SC	U80H-05109	Mzinto	22.90	19.89	C	Reinstate riparian zone. Improve flow (optimise	C	3.17	13.9%	5.75	25.1%	RDRM

IUA	**SQ node**	**River name**	**MAR (10^6 m^3)**		**RDRM EC**	**Comments**	**REC**	**Long-term requirements**				**Desktop method**
								Low flows		**Total flows**		
			Natural	**PD**				**10^6 m^3**	**MAR**	**10^6 m^3**	**MAR**	
						irrigation methods) and agricultural return flows – water quality.						
U8-SC	U80J-04979	Mpambanyoni	12.62	10.21	B		B	3.09	24.5%	4.55	36.1%	RDRM
U8-SC	U80J-05043	Ndonyane	6.52	5.67	B	Reinstate riparian zone. Erosion control.	B	1.29	19.7%	2.04	31.3%	RDRM
U8-SC	U80K-04952	Mpambanyoni	57.96	53.11	C	Water quality from irrigation return flows addressed. Reinstate riparian zone as buffer. Erosion control.	B	5.79	10.0%	11.72	20.2%	RDRM
U8-SC	U80L-05020	aMahlongwa	10.48	10.06	B/C	Reinstate riparian zone as buffer. Erosion control.	B	2.55	24.3%	3.73	35.6%	RDRM

1 Where there is no information provided under River name it means that the river has no name and this cell was therefore left blank

6 ESTUARINE ECOLOGICAL WATER REQUIREMENTS

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2b: Supporting Information on the Determination of Water Resource Classes – uMkhomazi (U1) Estuary EWR and Ecological Consequences of Operational Scenarios. Prepared by MER for Rivers for Africa eFlows Consulting PTY Ltd. December 2014. DWS Report: RDM/WMA11/00/CON/CLA/0614

Department of Water and Sanitation (DWS), South Africa. 2015a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2a: Supporting Information on the Determination of Water Resource Classes – Mvoti (U4) Estuary EWR and Ecological Consequences of Operational Scenarios. Prepared by CSIR for Rivers for Africa eFlows Consulting PTY Ltd. April 2015. DWS Report: RDM/WMA11/00/CON/CLA/0614.

Department of Water and Sanitation (DWS), South Africa. 2015b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2c: Supporting Information on the Determination of Water Resource Classes –Mhlali (U30E) Estuary EWR and Ecological Consequences of Operational Scenarios Prepared by: CSIR for Rivers for Africa eFlows Consulting PTY Ltd. April 2015. DWS Report: RDM/WMA11/00/CON/CLA/0614.

Note that this chapter only provides the EcoClassification component of the EWRs. The scenario that complies to the EWR will be discussed and presented in Chapter 9.

6.1 uMKHOMAZI (U1) ECOCLASSIFICATION

6.1.1 uMkhomazi PES

For the purposes of this EWR study, the geographical boundaries of the estuary are defined as follows (Figure 6.1):

Downstream boundary:	Estuary mouth: 30°12'4.45"S, 30°48'8.65"E
Upstream boundary:	30°10'25.64"S, 30°44'51.42"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 6.1 **Geographical boundaries of the uMkhomazi Estuary based on the Estuary Functional Zone (historical boundary delineated in dark blue)**

The uMkhomazi Estuary in its present state is 69% similar to the natural condition, which translates into a PES of a C EC (Table 6.1) and attributed to the following factors:

- The weir in the upper reaches reducing the connectivity between the river and estuary and contributing to loss of estuarine habitat.
- Sandmining that has taken away the sandbanks in the upper reaches (Zone C), resulting in loss of intertidal areas and backwater refuge areas. It has also impacted on access to cattle grazing areas as the river cannot be crossed in this section anymore.
- Recreational activities (e.g. boat launching) in the lower reaches affecting bird abundance.
- Over exploitation of living resources (e.g. cast netting and line fishing); and
- Agricultural activities and disturbance in the Estuary Functional Zone (EFZ) causing loss of estuarine habitat.

Table 6.1 **Estuarine Health Score for the uMkhomazi Estuary**

Variable	Estuarine health score		
	Overall	Excluding flow related pressures	Confidence
Hydrology	66.8	67	Medium
Hydrodynamics and mouth condition	95	95	Medium/High
Water quality	66.6	66.6	Medium
Physical habitat alteration	78	78	Medium
Habitat health score	**76**	**76**	**Medium**
Microalgae	90	99	Medium
Macrophytes	21	84	Medium
Invertebrates	75	78	High
Fish	60	70	Medium
Birds	60	70	Medium
Biotic health score	**61**	**80**	**Medium**

Variable	Estuarine health score		
	Overall	Excluding flow related pressures	Confidence
ESTUARY HEALTH SCORE	**69**	**78**	
PES	**C**	**B**	
OVERALL CONFIDENCE	**Medium**	**Low**	

6.1.2 Relative contribution of flow and non-flow related impacts on health

Using estimates of the contribution of non-flow related impacts on the level of degradation of each component led to an increase in the PES health score from 69 to 78, which would raise the health score to a B Category. This suggests that both flow and non-flow related impacts have played a role in the degradation of the estuary to a C.

The highest priority is to address the quality of influent water. Of the non-flow-related impacts, habitat loss (within the 5 m contour and above the Sappi weir) along with water quality problems as a result of the nutrient load associated with catchment inflows and the WWTWs (small) were the most important factors influencing ecological health of the system. The excess nutrients in the inflowing water are considered an important factor to consider with increased abstraction from the system. Retention of these high concentrations of nutrients will lead to nuisance algal growth, low DO in the water and reduced habitat quality.

6.1.3 Estuary importance

The Estuary Importance Score takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account. Biodiversity importance, in turn is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. Estuary Importance was estimated at 85, i.e. the estuary is rated as “Highly Important” (Table 6.2).

Table 6.2 Estuarine Importance scores for the uMkhomazi Estuary

Criterion	Weight	Score
Estuary Size	15	80
Zonal Rarity Type	10	30
Habitat Diversity	25	60
Biodiversity Importance	25	91.5
Functional Importance	25	100
Weighted Estuary Importance Score		**85**

The functional Importance of the uMkhomazi Estuary is very high. It serves as an important nursery for exploited fish stock and plays a very important role from a fish egg production perspective. In addition, it is also an important movement corridor for eels (CITES listed species).

The functional importance of uMkhomazi Estuary is also very high for the nearshore marine environment. It is one of five key systems (Mfolozi, Mvoti, uMngeni, uMkhomazi, and Umzimkulu) that supply sediment, nutrients and detritus to the coasts. The sediment load from the uMkhomazi is especially important as it is habitat forming and plays an important role in maintaining the beaches and near shore habitat along this coast.

The impact of further dam development on the nearshore marine environment was not assessed as part of this study, but should be evaluated to ensure that all ecological processes and related ecosystem services (e.g. nearshore pelagic and prawn fishery) are addressed.

The uMkhomazi forms part of the core set of priority estuaries identified in the National Estuary Biodiversity Plan in need of protections to meet biodiversity targets under the Biodiversity Act and National Estuarine Management Protocol promulgated under the Integrated Coastal Management Act. The National Estuary Biodiversity Plan requires that the uMkhomazi Estuary be partially protected (e.g. no-take fishing zone and 25% of riverine area left untransformed) with a Recommended Ecological Category (REC) of B.

6.1.4 Recommended Ecological Category

The REC represents the level of protection assigned to an estuary. The PES sets the minimum REC. The degree to which the REC needs to be elevated above the PES depends on the level of importance and level of protection or desired protection of a particular estuary. The PES for the uMkhomazi Estuary is a C, but the Estuary is rated as “Very Important” from a biodiversity perspective and should therefore be in a B Category (Table 6.3).

Table 6.3 Estuary protection status and importance, and the basis for assigning a REC

Protection status and importance	REC	Policy basis
Protected area	**A or BAS***	**Protected and desired protected areas should be restored to and maintained in the best possible state of health.**
Desired Protected Area		
Highly important	**PES + 1, min B**	**Highly important estuaries should be in an A or B Category.**
Important	PES + 1, min C	Important estuaries should be in an A, B or C Category.
Of low to average importance	PES, min D	Estuaries to remain in a D Category.

* Best Attainable State

In addition, the system also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan and the National Biodiversity Assessment (NBA) 2011 (Turpie *et al*., 2013; Van Niekerk and Turpie, 2012). The NBA 2011 recommends that the minimum Category for the uMkhomazi should be a B, it be granted full no-take protection, and that 25 % of the estuary margin be undeveloped.

Taking into account the current conditions (PES = C), the reversibility of the impacts, the ecological importance and the conservation requirements of the uMkhomazi Estuary the REC for the system is a B Category.

6.2 MVOTI (U4) ECOCLASSIFICATION

For the purposes of this EWR study, the geographical boundaries of the estuary are defined as follows (Figure 6.2):

Downstream boundary:	Estuary mouth: 29°23'31.08"S, 31°20'4.31"E
Upstream boundary:	29°22'12.68"S, 31°18'15.83"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 6.2. Geographical boundaries of the Mvoti Estuary based on the Estuary Functional Zone

6.2.1 Mvoti PES

The Mvoti Estuary in its present state is estimated to be 55% similar to natural condition, which translates into a PES of D Category. The PES is mostly attributed to the following factors:

- The high organic load in effluent from the SAPPI Stanger mill just upstream of the estuary head, which contribute to regular low oxygen events (< 4 mg/l).
- Increased nutrient input as a result of poor catchment practises, causing excessive growth of reeds and aquatic invasive plants in intertidal and subtidal habitats.
- Significant loss of habitat in the EFZ as a result of sugarcane farming;
- Changes in sediment structure due to sand mining; and
- The loss of resetting floods which otherwise assist in removing excess vegetation growth from intertidal, subtidal and supratidal areas (important bird habitat).

Table 6.4 Estuarine Health Score for the Mvoti Estuary

Variable	Estuarine health score		
	Overall	Excluding flow related pressures	Confidence
Hydrology	53.4	53	Medium
Hydrodynamics and mouth condition	95	95	High
Water quality	58.4	58.4	Medium
Physical habitat alteration	73	92	Medium
Habitat health score	**70**	**75**	
Microalgae	80	98	
Macrophytes	32	73	High
Invertebrates	25	96	Medium
Fish	55	87	Medium
Birds	10	64	High
Biotic health score	**40**	**88**	
Estuary Health Score	**55**	**81**	
Present Ecological Status (PES)	**D**	**B**	
Overall Confidence	**Medium**	**Low**	

6.2.2 Estuary importance

The Estuary Importance Score takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account. Biodiversity importance, in turn is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. The scores have been determined for all South African estuaries, apart from functional importance, which was scored by the specialists in the workshop. The Mvoti Estuary is rated as “Important”.

Even though the Mvoti Estuary tends to recruit high numbers of estuarine associated fish in spring and summer, it is of low nursery value as river flow is relatively high (for its size) for most of the year and there are few backwater areas for fish to take refuge in from the main currents. However the Mvoti Estuary is an important movement corridor for eels. This places significance on ecological flow and water quality requirements for the estuary (and the river).

In the 1980s Mvoti Estuary was noted for its high species richness of waterbirds, as well as a high density of waterbirds relative to the length of available shoreline (Ryan *et al.* 1986). The Mvoti Estuary is classified as a sub-regional Important Bird Area (IBA; Barnes, 1998). Large numbers of terns, up to 10 000 individual birds, have been recorded regularly roosting at the estuary on expansive and exposed islands in the main water channel. Another key waterbird species is the Collared Pratincole, a Red Data species (Barnes, 2000), which has been found breeding on the exposed sandbanks in the river. Other noteworthy Red Data waterbirds recorded at the estuary include African Marsh Harrier, Woolly-necked Stork and Chestnut-banded Plover. Mvoti Estuary has also boasted the regular presence of a large number of vagrant waterbirds over the years, making it a popular spot for bird-watching and bird-watchers. A recent investigation into the current IBA status of the Mvoti Estuary (Theron, 2012), however, reported that the aquatic avifauna of the site has deteriorated sharply since about the mid-2000s and recommended that the site be de-listed as an IBA. Since that time, large numbers of terns no longer roost at the estuary and nor do Collared Pratincoles nest there. The aquatic avifauna of the estuary is now a mere remnant of what it once was and the site is no longer attractive as a bird-watching locality.

The functional importance of Mvoti Estuary is very high for the nearshore marine environment. It is one of five key systems (Mfolozi, Mvoti, uMngeni, uMkhomazi, Umzimkulu) that supply sediment, nutrients and detritus to the coasts. The sediment load from the Mvoti is especially important, as it is habitat forming and plays an important role in maintaining the beaches and nearshore habitat along this coast. The potentially severe impact of dam development on the nearshore marine environment was not assessed as part of this study, but should be evaluated to ensure that all ecological processes and related ecosystem services (e.g. beaches, coastal buffers against storms, the KwaZulu-Natal prawn fishery) are considered.

Table 6.5 Estuarine importance scores for the Mvoti Estuary

Criterion	Weight	Score
Estuary Size	15	60
Zonal Rarity Type	10	70
Habitat Diversity	25	30
Biodiversity Importance	25	80.5
Functional Importance	25	100
Estuary Importance Score		**69**

6.2.3 Recommended Ecological Category

The PES for the Mvoti Estuary is a D. The Mvoti Estuary is rated as "Important" from a biodiversity perspective and should therefore be in a C Category.

The estuary also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets defined in the National Estuaries Biodiversity Plan and the NBA 2011 (Turpie *et al*.,2013, Van Niekerk and Turpie, 2012).

6.3 MHLALI (U3) ECOCLASSIFICATION

For the purposes of this EWR study, the geographical boundaries of the estuary are defined as follows (Figure 6.3):

Downstream boundary:	Estuary mouth: 29°27'41.37"S, 31°16'37.04"E
Upstream boundary:	29°26'40.83"S, 31°14'58.85"E
Lateral boundaries:	5 m contour above MSL along each bank

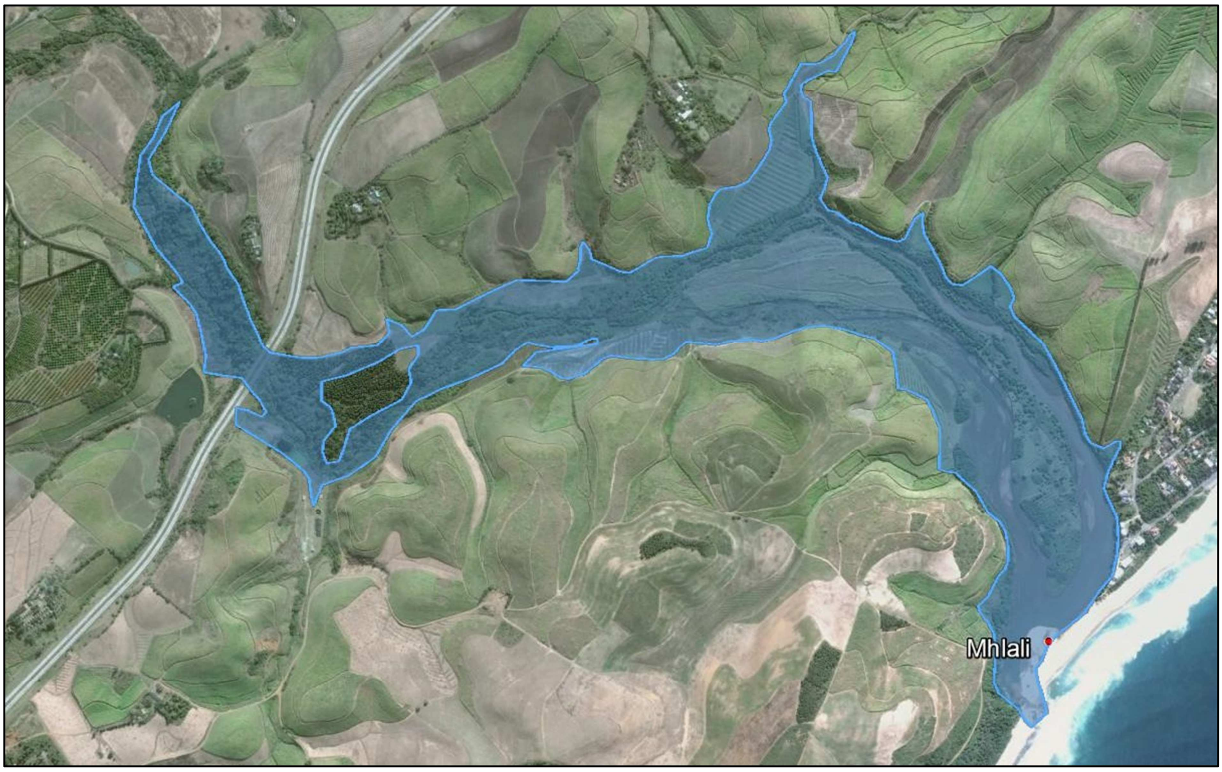

Table 6.6. Geographical boundaries of the Mhlali Estuary based on the Estuary Functional Zone

6.3.1 Mhlali PES

The scores allocated to the various abiotic and biotic health parameters for the Mhlali Estuary and the overall PES for the system are calculated by Estuarine Health Index (EHI) (see below). The Mhlali Estuary present state was estimated to be 57 (i.e. 57% similar to natural condition), which translates into a PES of Category D. The PES is mostly attributed to the following factors:

- Increase in nutrient input as a result of WWTW and poor catchments practises, causing excessive growth of reed and aquatic invasive plants in intertidal and subtidal habitats.
- Significant loss of habitat in the Estuary Functional Zone as a result of sugar cane farming; and
- Artificial breaching of the estuary mouth at lower than natural levels.

The Mhlali Estuary is on a steep trajectory downwards as significant further deterioration in estuary health is anticipated once the Shakaskraal WWTW runs at full capacity and the Tinley Manor WWTW (planned for 2015) discharges into the estuary.

Table 6.7 Estuarine Health Score for the Mvoti Estuary

Variable	Estuarine health score		
	Overall	Excluding flow related pressures	Confidence
Hydrology	62	62	Low
Hydrodynamics and mouth condition	80	80	Low
Water quality	62.2	62.2	Low
Physical habitat alteration	60	98	Low
Habitat health score	**66**	**76**	
Microalgae	50	100	Low
Macrophytes	51	90	Low/Medium
Invertebrates	40	88	Low

Variable	Estuarine health score		
	Overall	Excluding flow related pressures	Confidence
Fish	60	92	Low
Birds	40	92	Low
Biotic health score	**48**	**92**	
ESTUARY HEALTH SCORE	**57**	**84**	
PRESENT ECOLOGICAL STATUS (PES)	**D**	**B**	
OVERALL CONFIDENCE	**Low**	**Low**	

6.3.2 Relative contribution of flow and non-flow related impacts on health

Estimates of the contribution of non-flow related impacts on the level of degradation of each component led to an adjusted health score of 84, which would raise the PES to a B Category. This suggests that non-flow impacts have played a significant role in the degradation of the estuary to a D, but that flow-related impacts are also one of the main causes of degradation. **The highest priority is to address is the quality of influent water**. Of the non-flow-related impacts, water quality problem as a result of the high nutrient load associated with the WWTWs and poor catchments practises was found to be the most important factor that influenced the health of the system. The excess nutrients in the inflowing water increased plant growth and loss of open intertidal and riparian habitat (e.g. sand and mudbanks that use to be important bird habitats). Low oxygen events that is associated with high nutrient and organic inputs reduce invertebrate abundance to 40% of Reference Conditions and prevents the system from functioning as an effective fish nursery, thus in turn, reducing food availability to birds.

Another key non-flow related pressure was the **loss of riparian area due to sugarcane farming** in the EFZ, causing loss in estuary habitat and loss of a buffer area against human disturbance.

6.3.3 Estuary importance

The Estuary Importance Score takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account (see below). Biodiversity importance, in turn is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. The scores have been determined for all South African estuaries, apart from functional importance, which is scored by the specialists in the workshop. Historically the Mhlali supported a very good diversity of fish species. This is reduced under present day conditions. Although the Mhlali is a relatively small system located on a section of coast with a relative abundance of estuaries, the nature of the system (bathymetry, mouth dynamics and resulting salinity regimes over different states) renders its nursery potential good. From a functional importance perspective, it can be considered of medium nursery value for estuarine associated fish species in the region.

The EIS for the Mhlali Estuary, is estimated to be 63, i.e., the estuary is rated as “Important”.

Table 6.8 Estuarine Importance scores for the Mhlali Estuary

Criterion	Weight	Score
Estuary Size	15	60
Zonal Rarity Type	10	10
Habitat Diversity	25	90
Biodiversity Importance	25	80
Functional Importance	25	70
Weighted Estuary Importance Score		**63**

6.3.4 Recommended Ecological Category

The PES for the Mhlali Estuary is a D, with a sharp downwards trajectory. The Mhlali Estuary is rated as "Important" from a biodiversity perspective and should therefore be in a C Category.

In addition, the system also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets as defined in the National Estuaries Biodiversity Plan and the NBA 2011. The NBA 2011 recommends that the minimum Category for the Mhlali be a B, that the system be a granted partial no-take protection, and that 50% of the estuary margin be undeveloped.

Based on the above and the reversibility of impacts, the Recommended Ecological Category for the Mhlali Estuary is a B Category.

7 DESCRIPTION OF SCENARIOS

This chapter is an extract from the following reports:

Department of Water and Sanitation (DWS), South Africa. 2014c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Water Resource Analysis Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by WRP Consulting Engineers. October 2014. DWS Report: RDM/WMA11/00/CON/CLA/0414.

Department of Water and Sanitation (DWS), South Africa. 2015c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2015. DWS Report: RDM/WMA11/00/CON/CLA/0215.

Scenarios were identified from different sources of information and ongoing planning processes undertaken by the Department of Water Affairs and Municipalities as described below. The different scenarios and naming used during the course of the study are summarised in Appendix A.

7.1 BACKGROUND

The main purpose of the Water Resource Analysis task is to assess the water resource availability of the various water supply systems within the context of alternative development conditions. Within the integrated water resource management process outlined in Table 7.1, this task formed part of integrated Step 3 and 4. The delineation of the Integrated IUAs and the identification of biophysical nodes in the Mvoti WMA were done as part of the Status Quo assessment. Details of the IUAs and DBNs are described in the Status Quo report (DWA, 2013a) and were used as units of reference for the Water Resource Analyses. Natural and Present Day flow time series data were derived for all the DBNs as well as for the estuaries. System configurations of available Decision Support Systems (DSSs) were obtained and refined to enable modelling of PD flow at the DBNs. Operational scenarios were subsequently formulated and analysed for four selected catchments, namely the Lovu, Mvoti, uMkhomazi and the uMngeni.

The results of the Water Resource Analyses documented in this Chapter informed the EWR quantification and integrated water resource management processes.

Table 7.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	**Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.**
4	**Identify and evaluate scenarios within the Integrated Water Resource Management process.**
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.

Step	Description
7	Gazette and implement the class configuration and RQOs.

7.2 MVOTI RIVER CATCHMENT (U40A - U40D)

The proposed scenarios for the Mvoti system are summarised in Table 7.2 and each scenario and its associated variables are described in the sub-sections that follow. The PES and the REC for the EWR sites on the Mvoti River System and the estuary can be summarised as follows:

Mv_I_EWR1 (Heinespruit downstream (d/s) of Greytown):	PES = C = REC
Mv_I_EWR2 (d/s of Hlambitwa confluence):	PES = BC = REC
Estuary:	PES = D = REC

Table 7.2 Summarised description of Mvoti Scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	Yes	No	No	No	No
MV21	Yes	No	REC tot[2]	No	No
MV22	Yes	No	REC low[3]	No	No
MV3	Yes	Yes	No	Yes	Yes
MV41	Yes	Yes	REC tot[2]	Yes	Yes
MV42	Yes	Yes	REC low[3]	Yes	Yes
MV43	Yes	Yes	REC low+[4]	Yes	Yes

1 Mvoti River Development Project (Isithundu Dam). 2 Recommended Ecological Category (Total Flows)
3 Recommended Ecological Category (Low Flows).
4 Recommended Ecological Category (Total Flows for January, February, March and Low Flows for remaining months).

7.2.1 Scenario MV1: Present Day

The Water Resource Yield Model (WRYM) configurations from the original DWS Mvoti River Dam Feasibility Study were updated with the latest information available to produce the best possible estimate of present day flow. Information from the DWS All Towns Reconciliation Strategies and the Water Reconciliation Strategy Study for the KZN Coastal Metropolitan Areas was used to define the urban and industrial water requirements and return flows to PD levels (2007).

7.2.2 Scenarios MV21 and MV22: Present Day and REC EWR

For these scenarios, both the total flow EWRs set to achieve the REC (**MV21**) and the low flow EWRs set to achieve the REC (**MV22**) were included in the model and the modelled flows at the EWR sites were assessed for present day conditions.

The purpose of these scenarios is to determine to what degree both the two EWR flow scenarios (**MV21** and **MV22**) with the tributary inflows will achieve the REC and whether curtailments in the upstream water use are required under present day conditions bearing in mind that there is currently minimal storage regulation in the Mvoti River System, with the only noticeable dam being Lake Merthley in the upper reaches of the catchment (which supports Greytown).

In view of the current infrastructure no upstream releases can be made in support of Mv_I_EWR1 and Mv_I_EWR2. Restrictions can be implemented on two user groups supplied from run-of-river abstractions to meet the EWR at Mv_I_EWR2. The total demand for these two irrigation water user groups amounts to only 4.47 million m^3/a and support towards the EWR was found to be limited. The socio-economic implications of meeting the EWR through curtailments in upstream water use will therefore not be significant. The simulated average annual results for the two EWR sites and the estuary are summarised in Table 7.4.

7.2.3 Scenario MV3: Ultimate Development, Mvoti River Development Project and Imvutshane Dam

This scenario included estimates of increased water use and return flows for the domestic sector (Greytown and KwaDukuza). The increase was due to population growth and improved service delivery for the ultimate development scenario. Information on estimated increase in domestic use was sourced from the DWA's All Towns Strategies. Since Greytown's PD water use already exceeded the yield of Lake Merthley, it was assumed that the town's increased water use will be supplied from groundwater resources. To this end, adjustments were made to the natural surface runoff from the incremental catchment affected by the increased groundwater use. The runoff from simulation catchment MC3 was subsequently reduced by 2.1%. The projected 2040 return flows included for Greytown and KwaDukuza amounted to 1.578 and 7.26 million m^3/a respectively.

This scenario also included the implementation of the Mvoti River Development Project (Isithundu Dam with a gross storage capacity of 51.8 million m^3) and the Imvutshane Dam (located on a tributary of the Hlimbitwa River just above the Mvoti and Hlimbitwa confluence).

Information on the Imvutshane Dam was obtained from the Initial Feasibility Study for the Proposed Imvutshane Dam (Umgeni Water, 2009). The Imvutshane Dam is currently in construction and is situated on the Imvutshane River approximately 10 km from Mapumulo. The purpose of the Imvutshane Water Supply Scheme (WSS) is to augment the water supply to Mapumulo and Maqumbi. The initial total demand for Mapumulo and Maqumbi is estimated at 6Ml/d with an ultimate demand of 23 Ml/d by 2045. Umgeni Water (personal communication with Mr. P Sithole on 24 July 2014) confirmed that Phase 3 of the project, which involves an upgrade of the abstraction works to 12 Ml/d (4.38 million m^3/a) should be implemented around 2040. The supply from the Imvutshane Dam will also be augmented with an abstraction from the Hlimbitwa River. Information on environmental releases from the dam was sourced from the relevant licence application.

The following information relating to the Imvutshane WSS was adopted for inclusion in the WRYM configuration:

- Imvutshane Dam catchment area: 42.86 km^2.
- Imvutshane Dam NMAR: 8.80 million m^3/a.
- Full Supply Capacity (FSC) of dam: 3.11 million m^3.
- Buffer storage reserved for environmental releases: 0.311 million m^3 (10% of FSC).
- Abstraction from dam in 2040: 12Ml/d (4.38 million m^3/a).
- Maximum capacity for diversion from Hlimbitwa: 0.1 m^3/s.
- Environmental releases: 0.054 m^3/s May – October; 0.069 m^3/s November – April.

As indicated in Table 7.1 scenario **MV3** excluded the Mvoti EWRs and to be consistent no environmental releases were made from Imvutshane Dam for this scenario as well. The purpose of this scenario was to determine the Excess Firm Yield (EFY) at Isithundu Dam for the 2040 development conditions and to assess the modelled flows at the EWR sites with the system operated at the EFY (i.e. the EFY is imposed as a direct abstraction from Isithundu Dam. All downstream water users were supported from the proposed Isithundu Dam which means that the water resources of the Mvoti were fully utilised for this scenario.

7.2.4 Scenario MV41, MV42 and MV43: Ultimate Development, REC EWR and MRDP

These scenarios are based on Scenario **MV3** but the flows at the EWR sites are assessed for the implementation of the following alternative EWRs:

- Total flow EWRs set to achieve the REC (**MV41**).
- Low flow EWRs set to achieve the REC (**MV42**).
- Total Flows for January, February and March and Low Flows for the remaining months set to achieve the REC (**MV43**).

The purpose of these scenarios is to determine to what degree the total flow, low flow and the in between flow (low+) EWRs together with the dam spills and tributary inflows will achieve the REC EWRs. It is important to note that the Imvutshane environmental releases, as specified in Section 7.1.3, were implemented for all three of these scenarios.

The 'cost' of releasing an EWR from the future Isithundu Dam (and possibly Imvutshane Dam) can then be determined as an impact on the current socio-economics. To facilitate this, the EFY was determined for all three scenarios and the results are compared against the EFY of scenario **MV3** (considered as baseline) to evaluate the impact of implementing the alternative EWRs. The yield results are summarised in Table 7.3.

Table 7.3 Mvoti: Summary of Excess Firm Yield results

Scenario	EWR	Isithundu EFY (million m^3/a)	Reduction in yield due to EWR (million m^3/a)
MV3	No	34.88	-
MV41	REC tot	8.02	26.86
MV42	REC low	15.22	19.66
MV43	REC low+	13.77	21.11

The flows at the EWR sites and the estuary, as simulated for the three scenarios, are summarised in Table 7.4. As expected, the results for Mv_I_EWR1 are identical for all three scenarios. The simulated time series of flows were provided to the Ecological team for further assessment.

Table 7.4 Mvoti: Simulated results for scenarios MV41, MV42 and MV43

EWR site name	SQ reach	Total Flow: 1921 - 1994 (million m^3/a)			WRYM Channel No.
		MV41	MV42	MV43	
Mv_I_EWR1	U40B-03770	6.93	6.93	6.93	103
Mv_I_EWR2	U40H-04064	156.12	148.86	150.40	141
Estuary	-	217.02	209.13	211.12	58

7.3 LOVU RIVER CATCHMENT (U70A - U70D)

The proposed scenarios for the Lovu catchment are summarised in Table 7.5 and each scenario and its associated variables are described in the sub-sections that follow. The EWR for the rapid EWR1 site was not included in any of the operational scenarios and the flow simulated at Lo_R_EWR1 was merely evaluated against the EWR. The PES and the REC for the estuary can be summarised as follows:

- Estuary: PES = C, REC = A/B or BAS.

Table 7.5 Lovu: Summary of operational scenarios

Scenario	Scenario variables			
	Update water demands	Ultimate development demands and return flows (2040)	EWR	Reduced abstraction and afforested areas
LO1	Yes	No	No	No
LO2	Yes	Yes	No	No
LO3	Yes	Yes	No	Yes (25% reduction)
LO4	Yes	Yes	No	Yes (50% reduction)

7.3.1 Scenario LO1: Present Day

As mentioned, information from the WR2012 Study[1] was used for the Water Resources Simulation Model 2000 (WRSM2000) configuration. Updated information on the water abstractions from Nungwane Dam was also source from Umgeni Water and included in the analysis.

7.3.2 Scenario LO2: Ultimate Development (2040)

This scenario includes estimates of increased water use and return flows for the domestic sector due to population growth and improved service delivery for the ultimate development scenario. The return flows are from WWTW situated higher up in the catchment (U70B, Richmond and township). Information on increased water use and return flows for the domestic sector was sourced from the DWS All Towns Strategy Study and other sources such as available municipal documents.

The purpose of this scenario is to monitor the flows at the EWR sites for the ultimate development scenario.

7.3.3 Scenario LO3: Ultimate Development, Reduced Abstraction and Afforestation Areas (25%)

This scenario is based on Scenario **LO2** with a reduction in abstraction from Lovu Dam in the upper part of the catchment as well as a reduction in the afforested areas in order to increase base flows by 25%. The 'cost' of reducing the current abstractions and reducing the afforested areas can also be determined as an impact on the current socio-economics. This scenario will also need to be considered in a process of determining possible trade-offs with other adjacent estuaries.

7.3.4 Scenario LO3: Ultimate Development, Reduced Abstraction and Afforestation Areas (25%)

This scenario is based on Scenario **LO2** with a reduction in abstraction from Lovu Dam in the upper part of the catchment as well as a reduction in the afforested areas in order to increase base flows by 50%. The 'cost' of reducing the current abstractions and reducing the afforested areas can also be determined as an impact on the current socio-economics. This scenario will also need to be considered in a process of determining possible trade-offs with other adjacent estuaries.

7.4 uMNGENI RIVER CATCHMENT (U20A - U20M)

The proposed operational scenarios for the uMngeni catchment are summarised in Table 7.6 and each scenario and its associated variables are described in the sub-sections that follow. It is important to note that the EWRs were not included in any of the operational scenarios.

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[1] The WR2012 study is an update of the WR2005 study (Water Resources of South Africa 2005 study – WRC (2005)) and has not yet been completed.

The PES and the REC for the two intermediate EWR sites and the estuary can be summarised as follows:

Mg_I_EWR2 (between Midmar and Albert Falls):	PES = C = REC
Mg_I_EWR5 (between Nagle and Inanda):	PES = C/D = REC
Estuary:	PES= E, REC = D

Table 7.6 uMngeni Summary of operational scenarios

Scenario	Scenario Variables							
	Update water demands	Update demands and return flows (2022)	Ultimate development demands and return flows (2040)	EWR	MMTS2	uMWP-1[1]	Darvill re-use	eThekwini re-use
UM1	Yes	No	No	No	No	No	No	No
UM2	No	Yes	No	No	Yes	No	No	No
UM41	Yes	No	Yes[2]	No	Yes	No	No	No
UM42	Yes	No	Yes[3]	No	Yes	No	No	No
UM51	Yes	No	Yes[2]	No	Yes	No	Yes	Yes
UM52	Yes	No	Yes[3]	No	Yes	No	Yes	Yes

1 uMkhomazi Water Project Phase 1
2 All future return flows from Phoenix and Mhlanga WWTW to the uMngeni System: Total return flows of 282 Ml/d.
3 All future return flows from Phoenix, Umhlanga and Tongati WWTW to the uMngeni System: Total return flows of 408 Ml/d.

7.4.1 Scenario UM1: Present Day without MMTS2

The latest WRPM configuration used by Umgeni Water for the annual operating analysis of the uMngeni River System was utilised for the present day scenario. The purpose of the scenario was to monitor the flows at the EWR sites for present day (2012) conditions.

7.4.2 Scenario UM2: 2022 Development Level and MMTS2

Scenario **UM1** was updated to include the MMTS2 (Spring Grove Dam) inter-basin transfer as well as the estimates of increased water use and return flows for the domestic sector due to population growth and improved service delivery to represent the 2022 development level (i.e. one year before the implementation of Mkomazi Water Project). The MMTS2 inter-basin transfer discharges into the Mpofana River, which is a tributary of the Lions River that flows into the Midmar Dam catchment and will mainly impact on these two rivers.

This scenario also includes a maximum load shift volume from the Upper to the Lower uMngeni River System via the Western Aqueduct (direct support from Midmar Dam to the eThekwini Durban Heights WTW) while maintaining a 3 months available storage in Midmar Dam as a buffer storage for supplying the Upper uMngeni Demand Centres. Midmar (with support provided from MMTS2) is the only water source to most of the demand centres in the Upper uMngeni System, including Pietermaritzburg. A buffer storage should thus remain in Midmar Dam as a safety factor. A buffer storage in the order of 68 million m^3 was set as target for scenario **UM2** and the load shift volume was determined through iteration. The final analysis for scenario **UM2** included a maximum load shift of 55.23 million m^3/a with a resulting buffer storage of 68.45 million m^3 in Midmar Dam.

The following WWTW discharges representative of 2022 development conditions were included in scenario **UM2**:

- Howick WWTW: 2.468 million m^3/a.
- Darvill WWTW: 23.51 million m^3/a.

- Cato Ridge WWTW: 0.25 million m^3/a; and
- eThekwini WWTW: 61.87 million m^3/a.

The purpose of the scenario is to monitor the flows at the EWR sites for the 2022 development scenario (i.e. before the implementation of the uMWP-1).

7.4.3 Scenario UM41 and UM42: Ultimate Development and MMTS2

These scenarios are based on scenario **UM2** but no allowance was made for load shift from the Upper to Lower uMngeni. As for scenario UM2, water use and return flows for the domestic sector was set at 2022 development conditions. The uMWP-1 was not included in the scenario but demands were set to run the uMngeni system at a firm yield development level (i.e. the demands were adjusted to ensure full utilization of the existing uMngeni water resources).

Return flows were set at 2040 development level:

- Howick WWTW: 3.170 million m^3/a.
- Darvill WWTW: 34.46 million m^3/a.
- Cato Ridge WWTW: 0.25 million m^3/a; and
- eThekwini WWTW: Ultimate Waste Water Generation (2 alternatives as described below).

There are several existing and planned WWTW in the uMngeni catchment and water is also transferred from the Mhlanga River (Phoenix WWTW) to a tributary (Piesangs River) of the uMngeni River. The eThekwini WWTW ultimate waste water generation was included for the diversion of return flows from neighbouring catchments and the following two alternatives were considered:

- Scenario **UM41:** All future return flows from Phoenix and Mhlanga WWTW discharged to the uMngeni System with total return flows amounting to 282 Ml/d (103 million m^3/a).
- Scenario **UM42:** All future return flows from Phoenix, Umhlanga and Tongati WWTW discharged to the uMngeni System with total return flows of 408 Ml/d (149 million m^3/a).

The purpose of these scenarios is to monitor the flows at the EWR sites for the ultimate development scenario with the implementation of MMTS2 and for the two return flow cases (**UM41** and **UM42**).

7.4.4 Scenario UM51 and UM52: Ultimate Development, MMTS2, Darvill Re-use and eThekwini Direct Re-use

As for Scenarios **UM41** and **UM42** with the Darvill Re-use and the eThekwini Direct Re-use options included. Discharges from the Darvill WWTW (Pietermaritzburg area) enter the uMnsunduze River and affect the flow and especially the water quality of the river. Umgeni water is currently investigating the potential of re-using effluent from the Darvill WWTW, which could have a future impact on the uMnsunduze River and the uMngeni River after the uMnsunduze/uMngeni confluence. The eThekwini Municipality has conducted a feasibility study for the re-use of treated effluent in the eThekwini metropolitan area. The implementation of the investigated re-use schemes will have an impact on the WWTW return flows entering the uMngeni River System in the future.

The purpose of the scenarios is to monitor the flows at the EWR sites for the ultimate development scenario with the implementation of MMTS2, Darvill Re-use and eThekwini Re-use included for the two return flow cases (**UM51** and **UM52**) defined as follows:

- Scenario **UM51**: Darvill Re-use of 60 Ml/d (21.915 million m^3/a), i.e. reduce the Darvill return flows by 60 Ml/d.
- Scenario **UM52**: eThekwini Re-use of 41 million m^3/a, i.e. reduce the eThekwini return flows which enter the uMngeni River system just above the estuary by 41 million m^3/a.

7.4.5 Summary of scenario results

In summary the following should be noted in terms of the uMngeni operational scenarios:

- EWRs were not included as demands on the water resource system and the resulting flows at the selected EWR sites were merely evaluated. The standard EWR modelling structures were applied to compare with the simulated results for each scenario.
- Assumptions in terms of the Darvill WWTW return flows impact on the flow at Mg_R_EWR4 (situated on uMnsunduze River) and Mg_I_EWR5 (uMngeni River) as well as on the water supply from the downstream Inanda Dam.
- Assumptions regarding the eThekwini WWTW discharges do not impact on the water supply of the uMngeni system, but affect the inflow to the uMngeni estuary.

The operating rule adopted for the analyses of scenarios **UM41, UM42, UM51** and **UM52** was to ensure full utilization of the uMngeni water resources. This was achieved by iterative adjustment of the demands up to the point where no supply failures occur. The gross water requirements of the demand centres, as projected at the 2022 development level, formed the basis of the assessments and are summarised in Table 7.7 together with the firm supply results obtained for the relevant operational scenarios. Scenarios **UM42** and **UM52** are based on scenarios **UM41** and **UM51** respectively and differences between the scenarios only include changes to the eThekwini WWTW discharges that impact on the inflow to the estuary and not on the supply from the system.

Table 7.7 uMngeni: Demand and supply results for operational scenarios

Description of demand centre	Gross demand for 2022 (million m^3/a)	Firm supply for indicated operational scenarios (million m^3/a)		Difference in supply: UM41 vs UM51 (million m^3/a)
		UM41	UM51	
Durban Heights	219.73	219.71	219.71	0.00
Wiggins	107.50	25.4	3.25	22.15
Pietermaritzburg and Others	146.33	149.48	149.48	0.00
North Industrial re-use	8.80	8.8	8.8	0.00
Total	**482.35**	**403.39**	**381.24**	**22.15**

7.5 uMKHOMAZI RIVER CATCHMENT (U10A – U10M)

The proposed scenarios for the uMkhomazi catchment are summarised in Table 7.8 and each scenario and its associated variables are described in the sub-sections that follow.

The PES and the REC for the EWR sites and the estuary can be summarised as follows:

Mk_I_EWR1 (Lundy's Hill near Bulwer):	PES = C = REC
Mk_I_EWR2 (Hela Hela at start of gorge):	PES = B = REC
Mk_I_EWR3 (upstream of Sappi offtake and gauging weir):	PES = C = REC
Estuary:	PES= C, REC = B

Table 7.8 uMkhomazi: Summary of operational scenarios

Scenario	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini OCD[1]
MK1	Yes	No	No	No	No
MK2	Yes	Yes	No	Yes	Yes (no support)
MK21	Yes	Yes	REC tot[2] (EWR 2)	Yes	Yes (no support)
MK22	Yes	Yes	REC low[3] (EWR 2)	Yes	Yes (no support)
MK23	Yes	Yes	REC low+[4] (EWR 2)	Yes	Yes (no support)
MK31	Yes	Yes	REC tot[2] (EWR 3)	Yes	Yes (no support)
MK32	Yes	Yes	REC low[3] (EWR 3)	Yes	Yes (no support)
MK33	Yes	Yes	REC low+[4] (EWR 3)	Yes	Yes (no support)
MK4	Yes	Yes	No	Yes	Yes (with support)
MK41	Yes	Yes	REC tot[2] (EWR 2)	Yes	Yes (with support)
MK42	Yes	Yes	REC low[3] (EWR 2)	Yes	Yes (no support)

1 Off-channel Dam.
2 Recommended Ecological Category (Total Flows).
3 Recommended Ecological Category (Low Flows).
4 Recommended Ecological Category (Total Flows for January, February, March and Low Flows remaining months).

The EWR modelling structures compiled for the two EWR sites were applied in the WRYM to the simulated EWR demands. Since Mk_I_EWR1 is situated upstream of the proposed Smithfield Dam the EWR modelling structure for this site was not included in any of the operational scenarios.

7.5.1 Scenario MK1: Present Day

The latest WRYM configuration was sourced from the uMWP- 1: Module 1: Technical Feasibility Study Raw Water (DWA, 2014d). The WRYM setup representing the 2008 development level was refined to include modelling of the DBNs.

7.5.2 Scenario MK2: Ultimate Development, MWP and Ngwadini OCD (No MWP Support)

The purpose of this scenario is to determine the system yield prior to the implementation of the EWRs and to assess the flows at the selected two EWR sites (Mk_I_EWR2 and Mk_I_EWR3).

The scenario **MK2** analysis was based on the following assumptions:

- Catchment development was set to reflect the ultimate development level (2040).
- The MWP was implemented with Smithfield Dam operated at its HFY.
- Ngwadini OCD implemented with no support from Smithfield Dam and operated at its HFY.
- EWRs not implemented.
- Modelling of Bulwer WSS, SAPPI-SAICCOR and main stem irrigators.

As indicated above, the Ngwadini OCD was configured in the WRYM in such a way that no support was provided from Smithfield Dam. The strategy adopted for the assessment of Scenario **MK2,** was firstly to determine the HFY for Smithfield Dam and secondly to determine the HFY for

Ngwadini Dam whilst Smithfield is operated at its HFY. The system was finally run with both dams operated at their respective HFYs to get the final simulated flows for scenario **MK2**.

The HFYs for Smithfield and Ngwadini dams were found to be 196.0 million m^3/a and 11.99 million m^3/a respectively.

7.5.3 Scenario MK21, MK22, MK23: Ultimate Development, REC EWR (Mk_I_EWR2), MWP and Ngwadini OCD (No MWP Support)

These scenarios were based on Scenario **MK2** where the flows at the EWR sites were assessed for the following EWR flows:

- Total flow EWRs (Mk_I_EWR2) set to achieve the REC (**MK21**).
- Low flow EWRs (Mk_I_EWR) set to achieve the REC (**MK22**).
- Total Flows for January, February, March and Low Flows remaining months (Mk_I_EWR2) set to achieve the REC (**MK23**).

The purpose of these scenarios was to determine to what degree the total flow, low flow and the in between flow EWRs together with the dam spills and tributary inflows from the dam will achieve the REC at Mk_I_EWR2. The HFYs of Smithfield and Ngwadini were also assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can then be determined as an impact on the current socio-economics.

7.5.4 Scenario MK31, MK32, MK33: Ultimate Development, REC EWR (Mk_I_EWR3), MWP and Ngwadini OCD (No MWP Support)

These scenarios are based on **Scenario MK2** where the flows at the EWR sites will be assessed for the following EWR flows:

- Total flow EWRs (Mk_I_EWR3) set to achieve the REC (**MK31**).
- Low flow EWRs (Mk_I_EWR3) set to achieve the REC (**MK32**).
- Total flows for January, February, March and low flows remaining months (Mk_I_EWR3) set to achieve the REC (**MK33**).

The purpose of these scenarios is to determine to what degree the total flow, low flow and the in between flow EWRs together with the dam spills and tributary inflows from the dam will achieve the REC at Mk_I_EWR3. The HFYs of Smithfield and Ngwadini were also assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can also be determined as an impact on the current socio-economics.

7.5.5 Scenario MK4: Ultimate Development, MWP and Ngwadini OCD (No MWP Support)

This scenario is based on Scenario **MK2** with the only change being that the Ngwadini OCD was configured in the WRYM in such a way that support is provided from Smithfield Dam. The strategy adopted for the assessment of Scenario **MK4,** was firstly to determine the HFY for Ngwadini Dam and secondly to determine the HFY for Smithfield Dam whilst Ngwadini is operated at its HFY. The system was finally run with both dams operated at their respective HFYs to get the final simulated flows for scenario **MK4.**

The purpose of this scenario is to assess the flows at the EWR sites for the ultimate development level with MWP and Ngwadini OCD (with support provided from Smithfield Dam) in place. The HFYs of Smithfield and Ngwadini were assessed to determine the affect of implementing the EWR. The 'cost' of releasing an EWR from the future Smithfield Dam can also be determined as an impact on the current socio-economics.

7.5.6 Scenario MK41, MK42, MK43: Ultimate Development, REC EWR (Mk_I_EWR2), MWP and Ngwadini OCD (With MWP Support)

These scenarios are based on Scenario **MK4** and the flows at the EWR sites were assessed for the following EWR flows:

- Total flow EWRs (Mk_I_EWR2) set to achieve the REC (**MK41**).
- Low flow EWRs (Mk_I_EWR2) set to achieve the REC (**MK42**).

The purpose of these scenarios is to determine to what degree the total flow and low flow EWRs (Mk_I_EWR2) together with the dam spills and tributary inflows from the dam will achieve the REC at the EWR sites.

7.5.7 Summary of scenario results

The flows simulated at the two selected EWR sites (Mk_I_EWR2 and Mk_I_EWR3), as well as the inflow to the uMkhomazi estuary, were monitored for each of the operational scenarios. In additional to these three sites, a fourth site situated just downstream of Smithfield Dam, referred to as EWR_Site_1b, was also included in the evaluation. EWR_Site_1b relates to an EWR site that was analysed as part of the uMkhomazi Study (DWA, 2014d), but for the purposes of the classification study the site was merely monitored due to its location. The relevant time series of flow files generated for the four sites of interest were provided to the Ecological team for further evaluation.

Table 7.9 uMkhomazi: Summary of yield results for operational scenarios

Scenario	Description	Smithfield HFY (million $m^{3/}a$)	Ngwadini HFY (million $m^{3/}a$)	Total HFY (million $m^{3/}a$)	Difference in total HFY due to EWR (million $m^{3/}a$)
MK2	No EWR; No support to Ngwadini	196.0	11.99	207.99	-
MK21	Total Flow EWR (EWR2); No support to Ngwadini	142.2	8.03	150.23	57.76
MK22	Low Flow EWR (EWR2); No support to Ngwadini	150.6	8.03	158.63	49.36
MK23	Low Flow+ EWR (EWR2); No support to Ngwadini	150.6	8.03	158.63	49.36
MK31	Total Flow EWR (EWR3); No support to Ngwadini	150.1	5.98	156.08	51.91
MK32	Low Flow EWR (EWR3); No support to Ngwadini	161.0	6.63	167.63	40.36
MK33	Low Flow+ EWR (EWR3); No support to Ngwadini	161.0	6.63	167.63	40.36
MK4	No EWR; Support to Ngwadini	142.5	54.8	197.3	-
MK41	Total Flow EWR (EWR2) ; Support to Ngwadini	84.1	54.8	138.9	58.40
MK42	Low Flow EWR (EWR2); Support to Ngwadini	92.5	54.8	147.3	50.00

Since scenarios **MK2** and **MK4** do not include EWRs, the yield results of these scenarios are used as benchmark for assessing the impacts of implementing alternative EWRs for a specific EWR site or to determine which EWR site is the driver within the system. The impact on the yield due to the implementation of the various EWRs is indicated in Table 7.9.

The following conclusions are made based on the results presented in Table 7.9:

- Implementation of the Total Flow EWR at Mk_I_EWR2 (**MK21**) reduces the total yield of the system by 27.8% (57.8 million m^3/a).
- Implementation of the Total Flow EWR at Mk_I_EWR3 (**MK31**) reduces the total yield of the system by 25% (51.9 million m^3/a).
- Evaluation of the Scenario **MK21** and **MK31** yield results show that the implementation of the total EWR at Mk_I_EWR2 is causing the total HFY to be about 5.85 million m^3/a less compared to the when the total EWR at Mk_I_EWR3 is implemented.
- In general, the inclusion of the EWR at Mk_I_EWR2 has a higher impact on the total yield compared to the EWR at Mk_I_EWR3.
- Although the HFY for Ngwadini Dam increases by 42.81 million m^3/a when it is supported from Smithfield Dam (Scenario **MK4**), Smithfield's HFY decreases resulting in a lower total HFY compared to that of Scenario **MK2**. The difference in total yield between scenarios **MK2** and **MK4**, which amounts to 10.69 million m^3/a, is therefore due to the change in operating rule whereby support is given to Ngwadini. It is important to note that additional river losses (10%) are included with the Ngwadini support.
- The increase in yield at Ngwadini due to support from Smithfield Dam (**MK4**) should thus be evaluated within the context of the total yield which is 5% lower than that of scenario **MK2**.

7.6 WASTE WATER MANAGEMENT SCENARIOS

A key factor that was identified to influence the ecological health of several estuaries in the study area was 'treated wastewater discharges' servicing the various urban areas located along the coast. The extent of the current and potential future wastewater discharges are summarised in Table 7.10.

Table 7.10 Current and future potential wastewater discharge volumes in the three estuary cluster IUAs

Municipality	Current Discharge Volumes (Ml/day)	Percentage of total (%)	Future Scenario Discharge Volumes (Ml/day)	Percentage of total (%)
Southern Cluster (Ugu DM[1])	26.7	5.4%	44.9	3.5%
Northern Cluster (iLembe)	25.8	5.2%	63.9	4.9%
Central Cluster (eThekwini MM)	440	89.4%	1 188	91.6%
Total	492.5		1 296.8	

1 District Municipality.

Twenty five (25) of the sixty four (64) estuaries are affected by the wastewater discharges and the scenarios were formulated along selected themes as presented in the Table 7.11.

For each scenario theme, a subset of scenarios considering the following management measures was formulated:

- Additional treatment processes to reduce the nutrient pollution load discharged.
- Transferring treated waste from a sensitive estuary to a river and estuary system that is able to assimilate the additional load.
- Discharge of wastewater through sea outfall works - discharges to estuaries are reduced or eliminated.
- Re-use of treated wastewater, both direct and indirect.

Table 7.11 Primary themes defining wastewater management scenarios

Label	Scenario Description
A	Ecological protection is priority (minimum discharge to estuaries).
B	Minimum costs scenario (highest flow through estuaries).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.
E	Indirect re-use (consider volume and practicalities). Remainder According to Scenario C.
F	Direct re-use (consider volume and practicalities). Remainder According to Scenario C.
X	Alternative scenarios (combinations of alternative).

All the scenarios were formulated to handle the ultimate future wastewater volumes for each of the urban areas. The estuaries in the study areas were grouped into three Integrated Units of Analysis (IUAs) namely the Southern Cluster (SC) IUA, the Northern Cluster (NC) and the Central Cluster (CC) IUA with each cluster roughly following the municipal boundaries for Ugu and iLLembe DMs and eThekwini MM respectively.

It was deemed appropriate to subdivide the Southern Cluster further into two IUAs, north and south of the Umzimkulu River (see SC1 and SC 2 in Table 3.8). The motivation for this subdivision was to distinguish between the southern estuaries (SC2) where there are lower intensity development while the northern part (SC1) that is generally more developed as it is close to the highly developed Central Cluster (eThekwini Metropolitan Area).

8 RIVER ECOLOGICAL SCENARIO CONSEQUENCES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014d. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 1: Supporting Information on the Determination of Water Resource Classes – River Ecological Consequences of Operational Scenarios. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. September 2014. DWS Report: RDM/WMA11/00/CON/CLA/0514.

Department of Water and Sanitation (DWS), South Africa. 2014e. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River systems. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2014. DWS Report: RDM/WMA11/00/CON/CLA/1114.

Department of Water and Sanitation (DWS), South Africa. 2015c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2015.
DWS Report: RDM/WMA11/00/CON/CLA/0215.

8.1 BACKGROUND

Within the integrated water resource management process outlined in Table 8.1, this task formed part of integrated Step 4. The objective of this task was to provide the scenario analysis, assumptions and results and document the consequences of the scenarios for the various components under Task D4 which include:

- River Ecological Consequences: This Chapter.
- Estuarine Ecological Consequences: Chapter 9.
- Ecosystem Services Consequences: Chapter 10.
- Economic Scenario Consequences: Chapter 11; and
- Water Quality (User) Consequences: Chapter 12.

Table 8.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.
4	**Identify and evaluate scenarios within the Integrated Water Resource Management process.**
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This Chapter focuses on the results of the river ecological consequences of the operational scenarios at the key biophysical nodes (EWR sites) by evaluating and determining the impact on the EC.

8.2 uMKHOMAZI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

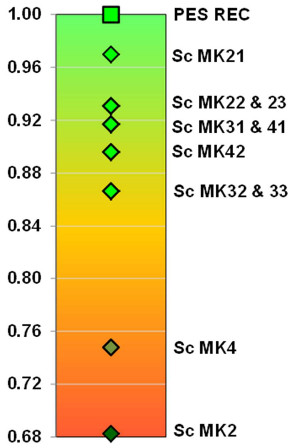
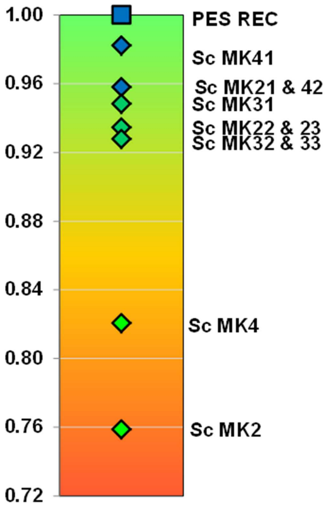
The ecological consequences are summarised in Table 8.2. The first column provides the ECs for each component at the EWR site. The second column provides a summary of the ecological consequences. The third column provides the ranking of the scenarios. The fourth column includes a short explanation of the consequences and ranking. A summary of the ranking is provided in Figure 8.1

MK_I_EWR1: The ranking shows that Sc MK2 and MK4 are the lowest in the ranking order at all sites and significantly lower than the other scenarios. This is because Sc MK2 and MK4 include Smithfield Dam with no EWRs. All the rest of the scenarios still maintain the EcoStatus of a C at Mk_I_EWR1 but do not achieve the REC (PES). The major problem at Mk_I_EWR1 is that the site is close to the dam and therefore only received the water being released from the dam or spills. As the river acts as a conduit to convey water from the dam down the system, the main reasons for not achieving the REC (PES) is the increased (above natural) and unseasonal base flows as well as the decrease in floods.

MK_I_EWR2: As one moves further downstream of the dam, the impacts become less pronounced. At Mk_I_EWR2, tributary inflows mitigate some of the impacts of the unseasonal flows and the lack of floods. However the main users are downstream of Mk_I_EWR2, and therefore the impacts are still felt to some degree. Scenario MK21, MK41 and MK42 still maintain the EcoStatus of a B with Sc MK41 being the better scenario.

MK_I_EWR3: Scenario MK 21 and MK41 are the best options as they are the closest to meeting the ecological objectives. Both these scenarios include the total EWR flows and the impacts are mostly due to the impacts on the dam itself, such as the barrier effect, impact on larger frequency of floods and largely due to the increased (above natural) base flows.

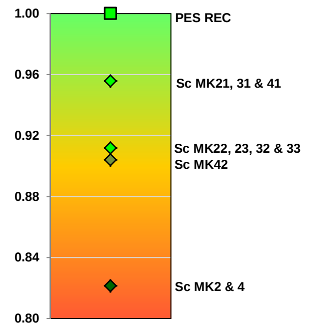
Table 8.2 uMkhomazi River System: Summary of ecological consequences at the EWR sites

<table>
<tr><th>Ecological consequences as ECs</th><th>Ecological consequences</th><th>Ranked scenarios</th><th>Ranking rationale</th></tr>
<tr><th colspan="4">MK_I_EWR1 (UMKHOMAZI RIVER)</th></tr>
<tr>
<td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MK2</th><th>Sc MK21</th><th>Sc MK22, 23</th><th>Sc MK31</th><th>Sc MK32, 33</th><th>Sc MK4</th><th>Sc MK41</th><th>Sc MK42</th></tr>
<tr><td>Physico chemical</td><td>A/B</td><td>C</td><td>A/B</td><td>A/B</td><td>B</td><td>B</td><td>B</td><td>A/B</td><td>A/B</td></tr>
<tr><td>Geom</td><td>A/B</td><td>C/D</td><td>B/C</td><td>C</td><td>B/C</td><td>C</td><td>C</td><td>B/C</td><td>C</td></tr>
<tr><td>Fish</td><td>B</td><td>D</td><td>B/C</td><td>C</td><td>C</td><td>C</td><td>D</td><td>C</td><td>C</td></tr>
<tr><td>Invertebrates</td><td>B/C</td><td>D</td><td>B/C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C</td><td>C</td></tr>
<tr><td>Riparian vegetation</td><td>C</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C/D</td><td>C/D</td></tr>
<tr><td>EcoStatus</td><td>C</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>C</td><td>C</td></tr>
</table>
</td>
<td>Geomorphology is reduced to different degrees under all scenarios due to the impact of the dam on sedimentation and possible erosion and accumulation of fines. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and 4 as they do not include EWR releases. This results in a lack of fast flowing habitats and possible reduction and/or eradication of *Amphilius natalensis and Barbus natalensis*. Scenarios that include EWR releases are an improvement, but the unseasonal releases and at times higher flows than natural are problematic.</td>
<td> </td>
<td>The results illustrate that most of the scenarios meet the ecological objectives in terms of EcoStatus except for Sc MK4 and MK2. These two scenarios do not cater for EWR requirements and are similar, however under Sc MK2 lower flows occur in all months and zero flows occur during drought periods in Oct – Dec and therefore Sc MK2 has the greatest impact. None of the scenarios meet the ecological objectives for all the components. Sc Mk 21 are the best of the options overall and is therefore ranked the highest.</td>
</tr>
<tr><th colspan="4">MK_I_EWR2 (UMKHOMAZI RIVER)</th></tr>
<tr>
<td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MK2</th><th>Sc MK21</th><th>Sc MK22, 23, 32, 33</th><th>Sc MK31</th><th>Sc MK4</th><th>Sc MK41</th><th>Sc MK42</th></tr>
<tr><td>Physico chemical</td><td>A/B</td><td>C</td><td>A/B</td><td>A/B</td><td>A/B</td><td>B</td><td>A</td><td>A</td></tr>
<tr><td>Geom</td><td>B</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>Fish</td><td>B</td><td>D</td><td>C</td><td>C</td><td>C</td><td>C/D</td><td>B/C</td><td>B/C</td></tr>
<tr><td>Invertebrates</td><td>B</td><td>D</td><td>B/C</td><td>B/C</td><td>B/C</td><td>C</td><td>B</td><td>B/C</td></tr>
<tr><td>Riparian vegetation</td><td>B</td><td>C</td><td>B</td><td>B/C</td><td>B</td><td>C</td><td>B</td><td>B</td></tr>
<tr><td>EcoStatus</td><td>B</td><td>C</td><td>B</td><td>B/C</td><td>B/C</td><td>C</td><td>B</td><td>B</td></tr>
</table>
</td>
<td>Geomorphology is reduced to a C under all scenarios due to the impact of the dam on sedimentation, channel narrowing and an increase in embeddedness. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and MK4 as they do not include EWR releases. The other scenarios include increased high flows in the dry season with a loss of slow habitats which impact on *Barbus anoplus* and *Barbus viviparus*.</td>
<td> </td>
<td>None of the scenarios meet the ecological objectives. Although Sc MK21, 41 and 42 results in the same EcoStatus, the instream biota are impacted by the reduced wet season base flows and reduced floods. Sc MK41 is the best scenario of these three scenarios because it provides more flows during wet season. Scenario MK2 and MK4 has the worst impact due to reductions in baseflows during dry and wet seasons.</td>
</tr>
</table>

MK_I_EWR3 (uMKHOMAZI RIVER)

Component	**PES & REC**	**Sc MK2**	**Sc MK21, 31, 41**	**Sc MK22, 23, 32, 33**	**Sc MK4**	**Sc MK42**
Physico chemical	**A/B**	**B/C**	**A/B**	**B**	**B/C**	**B**
Geom	**B**	**C**	**B/C**	**C**	**C**	**C**
Fish	**B**	**C**	**B/C**	**C**	**C**	**C**
Invertebrates	**B**	**C/D**	**B/C**	**C**	**C/D**	**C**
Riparian vegetation	**D**	**D**	**D**	**D**	**D**	**D**
EcoStatus	**C**	**D**	**C**	**C**	**D**	**C/D**

Geomorphology impacts are not as severe as at EWR 1 and 2 due to the distance of the dam. The reduction of large flood and delayed early wet season floods still cause impacts. These habitat changes impact on the instream biota. The worst scenarios are Sc MK2 and MK4 as they do not include EWR releases. The deterioration in fish and inverts, albeit mostly small, is related to the low flows for drought in wet months and impact on spawning. There is no impact on the riparian vegetation.



The results illustrate that none of the scenarios meet the ecological objectives. Sc MK 21, MK31 and MK41 results in the same EcoStatus and has the least impact with a slight deterioration in geomorphology and instream biota. Sc MK22, MK23, MK32 and MK33 also has the same EcoStatus as the PES/REC but there is further deterioration in the instream biota as well as geomorphology and water quality. Scenario MK2 and MK4 have the biggest impact as overall they drop a category for while Sc MK42 only caters for the low flow EWR and the impact is therefore slightly less, i.e. it drops half a category

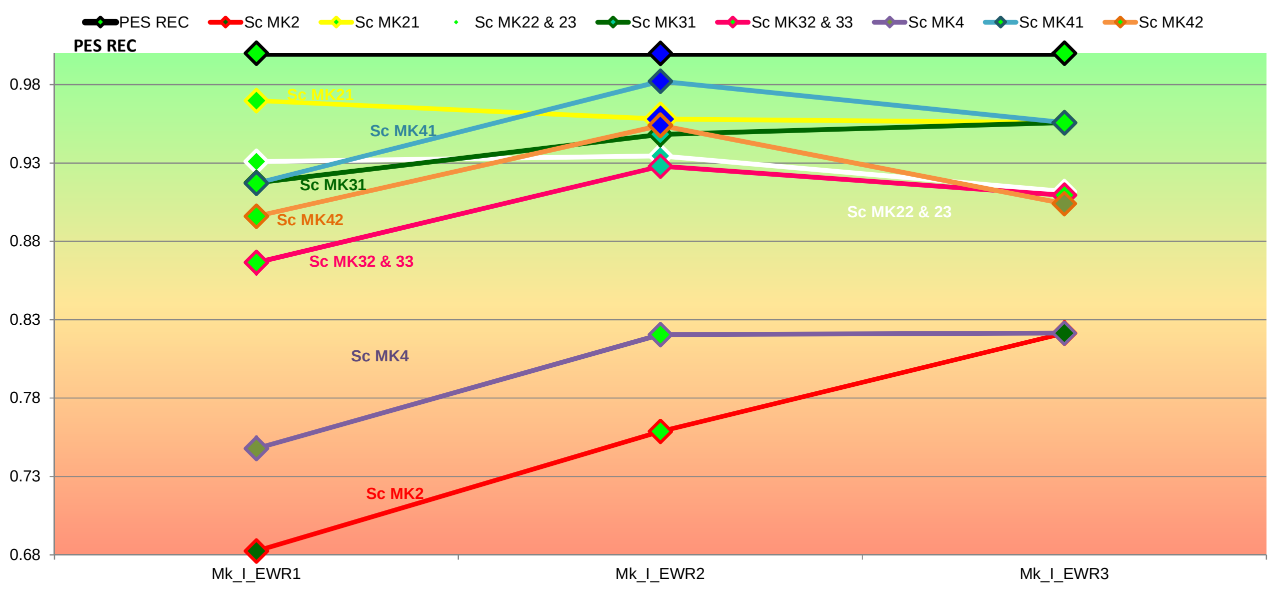


Figure 8.1 uMkhomazi River System: Ranking of scenarios at each EWR site

As there are three sites on the uMkhomazi River, these need to be integrated based on a system of weighting the importance of the sites. MK_I_EWR3 is the most important site due largely to the long river distance which the site represents (Table 8.3). The integrated ranking is showing in the Figure 8.2.

Table 8.3 Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Distance	Normalised Weight
EWR 1	C	Moderate	1	0.08	**0.22**
EWR 2	B	High	3	0.32	**0.37**
EWR 3	C	Moderate	1	0.6	**0.41**

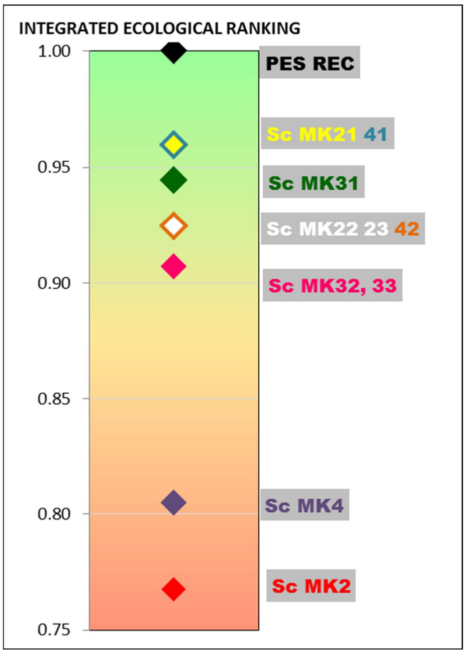


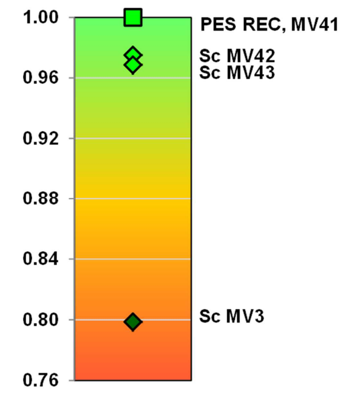
Figure 8.2 uMkhomazi River System: Integrated ecological ranking of the scenarios

8.3 MVOTI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

The ecological consequences are summarised in Table 8.4 and an integrated ranking illustrated in Figure 8.3.

Scenario MV41 which includes the dam and releases the full EWR will meet the ecological objectives. Scenario MV42 and MV43 are very similar, still maintain the REC EcoStatus but overall do not comply with all the objectives. Scenario MV3 is the least acceptable as it drops a category overall (D EC) and for most of the components.

Table 8.4 Mvoti River System: Summary of ecological consequences at the EWR sites

<table>
<tr><th>Ecological consequences as ECs</th><th>Ecological consequences</th><th>Ranked scenarios</th><th>Ranking rationale</th></tr>
<tr><td colspan="4">MV_I_EWR2 (MVOTI RIVER)</td></tr>
<tr><td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc MV3</th><th>Sc MV41</th><th>Sc MV42, 43</th></tr>
<tr><td>Physico chemical</td><td>C</td><td>C/D</td><td>C</td><td>B/C</td></tr>
<tr><td>Geom</td><td>C</td><td>C/D</td><td>C</td><td>C/D</td></tr>
<tr><td>Fish</td><td>B/C</td><td>C/D</td><td>B/C</td><td>C</td></tr>
<tr><td>Invertebrates</td><td>B/C</td><td>C/D</td><td>B/C</td><td>B/C</td></tr>
<tr><td>Riparian vegetation</td><td>C/D</td><td>D</td><td>C/D</td><td>C/D</td></tr>
<tr><td>EcoStatus</td><td>C</td><td>D</td><td>C</td><td>C</td></tr>
</table>
</td>
<td>Scenario MV3 is the worst case as it does not include EWR releases. The channel will narrow with vegetation encroachment. An overall loss of fast habitats will impact on the instream biota. Impacts associated with Sc MV42 and MV43 are less pronounced as it includes EWR releases to some degree. Scenario MV 41 supplied the total EWR and therefore meets the ecological objectives.</td>
<td>
</td>
<td>The results illustrate that Sc MV41 meet the ecological objectives. Although Sc MV42 and MV43 results in the same EcoStatus the ecological objectives are not met due to a slight deterioration in geomorphology and fish. Scenario MV3 has the biggest impact with deterioration in all components as the EWR are not provided.</td></tr>
</table>

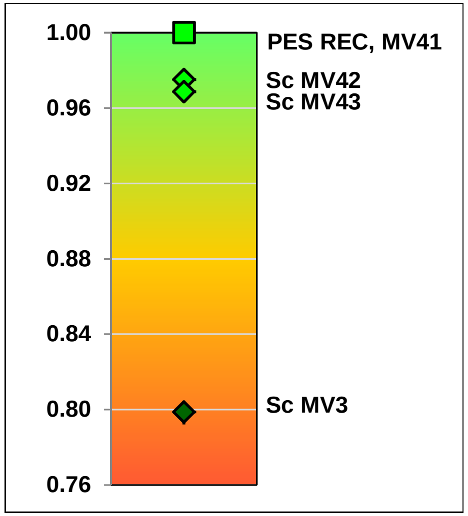


Figure 8.3 Ecological ranking of operational scenarios at MV_I_EWR2

8.4 LOVO AND uMNGENI RIVER SYSTEM: ECOLOGICAL CONSEQUENCES OF SCENARIOS AT THE EWR SITES

The only other rivers where scenarios have been evaluated are the uMngeni and Lovu Rivers (DWS, 2014d). The ecological consequences are summarised in Table 8.5. The individual site rankings are illustrated in Figure 8.4.

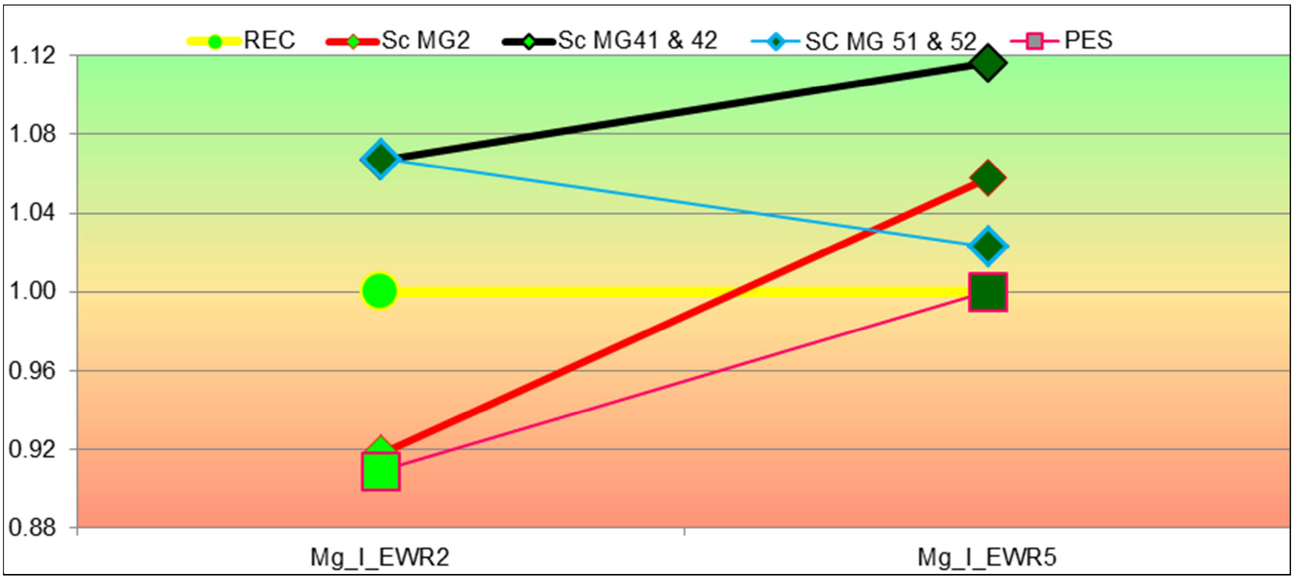
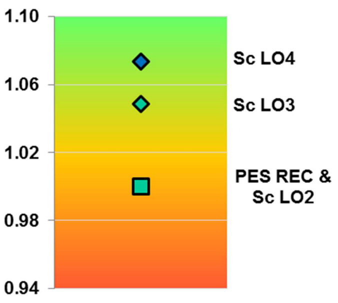
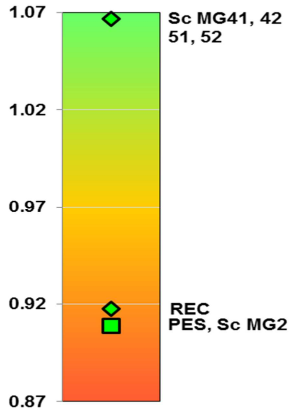


Figure 8.4 uMngeni River system: Ranking of scenarios

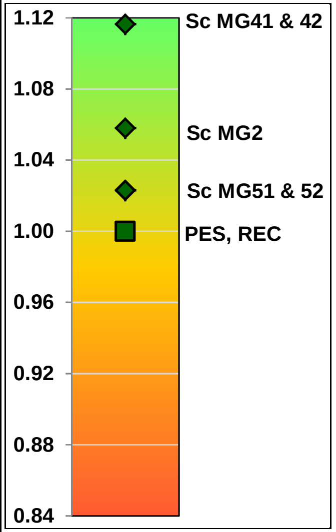
Table 8.5 Lovu and uMngeni River Systems: Summary of ecological consequences at the EWR sites

<table>
<tr><th>Ecological consequences as ECs</th><th>Ecological consequences</th><th>Ranked scenarios</th><th>Ranking rationale</th></tr>
<tr><td colspan="4">Lo_R_EWR (LOVU RIVER)</td></tr>
<tr>
<td>
<table>
<tr><th>Component</th><th>PES & REC</th><th>Sc LO2</th><th>Sc LO3</th><th>Sc LO4</th></tr>
<tr><td>Physico chemical</td><td>B/C</td><td>B/C</td><td>B</td><td>A/B</td></tr>
<tr><td>Geomorphology</td><td>B</td><td>B</td><td>B</td><td>B</td></tr>
<tr><td>Fish</td><td>B/C</td><td>B/C</td><td>B</td><td>A/B</td></tr>
<tr><td>Invertebrates</td><td>B/C</td><td>B/C</td><td>B</td><td>A/B</td></tr>
<tr><td>Riparian vegetation</td><td>B/C</td><td>B/C</td><td>B/C</td><td>B/C</td></tr>
<tr><td>EcoStatus</td><td>B/C</td><td>B/C</td><td>B/C</td><td>B</td></tr>
</table>
</td>
<td>Sc LO2 maintains the REC. Sc LO3 and LO4 improves the instream biota due to increased base (low flows). These flows will improve water quality, clean backwaters and provide more frequency of desired velocity-depth classes.</td>
<td>
</td>
<td>All the scenarios meet the REC while two scenarios improve the REC. Although improvement is not required, it would decrease the risk that the REC will not be maintained and may result reflect positively in the estuary.</td>
</tr>
<tr><td colspan="4">MG_I_EWR2 (UMNGENI RIVER)</td></tr>
<tr>
<td>
<table>
<tr><th>Component</th><th>PES</th><th>REC</th><th>Sc MG2</th><th>Sc MG41</th><th>Sc MG42</th><th>Sc MG51</th><th>Sc MG52</th></tr>
<tr><td>Physico chemical</td><td>C/D</td><td>C/D</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>Geomorphology</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr>
<tr><td>Fish</td><td>E</td><td>D</td><td>E</td><td>D</td><td>D</td><td>D</td><td>D</td></tr>
<tr><td>Invertebrates</td><td>C</td><td>C</td><td>C</td><td>B/C</td><td>B/C</td><td>B/C</td><td>B/C</td></tr>
<tr><td>Riparian vegetation</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td>EcoStatus</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
</table>
</td>
<td>The results illustrate that Sc MG41, 42, 51 and 52 meet the ecological objectives of the REC when the presence of alien fish species is excluded from FRAI calculations. Sc MG2 meets the ecological objectives of the PES but not the REC due to the lower flows and smaller improvements in water quality compared to other scenarios which do not result in the improvement of habitat or fish availability; and therefore the presence of alien fish species.
Note that although there are improvements, the EcoStatus stays a C for al scenarios.</td>
<td>
</td>
<td>The objectives are set to maintain the PES but to improve the fish. The problems with fish are partly due to the presence of alien fish, migratory barriers, flow changes and water quality problems. Scenarios only effect the last two issues. These (flow & quality) are improved by all the scenarios apart from Sc MG2 and therefore are all acceptable/desirable from an ecological viewpoint.</td>
</tr>
</table>

MG_I_EWR5 (UMNGENI RIVER)

Component	PES & REC	Sc MG2	Sc MG41	Sc MG42	Sc MG51	Sc MG52
Physico chemical	C/D	C	C	C	C	C
Geomorphology	C/D	C/D	C/D	C/D	D	D
Fish	D	C/D	C	C	D	D
Invertebrates	C/D	C	C	C	C	C
Riparian vegetation	D	D	D	D	D	D
EcoStatus	D	D	D	D	D	D

The results illustrate that Sc MG2, 41, 42, 51 and 52 meet the ecological objectives of the REC and is an improvement in some cases. Note that this improvement also relies on an eradication programme for alien fish. Sc MG 51 and 52 shows a decrease in geomorphology but an improvement in invertebrates and water quality.



As the ecological objectives are set to maintain the REC, all scenarios are acceptable. Sc MG41 and 42 would decrease the risk of the D dropping to an E EC.

The process to determine an integrated ranking of the different scenarios is described below. The first step was to determine the relative importance of the different EWR sites. The site weight (Table 8.6) indicates that the weight between the sites is similar. Mg_I_EWR2 carries the highest weight due to its PES and as it is situated in a private nature Reserve.

The weights are provided in the Table 8.5. The weight is based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 8.6 uMngeni River system: Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas (0 - 5)	Confidence	Normalised Weight
EWR 2	C	Moderate	2	3.5	0.52
EWR5	D	Moderate	1	4	0.48

The weight is applied to the ranking value for each scenario at each EWR site. The ranking of '1' refers to the REC and the rest of the ranking illustrate the degree to which the scenarios meet the REC. The results are provided in Table 8.7 after the weights have been taken into account.

Table 8.7 uMngeni River system: Ranking value for each scenario resulting in an integrated score and ranking

	PES	REC	Sc MG2	Sc MG41	Sc MG42	Sc MG51	Sc MG52
Mg_I_EWR2	0.48	0.52	0.48	0.56	0.56	0.56	0.56
Mg_I_EWR5	0.48	0.48	0.50	0.53	0.53	0.49	0.49
	0.952	**1.000**	**0.984**	**1.090**	**1.091**	**1.046**	**1.046**

The above results are plotted on a traffic diagram (Figure 8.5) to illustrate the integrated ecological ranking.

The integrated ecological ranking for the uMngeni River system that will be taken forward in the decision-making process on scenarios and Water Resource Class determination is summarised in Figure 8.5. The only scenario that does not meet the REC is Sc MG2. All other scenarios are an improvement of the REC and therefore are all rated equal.

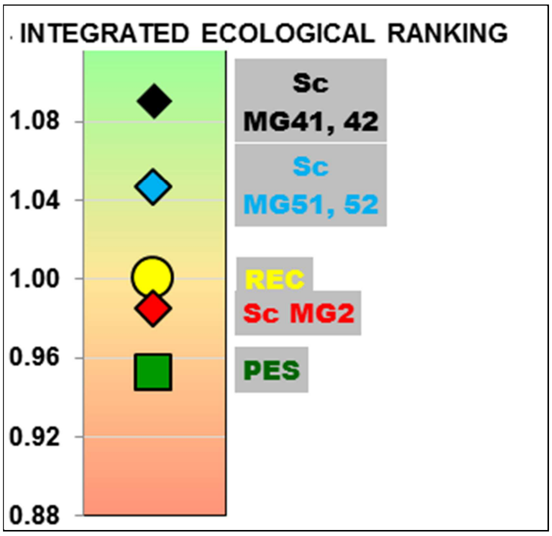


Figure 8.5 Ranking of scenarios for the uMngeni River system

9 ESTUARY ECOLOGICAL CONSEQUENCES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2b: Supporting Information on the Determination of Water Resource Classes – uMkhomazi (U1) Estuary EWR and Ecological Consequences of Operational Scenarios. Prepared by MER for Rivers for Africa eFlows Consulting PTY Ltd. December 2014. DWS Report: RDM/WMA11/00/CON/CLA/0614.

Department of Water and Sanitation (DWS), South Africa. 2015a. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2a: Supporting Information on the Determination of Water Resource Classes – Mvoti (U4) Estuary EWR and Ecological Consequences of Operational Scenarios. Prepared by CSIR for Rivers for Africa eFlows Consulting PTY Ltd. April 2015. DWS Report: RDM/WMA11/00/CON/CLA/0614.

Department of Water and Sanitation (DWS), South Africa. 2015b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu WMA: Volume 2c: Supporting Information on the Determination of Water Resource Classes –Mhlali (U30E) Estuary EWR and Ecological Consequences of Operational Scenarios Prepared by: CSIR for Rivers for Africa eFlows Consulting PTY Ltd. April 2015. DWS Report: RDM/WMA11/00/CON/CLA/0614.

9.1 BACKGROUND

The process to determine the ecological consequences consists of analysing the scenario's flow regime and determining how the biophysical components (abiotic drivers: hydrology, hydrodynamics (mouth state), water quality and physical habitat); and biotic responses: microalgae, macrophytes, invertebrates, fish and birds) of estuaries will respond to these changes.

9.2 MVOTI ESTUARY

For the Mvoti Estuary none of the scenarios (Groups A to D) achieved the REC of a C Category (Table 9.1). Therefore Scenario Group A (MV 21, MV22 and MV41) in conjunction with a number of management interventions is the recommended ecological flow scenario. Scenario Group C (MV42 and MV43) will also achieve the REC. The following management interventions are required to achieve the Mvoti REC:

- Remove organics from Sappi effluent to improve oxygen.
- Reduce nutrients from the catchment by 20% to control reed growth and aquatic invasive.
- Remove sugar cane from the EFZ (below 5 m contour) to allow for a buffer against human disturbance and the development of a transitional vegetation ecotone between estuarine and terrestrial ecosystems.

Table 9.1 Mvoti EHI scores and corresponding ECs under the different runoff scenarios

Variable	Weight	Scenario Group					
		Present	A (MV 21, 22, 41)	B (MV3)	C (MV42, 43)	D (MV5)	MV21, 22, 41 – ANT*
Hydrology	25	53.4	59	42	55	33	59
Hydrodynamics	25	95	99	95	99	70	99
Water quality	25	58.4	59	54	59	48	65
Physical habitat alteration	25	73	73	69	70	53	73
Habitat health score		**70**	**72**	**65**	**71**	**51**	**74**
Microalgae	20	80	80	65	80	50	85
Macrophytes	20	32	33	33	33	25	50
Invertebrates	20	25	25	15	25	10	60
Fish	20	55	55	55	55	50	75
Birds	20	10	10	10	10	5	45
Biotic health score		**40**	**41**	**36**	**14**	**28**	**63**
ESTUARY HEALTH SCORE		**55**	**56**	**50**	**56**	**39**	**68**
ECOLOGICAL STATUS		**D**	**D**	**D**	**D**	**D/E**	**C**

* with a reduction in non-flow related pressures.

9.3 uMKHOMAZI ESTUARY

For the uMkhomazi Estuary none of the scenarios achieved the REC of a B Category (Table 9.2). Therefore Scenario Group B (MK 21 and MK 42) in conjunction with a number of management interventions is the recommended ecological flow scenario. Scenario Group C (MK22, 23 and 43) will also achieve the REC. The following management interventions are required to achieve the uMkhomazi REC:

- Remove sandmining from the upper reaches below the Sappi Weir to increase natural function, i.e. restore intertidal area.
- Restoration of vegetation upper reaches and along the north bank, e.g. remove aliens and allow disturbed land to revert to natural land cover (is already on upwards trajectory).
- Curb recreational activities in the lower reaches through proper zonation and improve compliance.
- Reduce/remove castnetting in the mouth area through estuary zonation or increase compliance.
- Relocate or remove Sappi Weir to restore upper 15% of the estuary.

Table 9.2 uMkhomazi EHI scores and corresponding ECs under the different runoff scenarios

Variable	Weight	Scenario Group								
		Present	A MK2, 4	B MK21, 42	C MK22, 23, 43	D MK31	E MK 32, 33	F MK 21, 42 + WWTW	G MK 21, 42 –Ant +Weir	H MK 21, 42 – Anth – Weir
Hydrology	25	66.8	45	63	62	59	57	63	63	63
Hydrodynamics and mouth condition	25	95	75	95	95	38	38	95	95	97
Water quality	25	66.6	61	66	67	66	67	34	66	66
Physical habitat alteration	25	78	70	75	75	75	75	75	84	90
Habitat health score		**76**	**63**	**75**	**75**	**60**	**59**	**67**	**77**	**79**
Microalgae	20	80	65	80	80	80	80	50	80	90
Macrophytes	20	21	20	26	31	33	34	15	46	46
Invertebrates	20	75	60	75	75	70	70	50	85	90
Fish	20	60	35	60	60	60	55	50	70	75
Birds	20	60	50	55	55	55	55	50	57	65
Biotic health score		**59**	**46**	**59**	**60**	**60**	**59**	**43**	**68**	**73**
ESTUARY HEALTH SCORE		**68**	**54**	**67**	**67**	**60**	**59**	**55**	**72**	**76**
ECOLOGICAL STATUS		**C**	**D**	**C**	**C**	**C/D**	**D**	**D**	**B/C**	**B**

9.4 SUMMARY OF CONSEQUANSES OF WASTE WATER DISCHARGES ON THE ESTUARIES

In summary, the fair to poor PES of most of the smaller systems in the WMA is because of poor water quality and increased frequency of opening of estuary mouths. These impacts are associated with increased volumes and nutrient loading from WWTWs, as well as poor water quality entering from the catchment of some of the systems. As a result of their small assimilative capacities these systems are at a high risk of becoming eutrophic, especially when their mouths close during low flow and drought conditions. In turn, die-off of vegetation can result in high detrital loads, causing reduced dissolved oxygen levels which negatively impact fish and invertebrates. Fish kills are the end result and are indicative of the ecosystems reaching ecological tipping points. The consequences are summarised in the following sections and illustrated in Figure 9.1.

9.4.1 Southern Cluster IUA

In this cluster ten estuaries are of conservation importance: the Mtamvuna, Mpenjati, Zotsha, Mzimkulu, Damba, Koshwana, Intshambili, Mhlabatshane, Mfazazana and the Kwa-Makosi. The following overall ecological responses were noted:

- **Mpambanyoni:** All the scenarios maintain the current state (PES = C), with a slight decline under the worst case scenario (Sc 2).
- **Sezela:** Most of the scenarios maintain the current condition (PES = C), but the removal of the wastewater inputs (Sc A1) will improve the system's condition. Under the worst case scenarios (e.g. Sc D4, Sc 2) the estuary declines significantly further in condition to a C/D and D.
- **Koshwana:** Most of the scenarios maintain the present state (PES = C/D). While Sc A1 shows an improvement (Category C) and the worst case scenarios (e.g. Sc 2) results in a significant

decline in health to a Category D. The recent fish kill in this estuary shows that it is already at a tipping point.

- **Mbango:** Most of the scenarios maintain the current state (PES = E). Under Sc A1 (reduction in wastewater inputs) the systems shows a significant improvement in condition (Category D/E), while under the worst case scenarios (e.g. Sc A1a, Sc 2) it shows a further decline.
- **Boboyi** and **Mhlangeni:** Most of the scenarios result in these systems maintaining their current health (PES = B/C and C, respectively). However, declines in state will occur under the worst case WW scenarios (Sc 2).
- **Vungu:** The system will decline in health from the current state (PES = B) to Category B/C and C under the future conditions Sc C3, Sc D4, Sc A1a and Sc 2.
- **Kongweni:** The system is at present in a degraded condition (D/E category). Most of the scenarios will result in further significant decline in health to an E Category. A significant reduction in the WWTW effluent discharge will achieve the REC of Category D. This can also be achieved by a smaller reduction in WWTW effluent, together with other (non-flow related) interventions.
- **Mvutshi:** Most of the scenarios show a significant decline in health from the present condition (PES = B/C) as this estuary is sensitive to flow.
- **Mpenjati:** The scenarios maintain the current state (PES = B/C).
- **Tongazi:** While the scenarios maintain the PES = B/C, the estuary is sensitive to the increase in WWTW effluent discharge and will decrease in condition under Sc C3, Sc D4 and Sc 2.
- **Zolwane:** The system is still in a good condition (PES = B). The estuary is sensitive to increases in WWTW effluent. About half of the scenarios, Sc E5, Sc A1a and Sc2 , will result in a (significant) decline in condition to Category B/C or C. Other scenarios will maintain or improve the present state.

9.4.2 Central Cluster

In this cluster nine systems are of conservation importance: the Mahlongwa, Mahlongwane, uMkhomazi, Umgababa, Msimbazi, Lovu, Durban Bay, uMngeni and the Mhlanga. On a national and regional scale, estuary health is in a very poor state along this coast, with five systems in a degraded condition (< D/E): Little Manzimtoti, aManzimtoti, Mbokodweni, Sipingo, Durban Bay, Mgeni. Small systems in this cluster were also relative insensitive to level of WW treatment as they have very little assimilative capacity and therefore go eutrophic very easily.

The following overall responses were noted to the flow and WW scenarios:

- **uThonghathi:** The estuary is at present in fair state (PES = D). The estuary showed some sensitivity to the level of treatment, with Level 1 treatment generally being much worse than Level 2 and Level 2a treatment. Under Sc A1 (no WWTW discharges) the estuary increases in condition to a Category C/D. Under the Sc 2 (treatment level 1 and 2) the estuary degrades to a Category D/E, but it maintains the PES at treatment level 2a. Significant further deterioration in condition to Categories E to E/F is anticipated under the Sc 3 to Sc 6 as a result of the substantial increase in WWTW volume and nutrient loading to the system.
- **uMdloti:** The estuary is at present in fair state (PES = D). The system is small with a low assimilative capacity and therefore sensitive to increases in WWTW discharges. Water quality in river inflows is very poor. Therefore, future scenarios that result in more frequent mouth closure (i.e. in which flow is significantly reduced) will lead to deterioration in water quality and reduction in dissolved oxygen levels unless the water quality inflow from the catchment is improved. Examples of such scenarios are Sc H6_1o, Sc A1, Sc H6_1p, Sc A1a (L1). The estuary remained in a Category D under Sc C3 (l1), Sc C3 (L2), Sc 23_2 (L2), Sc 23_2 (L2a) irrespective of the treatment level. Significant further deterioration in condition to Categories

D/E and E is anticipated under Sc D4 (L2a), Sc 2 (L1) and Sc 2 (L2a) as a result of the substantial increase in WWTW volumes and nutrient loading to the system.

- **Mbokodweni:** The system is at present in a poor condition (PES = Category E). The system improves significantly to a Category D if WWTW effluent is reduced and/or removed from the system. Under Sc 2 (55 Ml/d) at all three levels of effluent treatment, the system will maintain PES. Under Sc 3 (30 Ml/d) the estuary show a severe decline in condition to a Category E/F.
- **Little Manzintoti:** The system is at present in a poor condition (PES = E). The system improves significantly to a Category D if WWTE effluent is reduced and/or removed. Under Sc 2a (8 Ml/d) at all three levels of effluent treatment, the system will maintain the PES. Under Sc 3 (30 Ml/d) the estuary shows a severe decline in condition to Category E/F and F.
- **uMkhomazi:** The estuary is of high ecological importance. All “flow” scenarios maintained the current state (PES = C). This system will require other (non-flow) interventions to attain the REC. Most of the future scenarios including WWTW discharges degrade the condition of this ecologically important estuary to a Category C/D or D. Even scenario MK1 (5 Ml/d), which potentially under average flow condition will maintain the PES, poses a risk of eutrophication and fish kills during low flow periods and droughts when the system closes.

9.4.3 Northern Cluster

In this cluster four systems are of conservation importance: the Mhlali, Mvoti, Mdlotane and the Zinkwasi. The following overall responses were noted:

- **Mhlali:** The PES is a Category C/D. Most of the future scenarios will result in a further decline in ecological health due to excessive nutrient loading from WWTW discharges into this small estuary. The only scenario that showed some improvement in condition is Sc 1 (no WWTW discharges) taking the system to a Category B/C.
- **Mvoti:** Under most flow scenarios the system maintains the PES (Category D). The system requires other (non-flow related) interventions to attain the REC. Additional WWTW discharge will reduce the current condition, but the estuary is likely to maintain the present condition category.
- **Nonoti:** All the waste water scenarios maintain the current condition (PES = C). Sc A1 will result in an improvement in condition from Present and the worst case scenario (Sc 2) will cause a decline in health.

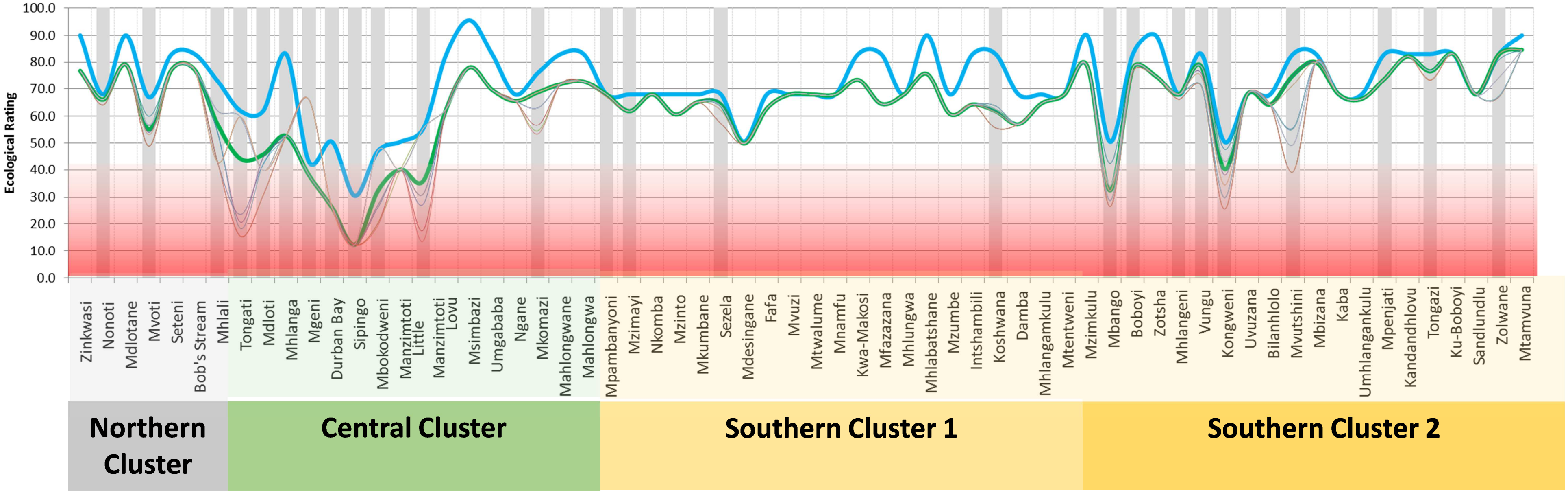


Figure 9.1 Summary of the PES, REC and scenario consequences for the estuaries of the Mvoti-Mzimkulu WMA

9.5 RANKING OF SCENARIOS PER IUA

Based on the preceding ecological results and the engineering feasibility assessment a number of operational scenario permutations were developed incorporating local constraints into a range of catchment scale alternatives. These were evaluated to determine the ranking per IUA and the results are provided below and illustrated on traffic diagrams in Figure 9.2.

9.5.1 Southern Cluster IUA

The following was concluded from the catchment-scale operational scenario assessment for the Southern Cluster (Figure 9.2):

- Overall, the scenario configuration Ai maintains the PES, while scenarios C, D, E, F, Di, Ei and Ci reduce the Southern Cluster estuaries conditions.
- Scenarios Aii, Aiii Aiv, Av, Bi, Bii and Biii further degrade the ecological condition of the systems. In addition, this group of scenarios increases the risk of eutrophication developing and fish kills occurring during low flows and droughts.

9.5.2 Central Cluster IUA

The following was concluded from the operational scenario assessment for the Central Cluster:

- Scenario configurations Ai, Aii, AiV and Av, as well as Ei improve the ecological condition of the Central Cluster estuaries.
- Scenario E and F maintain the PES, while scenarios Aiii, Bii, C D Ci and Di reduce the estuaries conditions.
- Scenario Bi further degrades the ecological condition of these systems significantly.
- The latter two groups of scenarios (Aiii, Bii, C, D, Ci, D and Bi) increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

9.5.3 Northern Cluster IUA

The following was concluded from the operational scenario assessment for the Northern Cluster:

- Scenario configurations Ai, E, F and Ei improve the ecological condition of the Northern Cluster estuaries.
- Scenarios C and D represent a slight decline in ecological health from present.
- Scenarios Aii, Aiii, Aiv, Av, Ci and Di show a further decline in ecological health.
- Scenarios Bi, Bii and Biii degrade the ecological condition of these systems the most.
- The A, C, D and B groups of scenarios all increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

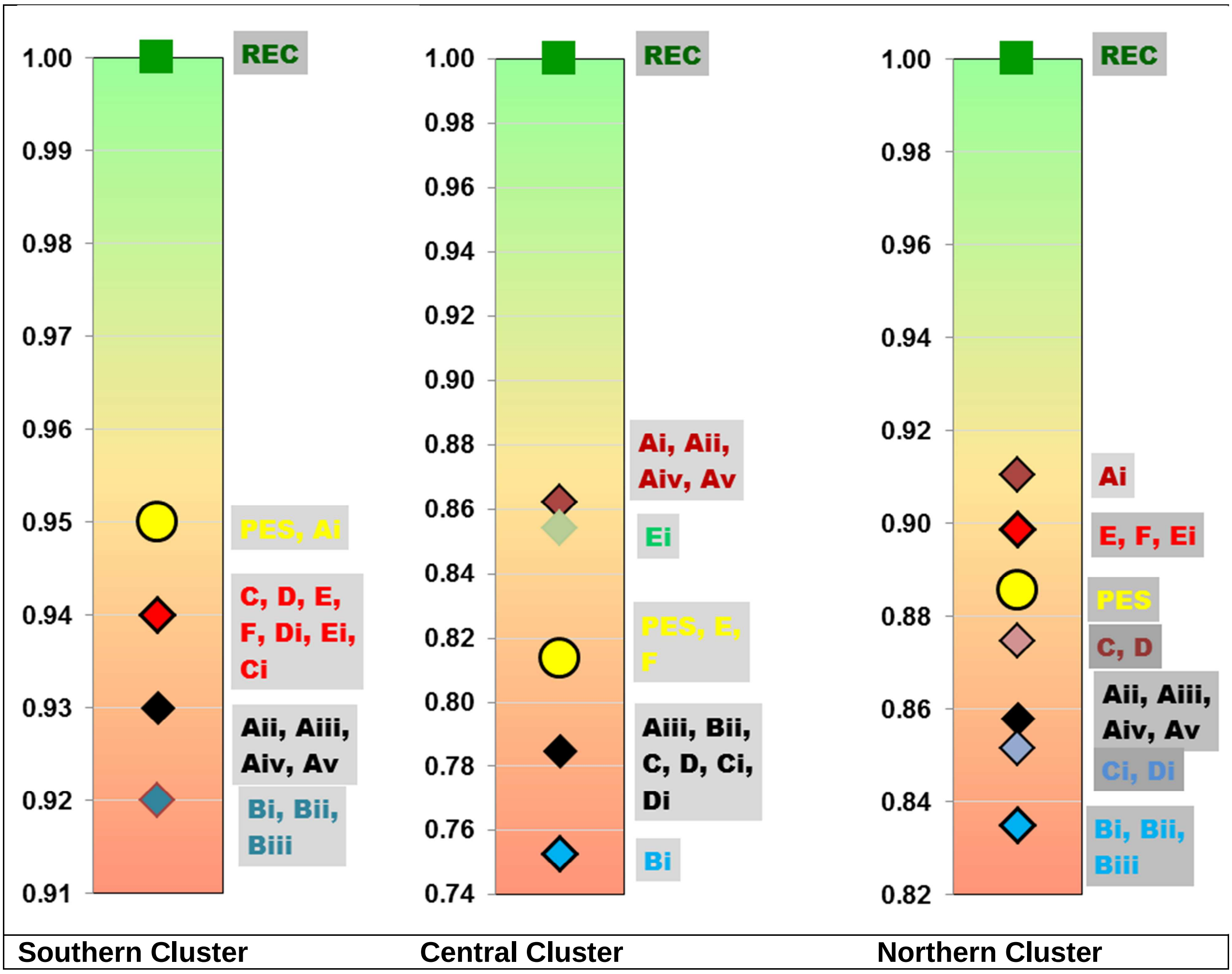


Figure 9.2 Summary of the operational scenario consequences in relation to the REC for the estuaries of the Mvoti-Umzimkulu WMA

10 ECOSYSTEM SERVICES SCENARIO CONSEQUENCES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014e. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River systems. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2014. DWS Report: RDM/WMA11/00/CON/CLA/1114.

Department of Water and Sanitation (DWS), South Africa. 2015c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2015.
DWS Report: RDM/WMA11/00/CON/CLA/0215.

10.1 BACKGROUND

An ecosystem services analysis of multiple sites along the Lovu, Mvoti, uMngeni and uMkhomazi Rivers was undertaken. This included a profile of ecosystem services associated with each site, keeping in mind they represent a wider area, and thereafter assessed against the planning scenarios applicable to the site.

Specifically an analysis of the EWR sites on the Lovu River, uMngeni, the three EWR sites on the uMkhomazi and Mv_I_EWR2 on the Mvoti was undertaken. Ecosystem Services associated with the sites, bearing in mind that they represent a wider area, were listed and where they were deemed to generate value they were evaluated against the scenarios applicable to the site. A list of the relevant ecosystem services that were found in the various reaches examined, and deemed to be significant, was generated as a table. These were cross checked with the biophysical experts that formed part of the project team at a specialist workshop held in 2014.

The biophysical specialists then identified the potential change that each of the key ecosystem services may undergo in each of the scenario clusters. The potential change will be noted as a factor and used in later calculations. For example, no change = 1, a 50% increase = 1.5, and a 20% decrease = 0.8.

The scenario impact on various ecosystem services (including botanical or fish species) were then amalgamated into overall categorisation of provisioning, regulating, cultural, and supporting services. The scenarios are also weighted with respect to the importance of the services at each EWR site. As such the score given to each of the services when the SQs are evaluated is examined against the nature of the particular EWR site and associated area. In an instance where regulating services, for example are deemed to be important, then these services are given a higher weight. The same goes for the other services. All weightings are normalised against a base score of 1. Where all four services are deemed to be of equal importance then a score of 0.25 would be allocated to each.

The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites. Here the perceived vulnerability of households dependent on the provisioning aspect of ecosystem services played a major role. Again all scores are normalised against a base score of 1. A similar exercise was undertaken for the estuaries.

10.2 uMKHOMAZI RIVER SYSTEM

10.2.1 MK_I_EWR1: uMkhomazi River

The site provides a relatively moderate to high abundance of provisioning resources (specifically fish and riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4, while cultural services are given a weighting of 0.3. Regulating and supporting services are weighted as 0.2 and 0.1 respectively.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 10.1). Scenario MK2 and MK31 show the highest reduction in ecosystem services with a weighted scope of 0.78 and 0.79 respectively – or a 20% reduction in function. The highest reductions include the abundance in terms of fish and riparian vegetation and noticeably a significant decrease in waste assimilation/dilution capability, while more moderate reductions are noted for flood regulation, bank protection, stream flow regulation and groundwater recharge.

Scenario MK4, MK32, MK41 and MK42 show moderate reductions in ecosystem function with an average weighted score of 0.86 – or 14% reduction in ecosystem function. The reduction in ecosystem functions is the same of Sc MK2 and MK31, however the reduction is not considered as significant.

Scenario MK21 and MK22 show the lowest reduction in ecosystem function, although there remain no likely improvements. Reduction in services is largely related to reduction in fish abundance, flood regulation, bank protection and stream flow regulation.

Table 10.1 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR1

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	0.65	0.70	0.88	0.87	0.84	0.79	0.77	0.77	0.40
Regulating services	0.74	0.84	0.97	0.95	0.92	0.91	1.00	0.99	0.20
Cultural services	0.90	0.90	0.90	0.90	0.57	0.90	0.90	0.90	0.30
Supporting services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.10
Score	0.78	0.82	0.92	0.91	0.79	0.87	0.88	0.87	1.00

10.2.2 MK_I_EWR2: uMkhomazi River

The site provides a relatively low to moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Provisioning services are provided the highest weighting of 0.35. However, the site also provides for relatively high cultural services related to recreation, and is thus this service is provided with a weighting of 0.25. Regulating services with respect to water assimilation and dilution as well as stream-flow regulation is moderate with a weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in low to moderate decreases in ecosystem provision, and no appreciable improvements (Table 10.2). Scenario MK2 shows the highest reduction in Ecosystem Services with a weighted scope of 0.89, which is specifically related to reductions in fish abundance, as well as reduction in waste assimilation and dilution services.

The remaining scenarios are largely consistent with equivalent reductions in Ecosystem Services. All scenarios results in the reduction of provisioning services (especially around certain fish and riparian vegetation species). Scenario MK41 and MK42 shows slight improvement in regulating services, while the remaining scenarios show reductions. This is generally attributed to improvements in waste assimilation and dilution services. Flood control related to scenarios MK2, MK4, MK21, MK22, MK31 and MK32 show sight improvements in terms of supporting cultivation along the river banks.

Table 10.2 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR2

Service	Sc MK2	Sc MK4	Sc MK21	Sc MK22	Sc MK31	Sc MK32	Sc MK41	Sc MK42	Weight
Provisioning services	0.79	0.81	0.90	0.89	0.90	0.89	0.94	0.94	0.35
Regulating services	0.92	0.98	1.00	1.01	1.00	0.99	1.03	1.03	0.25
Cultural services	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.25
Supporting services	1.10	1.05	1.05	1.05	1.05	1.05	1.00	1.00	0.15
Score	0.89	0.91	0.95	0.95	0.95	0.94	0.96	0.96	1.00

10.2.3 MK_I_EWR3: uMkhomazi River

The site provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.35. Cultural and regulating services are provided an equal weighting of 0.25, while supporting services is weighted as 0.15.

Scenarios that were assessed generally result in negligible overall changes (Table 10.3). Scenario MK2 shows the highest reduction in Ecosystem Services of all the scenarios, although the overall weighted score is only 0.95; related to reduced provisioning services of fish and riparian vegetation and changes in stream-flow. Scenario MK21 shows slight improvements in provisioning and regulating services, although this is considered to be minor and related to improvement in tree abundance due to improved flood attenuation. Scenarios MK22, MK32 and MK42 are considered to be largely static in terms of any potential changes in Ecosystem Services. Only very slight reductions in provisioning services (reduced provisioning services of fish) are noted.

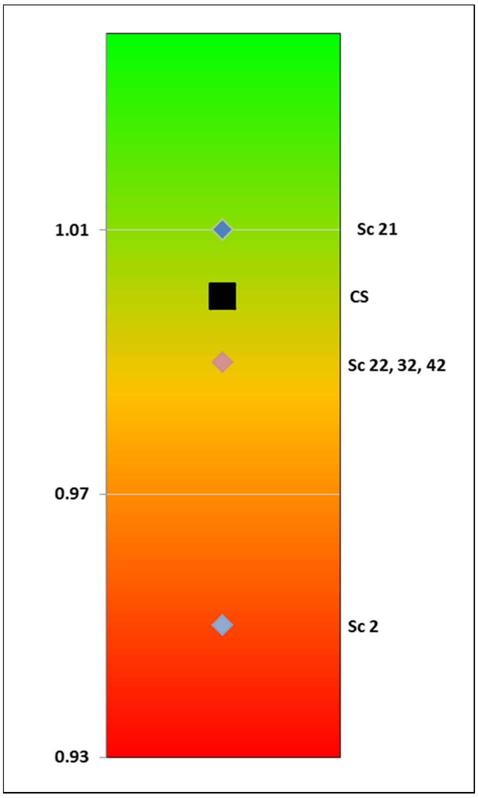
Table 10.3 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MK_I_EWR3

Service	Sc MK2	Sc MK21	Sc MK22	Sc MK32	Sc MK42	Weight
Provisioning services	0.92	1.01	0.98	0.98	0.98	0.35
Regulating services	0.95	1.01	1.00	1.00	1.00	0.25
Cultural services	0.97	1.00	1.00	1.00	1.00	0.25
Supporting services	1.00	1.00	1.00	1.00	1.00	0.15
Score	0.95	1.01	0.99	0.99	0.99	1.00

10.2.4 uMkhomazi River: Overall Scenario Ranking

The process to determine an integrated ranking of the different scenarios required determining the relative importance of the different EWR sites was undertaken for the uMkhomazi where multiple sites were considered. Here the perceived vulnerability of households dependent on the provisioning aspect of ecosystem services played a major role. Overall the results of the scenarios for the uMkhomazi River were ranked with the EWR sites weighted.

Again all scores are normalised against a base score of one. Results are presented in Figure 10.1 below.



CS = Current state

Figure 10.1 Integrated scenario results for EWR sites in the uMkhomazi River

10.2.5 uMkhomazi Estuary

The uMkhomazi Estuary provides a relatively moderate abundance of provisioning resources (specifically natural riparian vegetation and fish species) which is utilised by people to a moderate degree. Hence provisioning services are provided the highest weighting of 0.4. Cultural and regulating services are provided a weighting of 0.3 and 0.2 respectively, while supporting services is weighted as 0.1.

Scenarios that were assessed generally result in variable changes (Table 10.4). Scenario Group A and Scenario Group F show the greatest reduction in service provision. This is attributed to the reduction in fish abundance, waste dilution potential as well as increases in water-borne diseases.

Scenario Group C, as well as Group D and Group E are considered to be largely static in terms of any potential changes in ecosystem services. Only very slight reductions in provisioning services (reduced fish abundance) and regulating services are noted.

Scenarios Sc MK21 and MK41 + anthropogenic issues, Scenario Group G and Scenario Group H are the only that show positive trends in service provision. This is largely related to improved fish abundance, cultural use and improvement in human health.

Table 10.4 uMkhomazi River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at the uMkhomazi Estuary

Service	A[1]	Sc MK 21, 41 + anth[2]	C	D	E	F	G	H	Weight
Provisioning services	0.79	1.02	0.97	0.98	0.90	0.81	1.17	1.32	0.4
Regulating services	0.67	0.95	0.95	0.95	0.95	0.76	0.99	1.03	0.2
Cultural services	0.96	1.04	1.00	1.04	1.00	0.86	1.22	1.32	0.3
Supporting services	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.1
Score	0.84	1.01	0.98	0.99	0.95	0.83	1.13	1.23	1

1 Refer to Table 7.11 for scenario label descriptions.

2 Anthropogenic issues.

10.3 MVOTI RIVER SYSTEM

10.3.1 MV_I_EWR 2: Mvoti River

Given the relatively high abundance of natural resources and the moderate and high utilisation of these resources, the provisioning services are given the highest weighting of 0.35. Both regulating and cultural services are provided an equal weighting of 0.25. Supporting services are given the lowest weighting of 0.15.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (See Table 10.5). Scenario MV42 and MV43 are considered as equivalent in terms of the impact on Ecosystem Services including an improvement in riparian vegetation growth, water quality, waste dilution and groundwater recharge. Scenario MV3 shows some potential reduction in provisioning services, but an improvement in regulating services around flood regulation from stabilised baseflows.

Table 10.5 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at MV_I_EWR2

Service	Sc MV3	Sc MV42	Sc MV43	Weight
Provisioning services	0.97	1.02	1.02	0.35
Regulating services	1.02	1.22	1.22	0.25
Cultural services	1.00	1.00	1.00	0.25
Supporting services	1.10	1.05	1.05	0.15
Score	**1.01**	**1.07**	**1.07**	**1.00**

10.3.2 Mvoti Estuary

The Mvoti Estuary provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation which is underutilised. Hence, provisioning services is given a value of 0.2. The estuary provides moderate levels of regulating services, specifically flood attenuation, storm control, sediment supply to beach; but also has elevated levels of water-borne diseases (bilharzia and cholera). Hence regulating services are given the highest weighting of 0.4. The estuary provides limited cultural services with the exception of ritual uses. Recreational fishing and birding is limited. Hence cultural services are given a weighting of 0.3.

Scenarios, where the PES EWRs are reduced by 5 and 15% show a commensurate drop in Ecosystem Services (Table 10.6). The reduction is likely in provisioning, regulating and cultural services. Provisioning services are likely impacted by the reduction in fish abundance, while there is likely to be reductions in regulating services associated with flood attenuation and increases in water-borne diseases. Cultural services, related to aesthetic value, ritual use and birding is likely to be reduced.

The maintenance of the PES with a reduction in organics will see improvements in provisioning, regulating and cultural services (Table 10.6). This includes greater abundance of fish species, reduction in water-borne diseases and improved cultural services.

Table 10.6 Mvoti River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystem Services at the Mvoti Estuary

Service	PES (A+C)	B (-5%)[1]	A+C-Organics[2]	Weight
Provisioning services	1.00	0.98	1.16	0.2
Regulating services	1.00	0.89	1.16	0.4
Cultural services	1.00	0.88	1.55	0.3
Supporting services	1.00	1.00	1.00	0.1
Score	**1.00**	**0.92**	**1.26**	**1.0**

1 PES EWRs are reduced by 5%.
2 The maintenance of the PES with a reduction in organics under Scenario Group A and C

10.4 LOVU RIVER

This site has a moderate abundance of provisioning resources and moderate utilisation by local people, thus provisioning services are given the highest weighting of 0.4. Cultural service is weighted as 0.3 due to the utilisation of the river for recreational and subsistence fishing. Regulating and supporting services is given a weighting of 0.2 and 0.1 respectively.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 10.7). Both Sc LO3 and Sc LO4 show improvements in provisioning and regulating services, while Sc LO4 is the higher of the two. This is attributed to the improvements in river fish abundance as well as improvements in waste assimilation and dilution. There is no expected change in cultural and supporting services for either of the two scenarios.

Table 10.7 Lovu River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at the LO_R_EWR1 Site

Service	Sc LO3	Sc LO4	Weight
Provisioning services	1.05	1.07	0.40
Regulating services	1.05	1.12	0.20
Cultural services	1.00	1.00	0.30
Supporting services	1.00	1.00	0.10
Score	**1.03**	**1.05**	**1.00**

10.5 UMNGENI RIVER SYSTEM

10.5.1 MG_I_EWR2: uMngeni River

The EWR site provides limited provisioning services with respect to fish but has a moderate abundance of riparian vegetation. Utilisation by local people is likely to be low due to the site being located in a conservation area. Hence provisioning services are provided a weighting of 0.15. The conservation status of the EWR site elevates the weighting of both cultural and regulating services to 0.3, while supporting services is weighted as 0.25.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 10.8). Scenario MG2 would likely result in a static level of ESS, with slight improvement in regulation services around waste assimilation and dilution. Scenario MG41 shows better, but slight, improvement in all services barring cultural services, which is linked to improved waste assimilation/dilution, as well as an improvement in fish numbers.

Table 10.8 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MG_I_EWR2

Service	Sc MG2	Sc MG41	Weight
Provisioning services	1.00	1.03	0.15
Regulating services	1.02	1.09	0.30
Cultural services	1.00	1.00	0.30
Supporting services	1.00	0.98	0.25
Score	**1.01**	**1.02**	**1.00**

10.5.2 MG_I_EWR5: uMngeni River

The EWR site provides moderate provisioning services with respect to riparian vegetation, and utilisation of this resource is also moderate. Hence provisioning services are provided the highest weighting of 0.35. Cultural and regulating services are considered to be equal with a weighing of 0.25, while supporting services is given a weighting of 0.15.

Scenarios that were assessed generally result in either a static state in terms of ecosystem service functions, or slight improvements (Table 10.9). Scenario MG41 would likely result in a static level of ESS, but with slight improvements in provisioning and regulating services associated with slight increases in low water flow levels relative to PD. Scenario MG51 shows no real change in ecosystem service provision, with a slight reduction in regulating services related to the reduction in low water flows and reduction in stream-flow regulation and groundwater recharge. Unlike the other rivers an integrated traffic diagram is not provided for the uMngeni. This would be redundant as only MG 41 is common and this cores the same at both sites. Scenarios are very close to neutral in impact and as such show little sensitivity to ranking.

Table 10.9 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for ESS at MG_I_EWR5

Service	Sc MG41	Sc MG51	Weight
Provisioning services	1.04	1.01	0.35
Regulating services	1.04	0.97	0.25
Cultural services	1.00	1.00	0.25
Supporting services	1.00	1.00	0.15
Score	**1.02**	**0.99**	**1.00**

10.6 ESTUARIES SOUTHERN CLUSTER IUA

In this cluster the following estuaries were examined with respect to potential scenarios:

- **Mpambanyoni:** All the scenarios maintain the current state, with a slight decline under the worst case scenario where recreational and subsistence fishing may be impacted.

- **Sezela:** Most of the scenarios maintain the status quo, but the removal of the wastewater inputs (Sc A1) will improve the system's condition. Under the worst case scenarios (Sc D4, Sc 2) the estuary declines significantly further in condition and contact recreation and fishing will be expected to decline. Scenarios at Sezela may be important with the impact at Pennington Blue Flag Beach of some concern.
- **Koshwana:** Most of the scenarios maintain the present state or are marginally positive. Sc A1 shows an improvement and the worst case scenarios results in a significant decline in health. . Positive impact is largely related to potential improvements with respect to fishing under reduced waste water discharge. Scenarios with an elevated waste water discharges are negative for the reverse reasons.
- **Mbango:** Most of the scenarios maintain the status quo. Under Sc A1 (reduction in wastewater inputs) the systems shows a significant improvement in condition, while under the worst case scenarios (e.g. Sc A1a, Sc 2) it shows a further decline.
- **Boboyi** and **Mhlangeni:** Most of the scenarios result in these systems maintaining their current satus. However, declines in state will occur under the worst case WW scenarios (Sc 2).
- **Vungu:** The system will decline in health from the current state under the future conditions Sc C3, Sc D4, Sc A1a and Sc 2. This is largely related to declines in fish species and its impact on recreational fishing
- **Kongweni:** The system is at present in a degraded condition. Most of the scenarios will result in further significant decline in the presence of ecosystem services. A reduction in the WWTW effluent discharge will improve ecosystem service utilisation. This estuary is also associated with the Blue Flag beach at Margate.
- **Mvutshi:** Most of the scenarios show a significant decline in status quo) as this estuary is sensitive to flow. There is also a possible linkage with the Blue Flag beach at Ramsgate.
- **Tongazi:** While the scenarios maintain the status, the estuary is sensitive to the increase in WWTW effluent discharge and will decrease availability of ecosystem services.
- **Zolwane:** The system is still in a good condition. The estuary is sensitive to increases in WWTW effluent. About half of the scenarios, Sc E5, Sc A1a and Sc 2, will result in a (significant) decline in fishing and this is of some importance at this estuary. Other scenarios will maintain or improve the present state.

The relative weightings given to the importance of the estuaries is summarized in Table 10.10 below. It should be noted that the weight given to each estuary represents its relative importance where the total sum of importance for all estuaries considered is 100.

Table 10.10 Relative Importance of Estuaries

Estuary	Weight	Motivation
Mbango	4	Limited importance
Zolwane	5	Limited importance
Boboyi	6	Limited importance
Mvutshini	9	Limited importance
Koshwana	9	Limited importance
Sezela	9	Limited importance
Tongazi	10	Limited importance
Mhlangeni	10	Recreational
Vungu	**12**	Recreational
Mpambanyoni	**12**	Recreational

Estuary	Weight	Motivation
Kongweni	**15**	Aesthetic, recreational use
Score	**100**	

Figure 10.2 below summaries the relative ranking of all scenarios in the Southern Cluster of estuaries. Scenarios in the B cluster are overall the worst case scenarios due to multiple impacts mostly related to fishing losses (recreational and subsistence) as well as contact recreation impacts and loss of harvested invertebrates

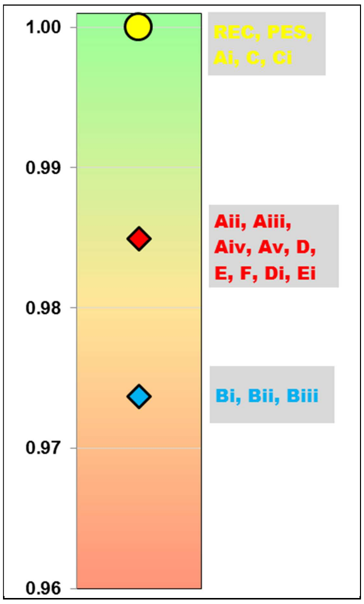


Figure 10.2 Ranking of impact of scenarios in the Southern Cluster

10.7 ESTUARIES CENTRAL CLUSTER IUA

- **uThongathi:** The estuary showed some sensitivity to the level of treatment, Under ScA1 (no WWTW discharges) the estuary will perform more positively in terms of ecosystem services, particularly those related to fishing, harvesting of invertebrate and contact recreation. Under the Sc 2 the estuary degrades. The more WWTW discharges the greater the negative impact on ecosystem services.
- **uMdloti:** The system is small with a low assimilative capacity and therefore sensitive to increases in WWTW discharges. As with the Tongati, the greater the WWTW discharges the greater the negative impact on ecosystem services.
- **Mbokodweni:** The system is at present in a poor condition. The system improves significantly to if WWTW effluent is reduced and/or removed from the system. However as with the Tongati the more WWTW discharges the greater the negative impact on ecosystem services
- **Little Manzintoti:** The system is at present in a poor condition. As with the other systems in this cluster the greater the WW discharge the greater the negative impact.
- **uMkhomazi:** The estuary is of high ecological importance. All “flow” scenarios maintained the current state. Most of the future scenarios including WWTW discharges degrade the condition of this estuary. Contact recreation, harvesting of invertebrates and estuarine vegetation will suffer as will the presence of fishing that is important both for recreational purposes as well as subsistence.

The relative weightings given to the importance of the estuaries is summarized in the Table 10.11 below. Again it should be noted that the weight given to each estuary represents its relative importance where the total sum of importance for all estuaries considered is 100.

Table 10.11 Relative Importance of Estuaries

Estuary	Weight	Motivation
Little Manzimtoti	17	**Aesthetic**
uThongathi	18	Average score
Mbokodweni	20	Recreational use
uMdloti	22	Aesthetic
uMkhomazi	23	Aesthetic, recreational use, ritual, historic
Score	**100**	

Figure 10.3 below summaries the relative ranking of all scenarios in the Central Cluster of estuaries. Most A cluster scenarios maintain and improve the current ecosystem services state. Taking into account that the Mkomazi is the most important, the range of A Sc and EI that improves it would be recommended. Sc Biii represents the worst case scenario due to impacts largely associated with recreational losses as well as livelihood losses in some instances.

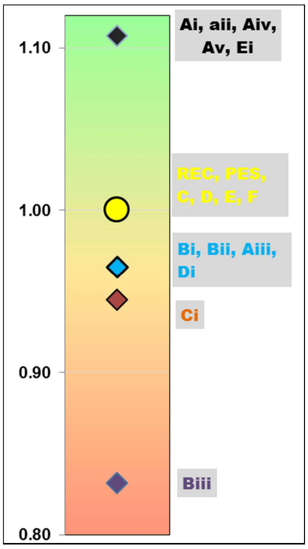


Figure 10.3 Ranking of impact of scenarios in the Central Cluster

10.8 ESTUARIES NORTHERN CLUSTER IUA

- **uMhlali:** A group of scenarios that either maintain current state or have increased WW shows an improvement due to overall improvement in ecological functioning. Scenarios that impact negatively on water quality and mouth closure show negative ecosystem services for invertebrate and fish presence.
- **Mvoti:** All the WW scenarios maintain the current condition. Sc A1 will result in an improvement in condition from due to increased availability of fish. Scenarios that include discharge show a decline in fish presence**.**
- **Nonoti:** As with the Mvoti All the WW scenarios maintain the current condition. Sc A1 will result in an improvement in condition from due to increased availability of fish. Scenarios that include discharge show a decline in fish presence.

The relative weightings given to the importance of the estuaries is summarized in the Table 10.12 below. Again it should be noted that the weight given to each estuary represents its relative importance where the total sum of importance for all estuaries considered is 100.

Table 10.12 Relative Importance of Estuaries

Estuary	Weight	Motivation
Mhlali	28	**Aesthetic and Recreational use**
Mvoti	27	Average score
Nonoti	45	Aesthetic
Score	**100**	

Figure 10.4 below summaries the relative ranking of all scenarios in the Northern Cluster of estuaries. Again the B cluster scenarios are the most negative in terms of impact.

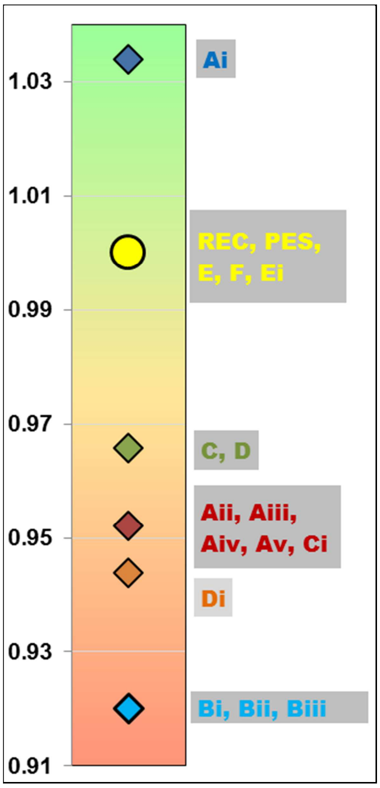


Figure 10.4 Ranking of impact of scenarios in the Northern Cluster

11 ECONOMIC SCENARIO CONSEQUENCES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014e. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River systems. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2014. DWS Report: RDM/WMA11/00/CON/CLA/1114.

Department of Water and Sanitation (DWS), South Africa. 2015c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2015.
DWS Report: RDM/WMA11/00/CON/CLA/0215.

Department of Water and Sanitation (DWS), South Africa. 2014f. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 4: Economic Consequences of Operational Scenarios. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Conningarth Economists. October, 2014. DWS Report: RDM/WMA11/00/CON/CLA/0814.

11.1 BACKGROUND

The results of different scenarios of each catchment as it impacted on the different economic sectors are presented in this Chapter. The impact on Gross Domestic Product (GDP) as an economic indicator and then on labour as a social indicator is provided to produce a value that can be integrated in the final result. The econometric model is based on the original economic baseline calculated and the change in the volume of available water per scenario drives the projections.

11.2 RESULTS PRESENTATION

The results are displayed in the format of the discounted total GDP which also reflects the cost of the water resource developments and employment calculated.

Discounted Values
As already explained the total capital cost of a proposed project per catchment is entered together with the annual operational and maintenance costs to provide a total annual cost for the future - 40 years. The total GDP from the different identified benefits are calculated over the period. The two sets of values are subtracted to provide a Present Value, this value is then discounted over the period to provide a GDP Net Present Value expressed in Rand. This is then presented as the GDP benefit from the additional water.

The total estimated number of jobs is also calculated, then discounted and presented as the employment benefit of the additional water. The discount rate used is 8% as recommended by the CBA manual.

11.3 MVOTI RIVER SYSTEM

In Table 11.1 the results of the different operational scenarios for the Mvoti catchment are presented.

Table 11.1 Results of the operational scenarios in the Mvoti Catchment

Scenario	Projected GDP growth (R million)	Projected additional labour
MV3	R 39 637.65	21 661
MV41	R 15 808.43	6 427
MV42	R 25 713.48	11 360
MV43	R 23 996.70	10 412

The results of operational scenarios in terms of economic preference are presented in Table 11.2 and Figure 11.1.

Table 11.2 Mvoti results ranked

Position	Projected GDP	Projected Employment
1	MV3	MV3
2	MV42	MV42
3	MV43	MV43
4	MV41	MV41

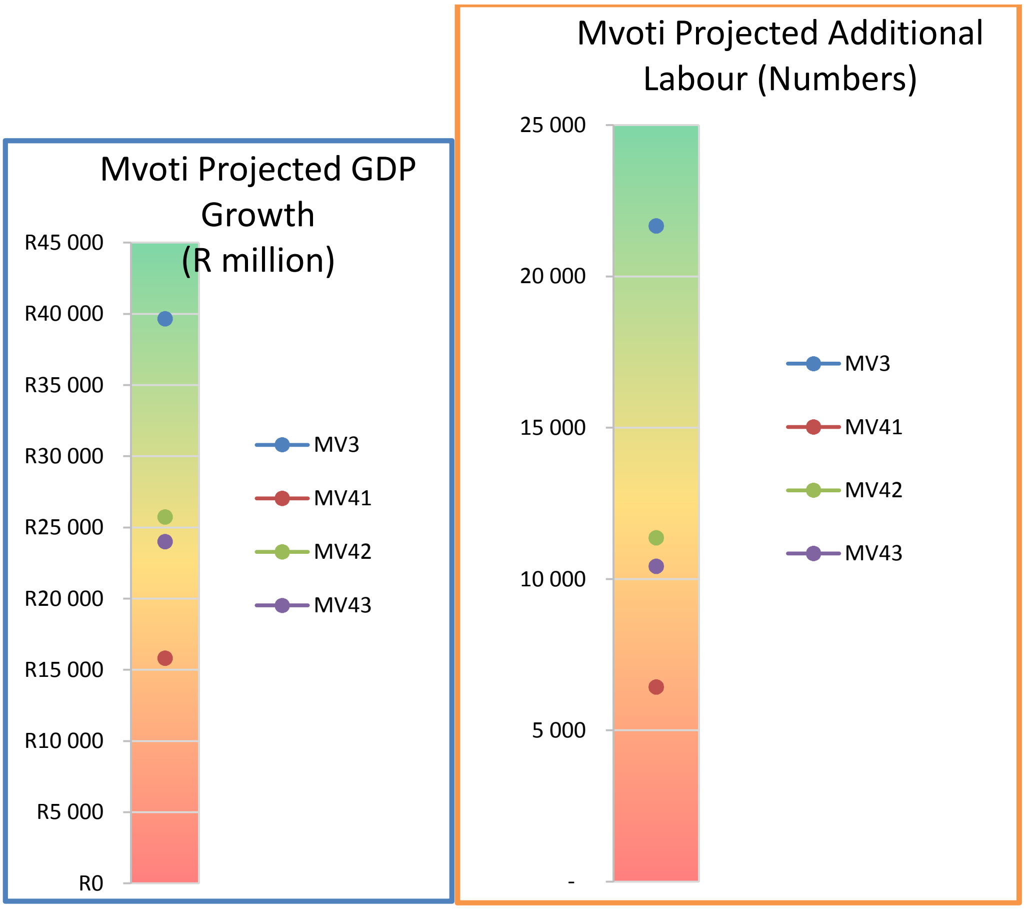


Figure 11.1 Mvoti projected GDP growth and additional labour

Table 11.2 and Figure 11.1 indicate that in economic terms, Sc MV3 is the most preferable option with Sc MV41 the worst option.

11.4 uMKHOMAZI RIVER SYSTEM

The results of the different operational scenarios for the uMkhomazi catchment are presented in Table 11.3. The results represent not only the possible impact in the uMkhomazi but also the impact of the different volumes that can be transferred.

Table 11.3 Results of the operational scenarios in the uMkhomazi Catchment

Scenario	Smithfield HFY	Ngwadini HFY	Projected GDP growth (R million)	Projected additional labour
MK2	196.00	11.99	R 386 158	402 685
MK21	142.20	8.03	R 348 392	342 577
MK22	150.60	8.03	R 354 093	353 837
MK23	150.60	8.03	R 354 093	353 837
MK31	150.10	5.98	R 351 204	351 777
MK32	161.00	6.63	R 358 397	365 594
MK33	161.00	6.63	R 358 397	365 594
MK4	142.50	54.80	R 357 056	346 582
MK41	84.10	54.80	R 290 228	243 680
MK42	92.50	54.80	R 303 646	261 266

The results of operational scenarios in terms of economic preference are presented in Table 11.4 and Figure 11.2.

Table 11.4 uMkhomazi results ranked

Position	Projected GDP	Projected Employment
1	MK2	MK2
2	MK 32 and MK 33	MK 32 and MK 33
3	MK 4	MK22 and MK33
4	MK 22 and MK 33	MK31
5	MK 31	MK4
6	MK 21	MK21
7	MK 42	MK42
8	MK 41	MK41

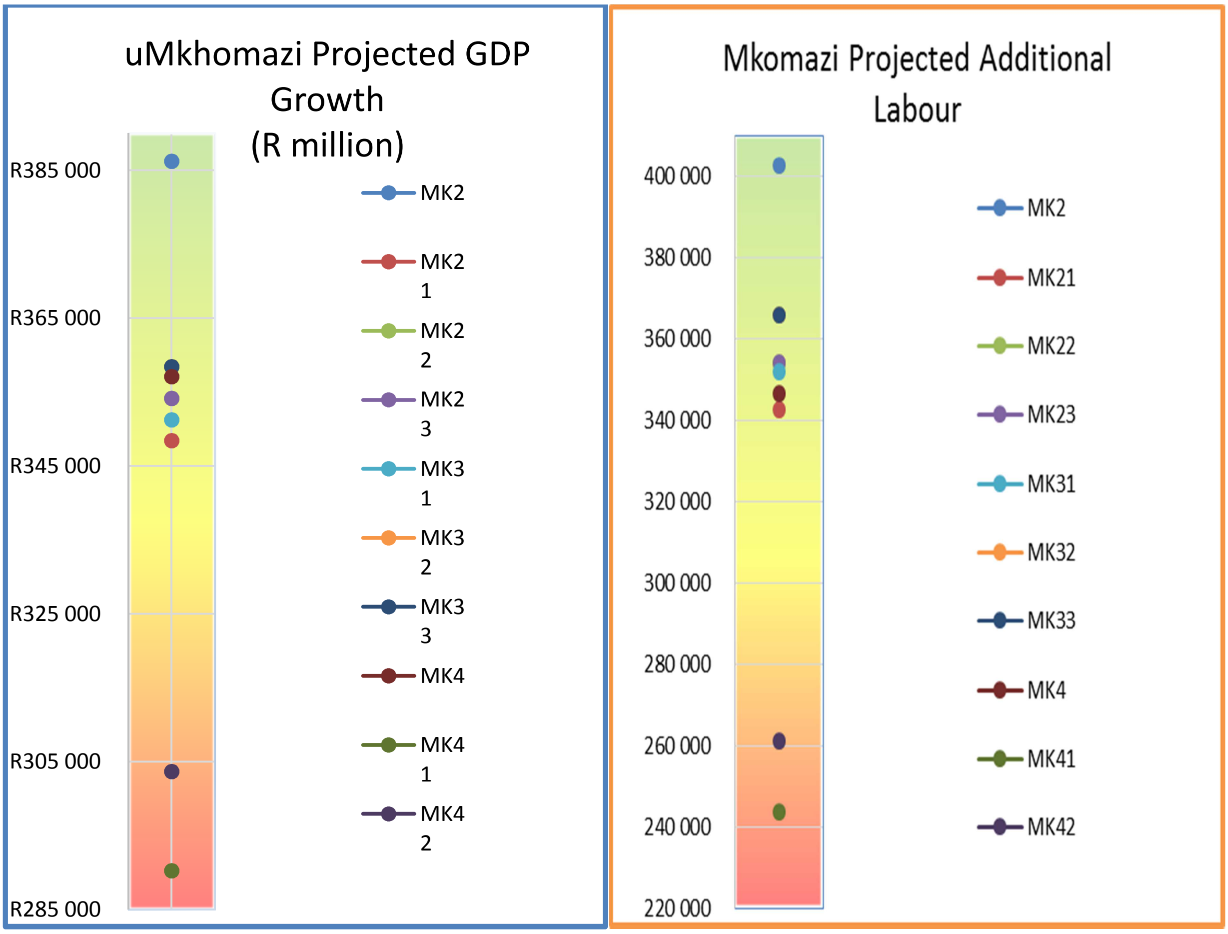


Figure 11.2 uMkhomazi projected GDP growth and additional labour

All the scenarios provide positive results, but the rating differs in the lower rankings. For both measuring instruments Sc MK2 is the preferable option. Scenario MK42 is economically the least preferred option.

11.5 uMNGENI AND LOVU RIVER SYSTEM

The results of the different operational scenarios for the uMngeni and Lovu catchment are presented in Table 11.5 and Table 11.6 respectively.

Table 11.5 Results of the operational scenarios in the uMngeni Catchment

Sc	Additional allocation (million m^3/a)	Projected GDP growth (R million)	Projected additional labour	URV^1 (R/m^3)	URV (Number/mm^3)
UM41	142.2	R 13 927	208 611	R15.95	239
UM51	205	R 11 942	232 725	R10.73	209

1 Unit Reference Value.

Both scenarios provides positive answers with Sc UM51 in economic terms the preferred option and as the URV value indicate the cheaper option per unit water to implement.

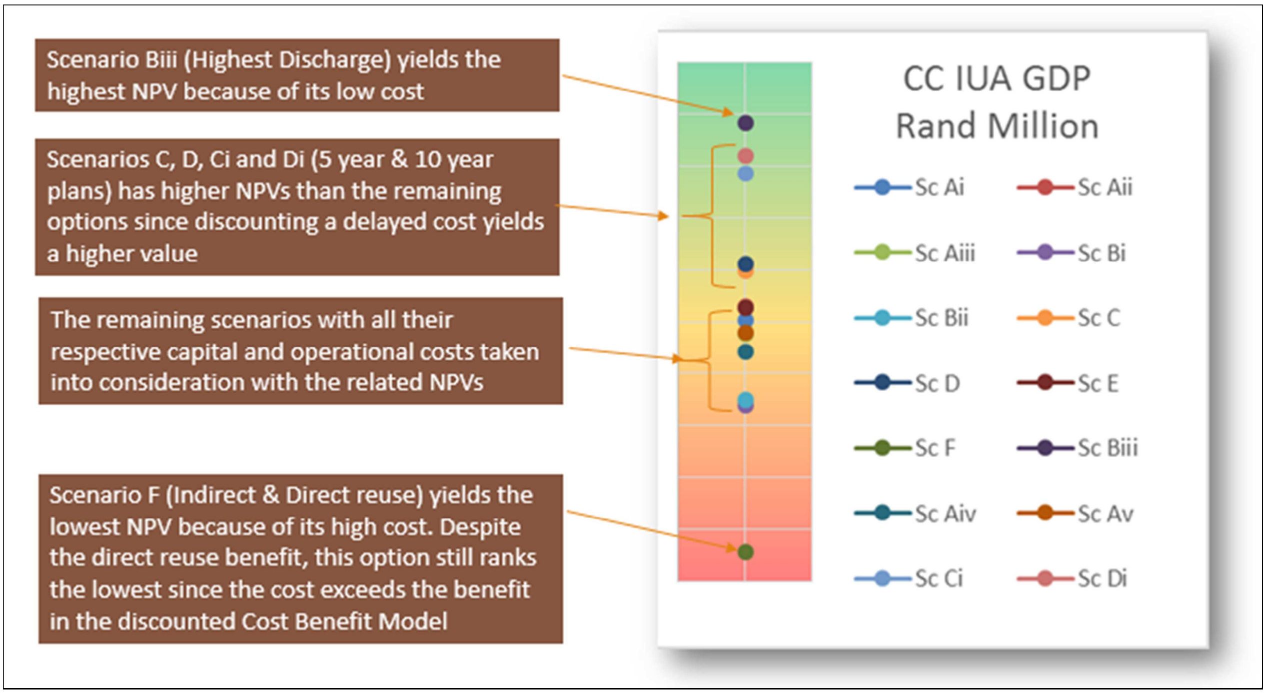
Table 11.6 Results of the operational scenarios in the Lovu Catchment

Sc	Reduction in forestry water volume (mm3/a)	Projected GDP growth (R million)	Projected additional labour
LO3	2.65	R -388	-4 156
LO4	5.30	R -775	-8 312

Table 11.6 presents the results of the proposed water reduction on the commercial forestry activity in the catchment. Scenario LO3 with the smallest negative economic impact will be the preferable scenario.

11.6 CENTRAL CLUSTER IUA RESULTS

The results are provided in traffic diagrams below (Figure 11.3 and Figure 11.4) with explanations of the results adjacent to the traffic diagrams. It appears that Sc Biii is the economic preferable option with Sc F the least preferable option.



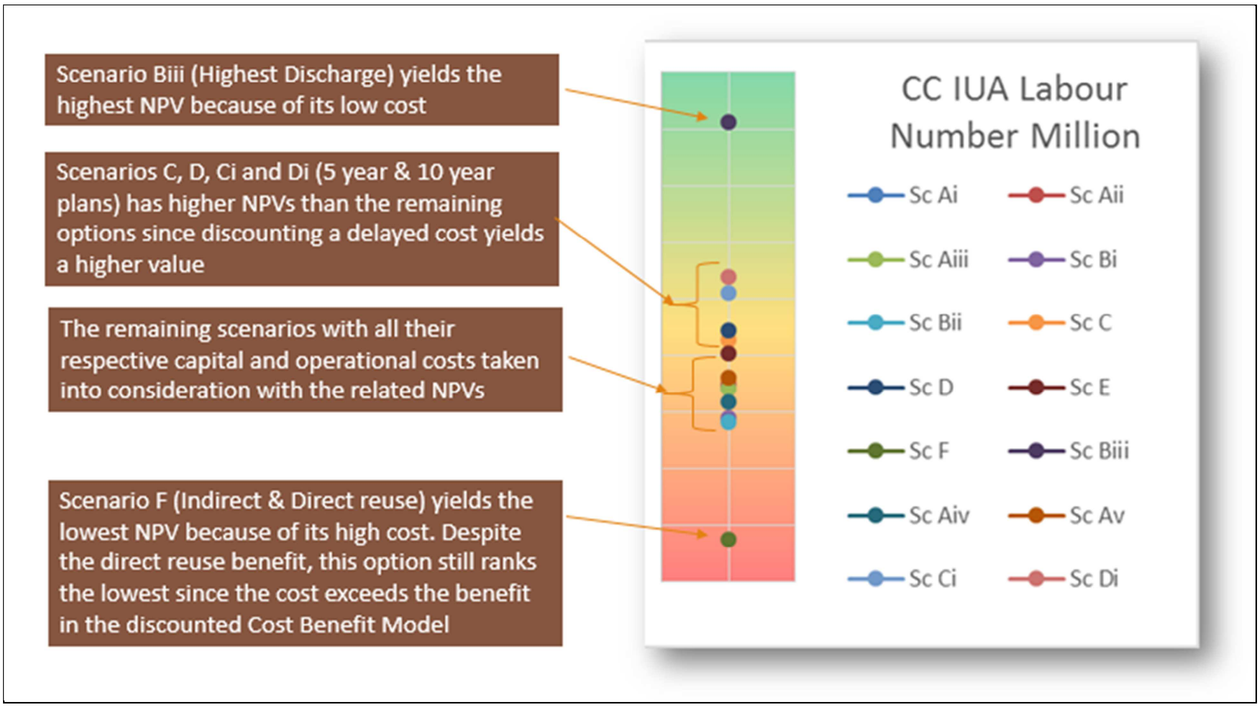
Scenario Biii (Highest Discharge) yields the highest NPV because of its low cost

Scenarios C, D, Ci and Di (5 year & 10 year plans) has higher NPVs than the remaining options since discounting a delayed cost yields a higher value

The remaining scenarios with all their respective capital and operational costs taken into consideration with the related NPVs

Scenario F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, this option still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.3 Central Cluster GDP Ranking



Scenario Biii (Highest Discharge) yields the highest NPV because of its low cost

Scenarios C, D, Ci and Di (5 year & 10 year plans) has higher NPVs than the remaining options since discounting a delayed cost yields a higher value

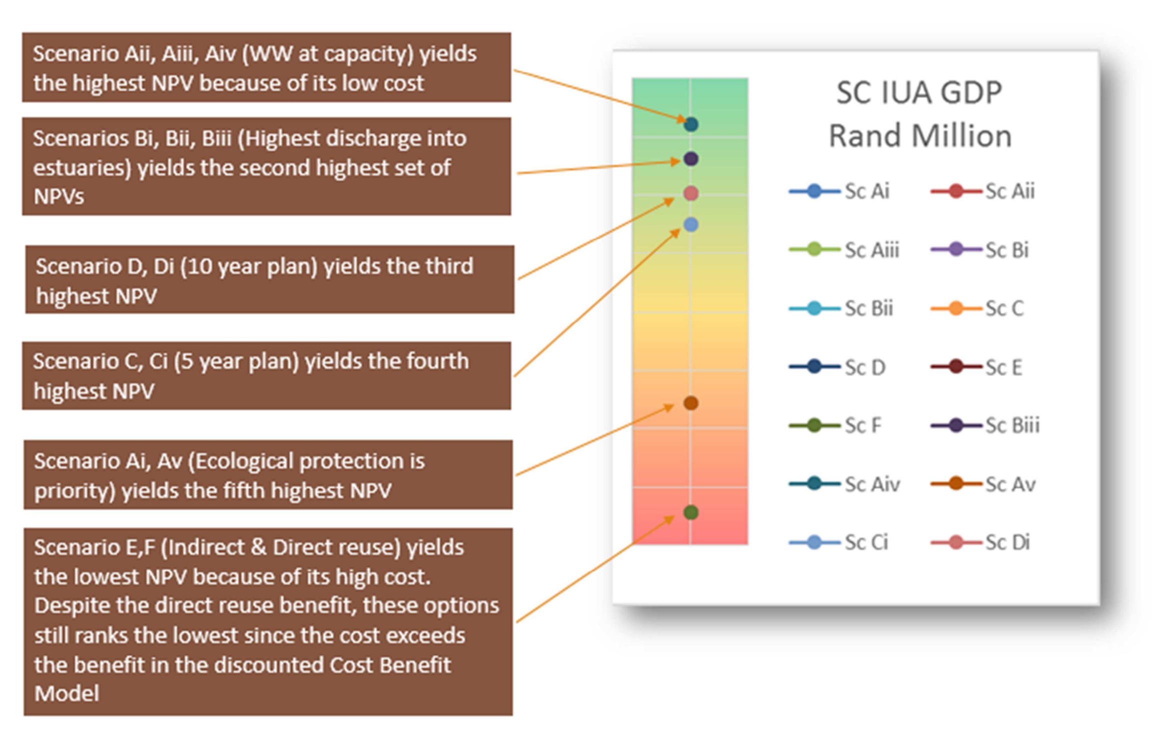
The remaining scenarios with all their respective capital and operational costs taken into consideration with the related NPVs

Scenario F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, this option still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.4 Central Cluster Employment Ranking

11.7 SOUTHERN CLUSTER IUA RESULTS

The results are provided in traffic diagrams below (Figure 11.5 and Figure 11.6) with explanations of the results adjacent to the traffic diagrams. It appears that Sc Aii, Sc Aiii and Sc Aiv are the economic preferable options with Sc E and Sc F the least preferable options.



Scenario Aii, Aiii, Aiv (WW at capacity) yields the highest NPV because of its low cost

Scenarios Bi, Bii, Biii (Highest discharge into estuaries) yields the second highest set of NPVs

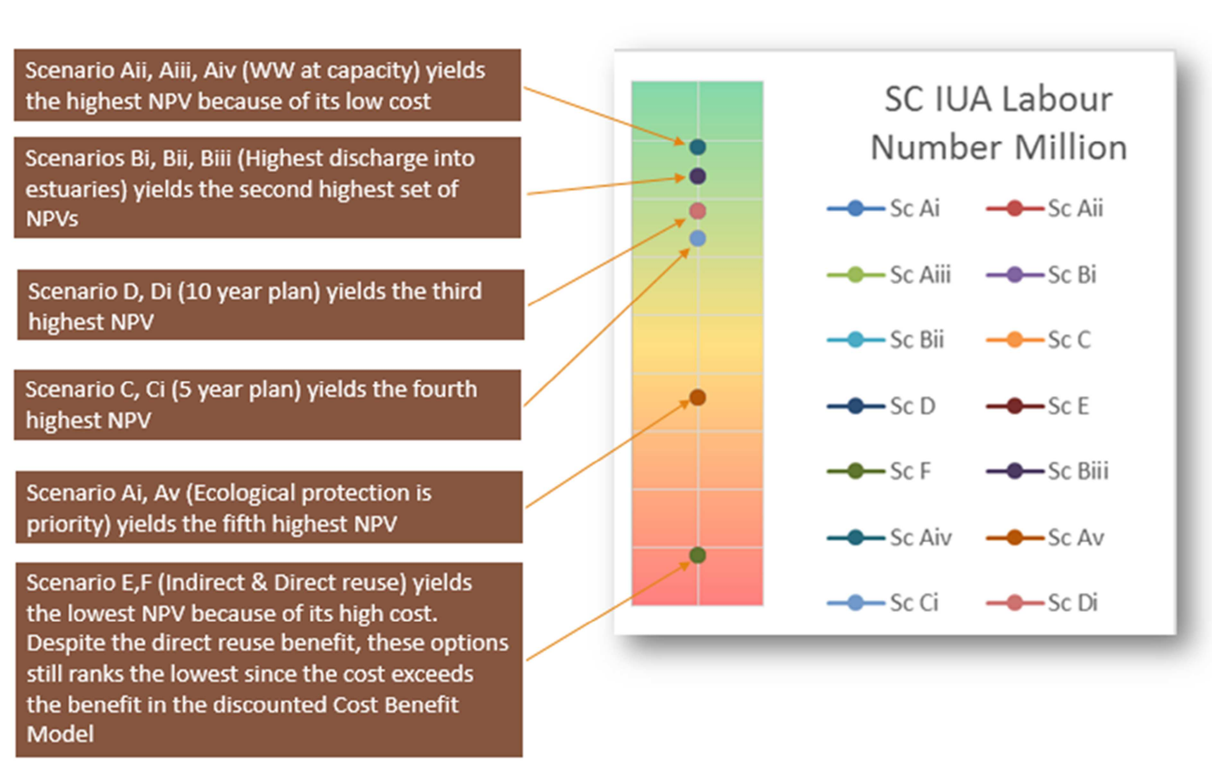
Scenario D, Di (10 year plan) yields the third highest NPV

Scenario C, Ci (5 year plan) yields the fourth highest NPV

Scenario Ai, Av (Ecological protection is priority) yields the fifth highest NPV

Scenario E,F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, these options still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.5 Southern Cluster GDP Ranking



Scenario Aii, Aiii, Aiv (WW at capacity) yields the highest NPV because of its low cost

Scenarios Bi, Bii, Biii (Highest discharge into estuaries) yields the second highest set of NPVs

Scenario D, Di (10 year plan) yields the third highest NPV

Scenario C, Ci (5 year plan) yields the fourth highest NPV

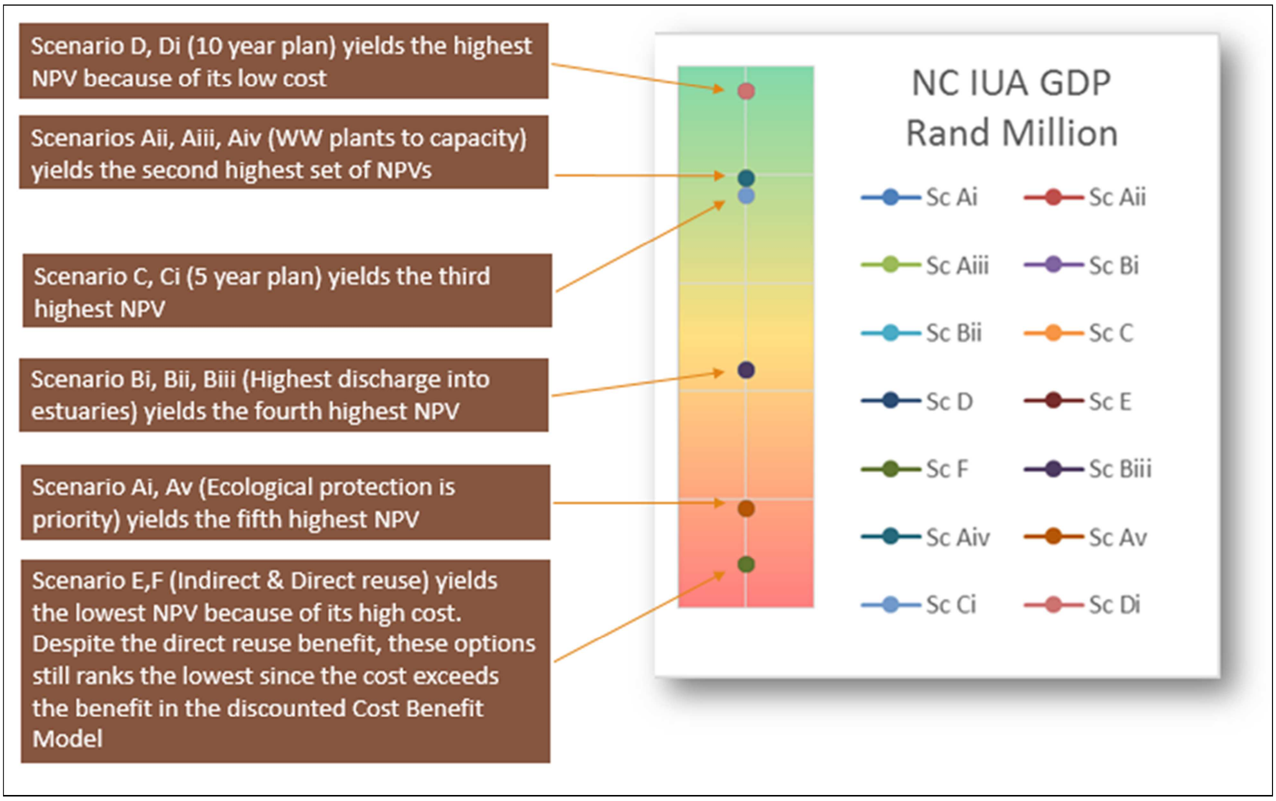
Scenario Ai, Av (Ecological protection is priority) yields the fifth highest NPV

Scenario E,F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, these options still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.6 Southern Cluster Employment Ranking

11.8 NORTHERN CLUSTER IUA RESULTS

The results are provided in traffic diagrams below (Figure 11.7 and Figure 11.8) with explanations of the results adjacent to the traffic diagrams. It appears that Sc D and Sc Di are the economic preferable options with Sc E and F the least preferable options.



Scenario D, Di (10 year plan) yields the highest NPV because of its low cost

Scenarios Aii, Aiii, Aiv (WW plants to capacity) yields the second highest set of NPVs

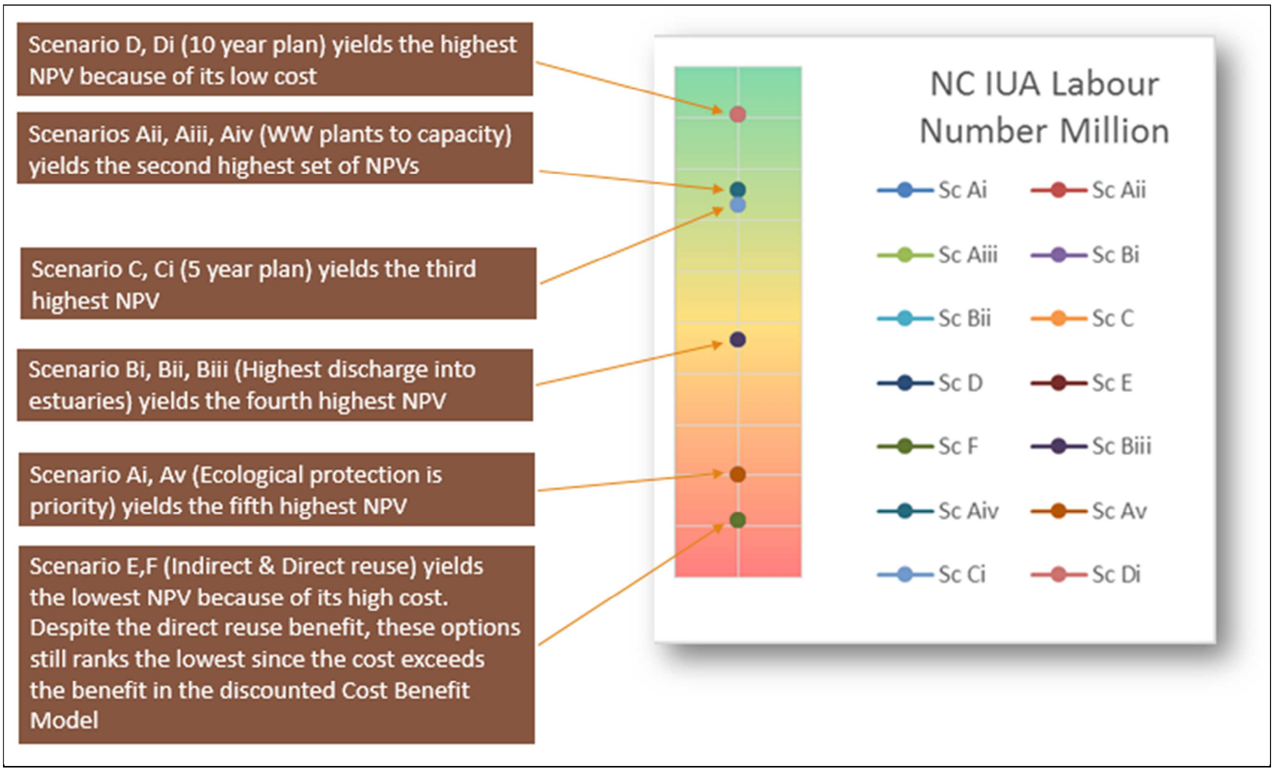
Scenario C, Ci (5 year plan) yields the third highest NPV

Scenario Bi, Bii, Biii (Highest discharge into estuaries) yields the fourth highest NPV

Scenario Ai, Av (Ecological protection is priority) yields the fifth highest NPV

Scenario E,F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, these options still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.7 Northern Cluster GDP Ranking



Scenario D, Di (10 year plan) yields the highest NPV because of its low cost

Scenarios Aii, Aiii, Aiv (WW plants to capacity) yields the second highest set of NPVs

Scenario C, Ci (5 year plan) yields the third highest NPV

Scenario Bi, Bii, Biii (Highest discharge into estuaries) yields the fourth highest NPV

Scenario Ai, Av (Ecological protection is priority) yields the fifth highest NPV

Scenario E,F (Indirect & Direct reuse) yields the lowest NPV because of its high cost. Despite the direct reuse benefit, these options still ranks the lowest since the cost exceeds the benefit in the discounted Cost Benefit Model

Figure 11.8 Northern Cluster Employment Ranking

11.9 CONCLUSION

The various operational scenarios all present positive answers for all the catchments, except in the case of the Lovu, and should all make positive contributions to the economic growth and employment creation in the Mvoti, uMkhomazi, uMngeni catchments and in the Central, Southern and Northern clusters. The exception is the Lovu where a negative impact is indicated.

The final preferred option will depend on the interaction between the economic values, the goods and services and the environmental impacts.

12 WATER QUALITY (USER) CONSEQUENCES

This chapter is an extract from the following report:
Department of Water and Sanitation (DWS), South Africa. 2015d. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 6: Supporting Information on the Determination of Water Resource Classes – User Water Quality Consequences of Operational Scenarios. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Scherman, P-A. March 2015. DWS Report: RDM/WMA11/00/CON/CLA/1014.

12.1 BACKGROUND

The purpose of this Chapter is to describe and document an approach as to how operational scenarios may impact on water quality for users or water quality role players other than the aquatic ecosystem (for example: Domestic Use, Agriculture - Stock Watering, Agriculture – Irrigation, Industrial - Category 3 and Recreation - Intermediate Contact). The document therefore presents the approach undertaken to include user water quality into the consequences evaluation and the results of this assessment. Note that only sites relevant to scenarios were assessed.

Priority RUs or MRUs for the determination of consequences to users are those reaches containing the EWR sites which may potentially be impacted by operational scenarios. The impact of operational scenarios has therefore been assessed at these key biophysical nodes in the study area:

- uMkhomazi (U1), reaches containing EWR sites Mk_I_EWR_1, Mk_I_EWR_2 and Mk_I_EWR_3.
- uMngeni (U2), reaches containing Mg_I_EWR2 and Mg_I_EWR5.
- Mvoti (U4), reach containing Mv_I_EWR2.
- Lovu (U7), reach containing Lo_R_EWR1.

12.2 RESULTS

The qualitative assessment of the consequences of operational scenarios on user water quality showed that little impact is expected under any of the operational scenarios assessed at selected reaches, as can be seen from Figures 12.1 to 12.3 below. Note the following explanatory points:

- Each figure shows the identified primary water quality role players in the area, together with the primary driving variables.
- No scale is shown on the bars as the process undertaken was qualitative and in relation to CS.
- CS shown on the bar relates to the water quality state, for example, a Good CS will be located along the upper third and in the green portion of the bar.
- CS per river reach can therefore be assessed comparatively, that is, if CS is lower on one bar than the other, then water quality is assumed to be poorer at that site.
- The impact of operational scenarios (denoted as Sc x) have been considered in relation to CS.

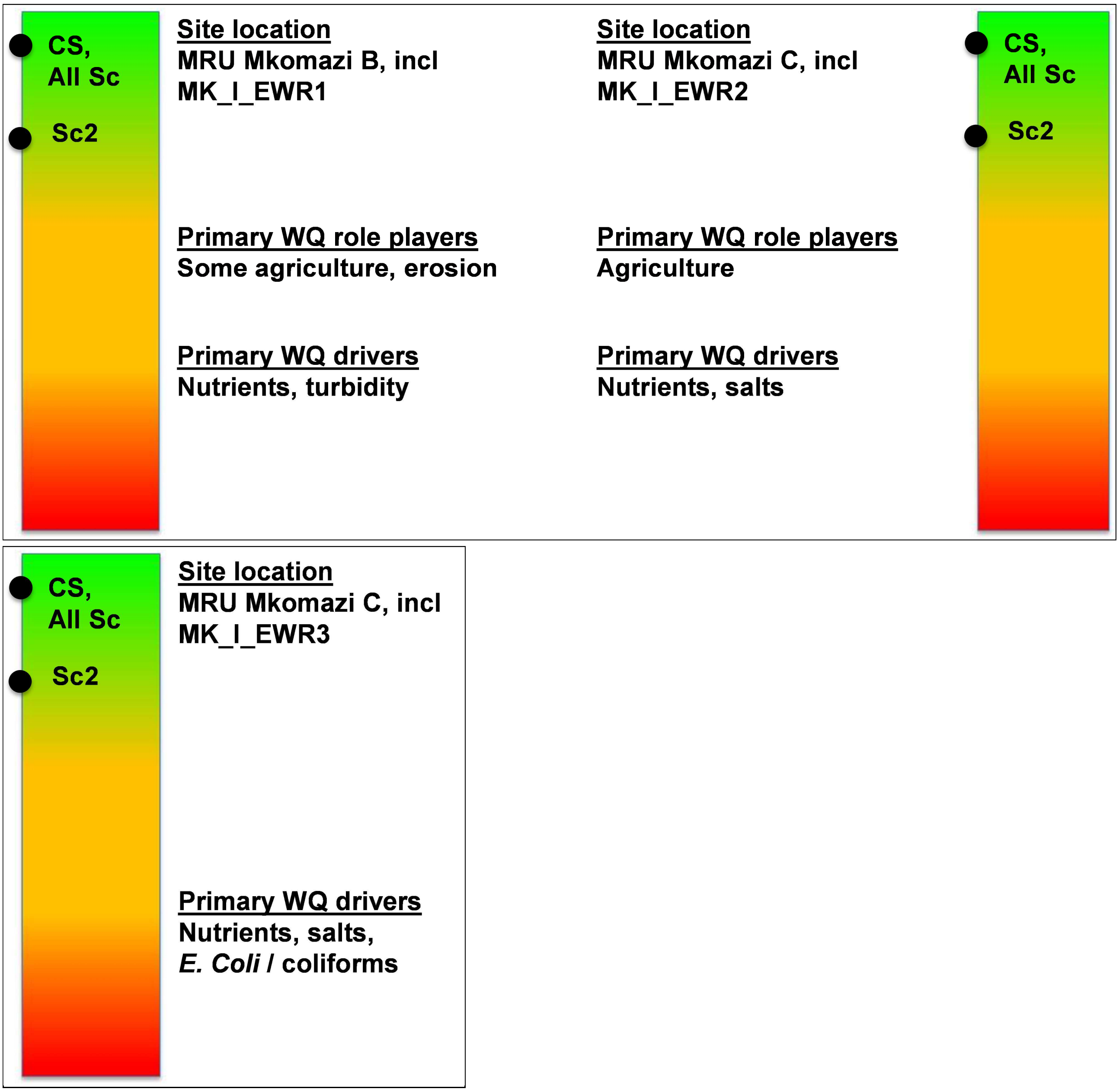


Figure 12.12.1 Consequences of selected scenarios on user water quality drivers of selected reaches of the uMkhomazi River (U1)

Figure 12.12.2 Consequences of selected scenarios on user water quality drivers of selected reaches of the uMngeni River (U2)

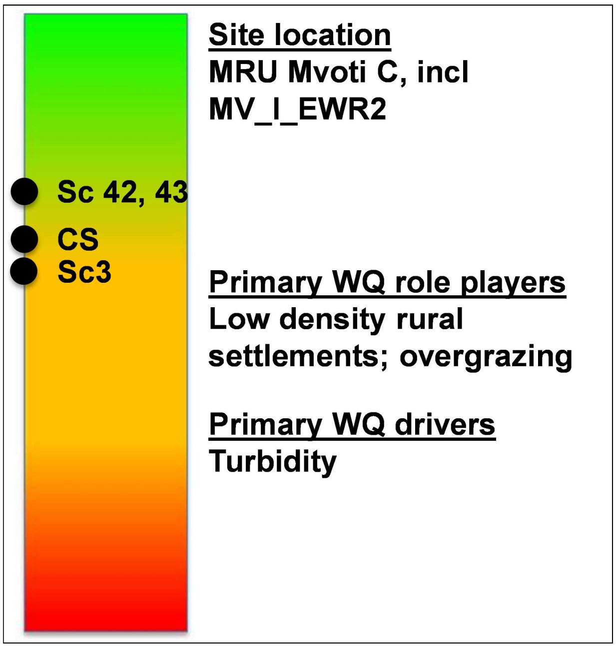


Figure 12.3 Consequences of selected scenarios on user water quality drivers of selected reaches of the Mvoti River (U4)

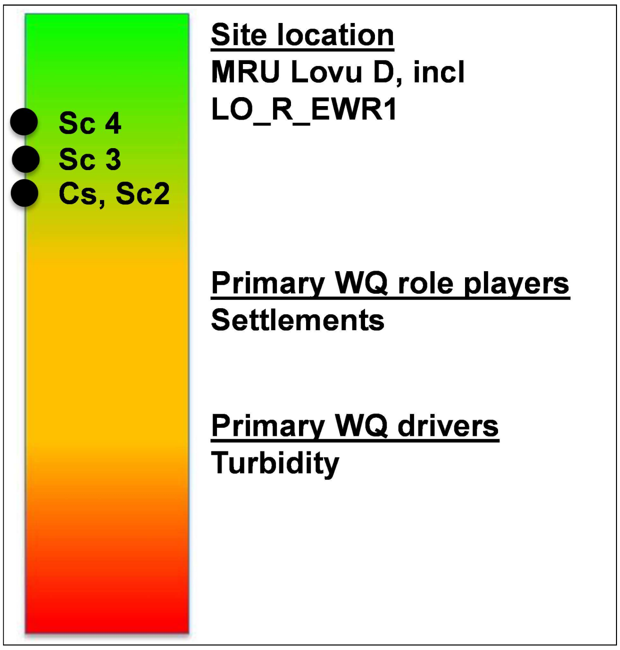


Figure 12.4 Consequences of selected scenarios on user water quality drivers of selected reaches of the Lovu River (U7)

12.3 CONCLUSIONS

For a number of the reaches containing EWR sites, conditions may improve slightly for users due to improved flows (and therefore improved water quality state) under the scenarios. Note that scenarios including increased releases from Phoenix, Mhlanga, Tongati and Darvill WWTW assume that releases will meet required water quality standards.

The ranking of scenario impacts on user water quality was not undertaken for the Mvoti – Umzimkulu study due to the small differences and lack of resolution to differentiate between the scenarios for the various sites.

13 WATER RESOURCE CLASSES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2014e. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River systems. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2014. DWS Report: RDM/WMA11/00/CON/CLA/1114.

Department of Water and Sanitation (DWS), South Africa. 2015c. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, William Mullins, Greg Huggins, Lara van Niekerk. September 2015.
DWS Report: RDM/WMA11/00/CON/CLA/0215.

13.1 BACKGROUND

Within the integrated water resource management process outlined in Table 13.1, integrated step 4 refers to: The identification and evaluation of scenarios within the Integrated Water Resource Management Process. This step is closely linked to the next step where the scenarios are tested with stakeholders and the draft Water Resource Classes are determined. The results of Step 4 are documented in this Chapter.

Table 13.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.
4	**Identify and evaluate scenarios within the Integrated Water Resource Management process.**
5	**Evaluate the scenarios with stakeholders and determine Water Resource Classes.**
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

13.2 WATER RESOURCE CLASS CRITERIA TABLE

A range of alternative water resource criteria settings were evaluated by the study team leading to the recommended criteria parameters presented in Table 13.2.

Table 13.2 Recommended Water Resource Class criteria table

		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥ C	≥ D	< D
Class 1		0	60	80	95	5
Class 2			0	70	90	10
Class 3	**Either**			0	80	20
	Or				100	

The above table was applied and the resulting Water Resource Classes and catchment configuration are provided in the next sections.

These Water Resource Classes and catchment configuration results are the recommendations that were presented at the Project Steering Committee Meeting held in November 2014 and 16 September 2015 for comments after which the final scenario and results was prepared for gazetting.

13.3 DETERMINATION OF THE CATCHMENT CONFIGURATION

The catchment configuration is expressed as the Target Ecological Category (TEC). In the process to make recommendations regarding the Class and the TEC, one would always aim to meet the REC. However, in order to achieve a balance, the implications of meeting the REC are considered. The TEC could therefore be any EC. According to the above guideline (Table 13.2), it could also be worse than a D category. Any TEC worse than a D is referred to as an EF.

The steps to decide on a recommended catchment configuration and TECs are as follows:

- PES and REC evaluated and interventions required to achieve the REC identified.
- Evaluate implications of interventions.
- Identify best compromise/balance scenarios.
- Compare ecological consequences to REC.
- Considering all consequences, derive a TEC (focus on immediately applicable).
- Provide implications of the TEC for future development and use of the system.
- Present for stakeholder input

13.4 WATER RESOURCE CLASS

When applying the criteria presented in Table 13.2 to the resulting ECs, the Water Resource Classes for the different IUAs in the respective river systems are as listed in Table 13.3 (Maps illustrated in Appendix C).

Table 13.3 Resulting IUA Water Resource Classes for each scenario

IUA	PES	REC	TEC
T4: Mtamvuna			
T4-1	II	II	II
T5: Umzimkulu			
T5-1	I	I	I
T5-2	II	II	II
T5-3	I	I	I
U1:uMkhomazi			
U1-1	I	I	I
U1-2	II	II	II
U1-3	I	I	I
U1-4	II	II	II
U2: uMngeni			
U2-1	II	II	II
U2-2	III	III	III
U2-3	III	III	III
U2-4	III	II	II
U2-5	III	III	III
U2-6	III	III	III
U3: uMdloti and uThongathi			
U3-1	III	III	III
U3-2	II	II	II
U3-3	II	II	II
U4: Mvoti			
U4-1	II	II	II
U4-2	II	I	I
U4-3	II	II	II
U6: uMlazi			
U6-1	III	III	III
U6-2	III	III	III
U6-3	II	I	I
U7: Lovu			
U7-1	III	III	III
U8: Mtwalume and Mzumbe			
U8-1	I	I	I
U8-2	II	I	II
Estuary IUAs			
SC1	I	I	I
SC2	II	II	II
CC	XXX	III	III
NC	III	II	III

Note: XXX depicts that the IUA does not comply with a Water Resource Class of III.

Of the 30 IUAs indicated in this table, there are 27% Class I; 40% in Class II and 33% in Class III.

13.5 CATCHMENT CONFIGURATION

The catchment configuration associated with the Water Resource Class is provided in Table 13.4 and 13.5.

It must be noted that various nodes require improvements (Table 13.6 and 13.10) based largely on non flow-related/anthropogenic issues that have to be addressed. Where it is deemed that the REC is attainable, it has been included in the catchment configuration. The red outlined cells in the TEC columns indicate that there are actions required to improve the PES to the TEC.

Table 13.4 Mvoti to Umzimkulu WMA: Recommended ECs and Water Resource Classes for the river dominated IUAs

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
T4: Mtamvuna					
T4-1	**II**	T40A-05450	Mafadobo	19.3	**B**
		T40A-05487	Goxe	36.2	**B**
		T40B-05337	Weza	43.0	**C**
		T40C-05510	Mtamvuna	13.6	**B**
		T40C-05520	Mtamvuna	19.2	**C**
		T40C-05530	Mtamvuna	5.4	**B**
		T40C-05566	Ludeke	9.3	**B**
		T40C-05589	KuNtlamvukazi	20.5	**B**
		T40C-05600	Ludeke	18.8	**B**
		T40D-05537	Mtamvuna	8.8	**C**
		T40D-05584	Mtamvuna	31.5	**C**
		T40D-05615	Tungwana	10.5	**B**
		T40D-05643	Gwala	19.1	**B**
		T40D-05683	Ntelekweni	28.7	**B/C**
		T40D-05707	Mtamvuna	0.8	**C**
		T40D-05719	Londobezi	17.5	**B**
		Mt_R_EWR1	Mtamvuna	49.5	**C**
		T40E-05767	Hlolweni	25.4	**B**
T5: Umzimkulu					
T5-1	**I**	T51A-04431	Mzimkhulu	27.4	**B**
		T51A-04522	Mzimude	34.2	**B**
		T51A-04608		3.0	**B**
		T51A-04551	Mzimude	16.1	**B**
		T51B-04421	Mzimkhulu	23.1	**B**
		T51D-04404	Pholela	30.8	**B**
		T51F-04566	Boesmans	12.6	**A**
		T51F-04674		6.4	**C**
		T51G-04669	Ndawana	19.4	**B**
		T51G-04722	Ndawana	26.2	**C**
T5-2	**II**	T51C-04606		6.4	**C**
		MzEWR2i	Mzimkhulu	76.0	**B**
		T51D-04460	Pholelana	12.4	**D/E**
		T51E-04536		14.1	**C**
		MzEWR9r	Pholela	73.0	**B/C**
		T51F-04611	Ngwangwane	12.6	**A**
		MzEWR8r	Ngwangwane	123.0	**C**

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
		T51G-04751		5.0	B
		T51H-04828	Gungununu	13.6	A/B
		T51H-04846	Lubhukwini	18.7	A
		T51H-04913	Nonginqa	23.2	B/C
		T51H-04923	Malenge	36.9	B
		T51H-04808	Gungununu	30.7	B
		T51H-04884	Gungununu	10.1	B/C
		T51H-04908	Gungununu	3.1	B/C
		MzEWR3i	Mzimkhulu	21.4	B
		T52B-04947	Cabane	46.4	B
		T52C-04880		15.9	C
		T52C-04960	Mzimkhulu	4.8	B
		T52D-05024	Ncalu	20.4	B
		T52D-05061	Mgodi	26.3	B
		T52D-04948	Mzimkhulu	50.6	B
		T52D-05137	Mzimkhulu	4.7	B
		T52E-05053	Upper Bisi	49.7	B
		T52F-05104	Little Bisi	39.2	C
		T52F-05190	Mbumba	33.1	B/C
		T52F-05139	Little Bisi	13.8	B
		T52G-05226	uMbumbane	19.8	B/C
		T52G-05171	Bisi	10.3	B
		T52H-05244	Mahobe	22.0	B/C
		T52H-05178	Bisi	16.9	B
		T52K-05475	Nkondwana	20.4	B/C
		MzEWR17i	Mzimkhulwana	87.2	B
T5-3	I	T52H-05295	Magogo	28.6	B
		MzEWR14r	Bisi	20.1	B/C
		T52H-05189	Bisi	12.0	B
		MzEWR6i	Mzimkhulu	133.2	A/B
U1: uMkhomazi					
U1-1	I	U10A-04115	Lotheni	27.0	A/B
		U10A-04202	Nhlathimbe	25.7	B
		U10A-04301	Lotheni	18.9	B
		U10B-04239	uMkhomazi	18.3	B
		U10B-04251	uMkhomazi	8.3	A
		U10B-04274	Nhlangeni	9.7	A
		U10B-04337	uMkhomazi	28.1	B
		U10B-04343	Mqatsheni	25.1	B
		U10C-04347	Mkhomazana	68.4	B
		U10D-04199	Nzinga	19.3	A
		U10D-04222	Rooidraai	13.0	B
		U10D-04298	Nzinga	27.1	B
		U10D-04349	uMkhomazi	17.2	B

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
		U10D-04434	uMkhomazi	1.4	**B**
U1-2	**II**	U10E-04380	uMkhomazi	39.5	**C**
		U10F-04528	uMkhomazi	7.0	**C**
		Mk_I_EWR1	uMkhomazi	14.0	**C**
		U10G-04388	Elands	26.5	**B**
		U10G-04405		12.2	**C**
		U10G-04473	Elands	44.5	**B**
U1-3	**I**	U10H-04576	Tholeni	15.8	**B**
		U10H-04666	Ngudwini	36.1	**B**
		U10H-04708	Ngudwini	7.5	**B**
		U10H-04729	Mzalanyoni	24.4	**C**
		Mk_I_EWR2	uMkhomazi	49.0	**B**
		U10J-04721	Pateni	13.8	**B**
U1-4	**II**	U10J-04713	Mkobeni	24.2	**B**
		U10J-04820	Lufafa	43.2	**B**
		U10J-04837		4.0	**A/B**
		U10K-04842	Nhlavini	26.2	**B**
		U10K-04899	Xobho	44.3	**C/D**
		U10K-04946	Nhlavini	21.8	**B/C**
		Mk_I_EWR3	uMkhomazi	113.0	**C**
U2: uMngeni					
U2-1	II	Mg_R_EWR1	uMngeni	62.1	**C/D**
		U20B-04074	Ndiza	21.1	**B**
		U20B-04144	Mpofana	20.1	**C**
		U20B-04173	Lions	50.4	**B**
		U20B-04185	Lions	9.2	**B/C**
		U20C-04190	Lions	18.1	**B**
		U20C-04332	Gqishi	14.8	**B**
		U20C-04340	Nguklu	14.5	**C**
U2-2	III	U20D-04029	Yarrow	18.8	**B**
		U20D-04032	Karkloof	39.4	**C**
		U20D-04098	Kusane	34.2	**D**
		U20D-04151	Karkloof	5.5	**B**
		U20E-04136	Nculwane	23.0	**C**
		Mg_R_EWR3	Karkloof	17.6	**B**
		U20E-04221	uMngeni	5.5	**B/C**
		Mg_I_EWR 2	uMngeni	22.8	**C**
		U20E-04271	Doring Spruit	12.9	**B/C**
		U20F-04011	Sterkspruit	43.2	**C/D**
U2-3	III	U20F-04095	Mpolweni	30.0	**C/D**
		U20F-04131	Mhlalane	18.8	**C/D**
		U20F-04204	Sterkspruit	11.5	**B/C**
		U20F-04224	Mpolweni	7.4	**B/C**
		U20G-04194	Mkabela	35.5	**C/D**

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
		U20G-04215	Cramond Stream	3.8	**B/C**
		U20G-04240	uMngeni	9.5	**B/C**
		U20G-04259	uMngeni	38.8	**B/C**
		U20G-04385US	uMngeni	3.8	**B/C**
U2-4	II	U20H-04410	Nqabeni	10.1	**C**
		U20H-04449	uMnsunduze	38.1	**C**
		Mg_R_EWR4	uMnsunduze	23.9	**D**
		U20J-04391	uMnsunduze	29.2	**C**
		U20J-04401	uMnsunduze	20.7	**D**
		U20J-04452	Mpushini	22.6	**B**
		U20J-04459	uMnsunduze	19.4	**C**
		U20J-04461	Slang Spruit	13.8	**C/D**
		U20J-04488	Mshwati	23.5	**B**
U2-5	III	U20K-04181	Mqeku	30.4	**C**
		U20K-04296	Tholeni	21.2	**B/C**
		U20K-04411	Mqeku	7.3	**B**
		Mg_I_EWR 5	uMngeni	30.5	**D**
U2-6	III	U20M-04625		2.4	**D**
		U20M-04639	Palmiet	1.1	**D**
		U20M-04642	Palmiet	7.8	**D**
		U20M-04649	Mbongokazi	5.7	**C**
		U20M-04653	Palmiet	0.9	**C/D**
		U20M-04659	Palmiet	11.3	**C**
		U20M-04682		1.3	**C/D**
U3: uMdloti and uThongathi					
U3-1	III	U30A-04228	Mdloti	36.0	**B**
		U30A-04360	Mdloti	37.4	**D**
		U30A-04363	Mwangala	17.6	**B**
U3-2	II	U30B-04465	Black Mhlashini	17.3	**B/C**
U3-3	II	U30C-04227	uThongathi	44.4	**B/C**
		U30C-04272	Mona	39.7	**B**
U4-Mvoti					
U4-1	**II**	U40A-03869	Mvoti	54.5	**B**
		U40B-03708	Intinda	18.7	**C**
		U40B-03740	Mvozana	11.0	**C**
		Mv_I_EWR_1	Heinespruit	27.8	**C**
		U40B-03832	Mvozana	16.7	**C/D**
		U40B-03896	Mvoti	9.7	**C**
		U40C-03982	Khamanzi	40.2	**B**
		U40D-03867	Mvoti	18.6	**B**
U4-2	**I**	U40D-03908	Mtize	18.9	**B**
		U40D-03957	Mvoti	27.7	**B**

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
		U40E-03967	Mvoti	8.4	B/C
		U40E-03985	Mvoti	27.7	B
		U40E-04079	Faye	21.2	B
		U40E-04082	Sikoto	8.0	B
		U40E-04137	Sikoto	23.1	B
		U40F-03690	Potspruit	17.3	C
		U40F-03694	Hlimbitwa	11.0	C
		U40F-03730	Cubhu	24.3	C
		U40F-03769	Hlimbitwa	13.3	C
		U40F-03790	Nseleni	5.9	B/C
		U40F-03806	Hlimbitwa	6.1	B
		U40G-03843	Hlimbitwa	42.5	B
U4-3	**II**	Mv_I_EWR_2	Mvoti	62.9	C
		U40H-04091	Pambela	17.5	B
		U40H-04117	Nsuze	2.7	B
		U40H-04133	Nsuze	27.9	B
U6: uMlazi					
U6-1	III	U60A-04533	uMlazi	43.2	C
		U60B-04614	Mkuzane	26.8	C/D
		U60C-04555	uMlazi	52.9	C/D
		U60C-04556	Sterkspruit	60.9	D
		U60C-04613	Wekeweke	31.8	C
U6-2	III	U60D-04661	uMlazi	42.1	C/D
U6-3	I	U60E-04714	Mbokodweni	54.5	B
		U60E-04792	Mbokodweni	31.4	C
		U60E-04795	Bivane	60.7	B
U7: Lovu					
U7-1	III	U70A-04599	Serpentine	12.0	C
		U70A-04609	Lovu	4.7	B/C
		U70A-04618		7.1	C
		U70A-04685	Lovu	5.4	C
		U70B-04655	Lovu	95.8	C/D
		U70C-04710	Mgwahumbe	46.6	C
		U70C-04724		1.0	C
		U70C-04732		0.9	C
		Lo_R_EWR1	Lovu	28.3	B/C
		U70D-04800	Nungwane	30.4	B/C
U8: Mtwalume and Mzumbe					
U8-1	I	U80B-05145	Mzumbe_Est	23.1	B
		U80B-05161	Mhlabatshane	24.6	B
		U80C-05231	Mzumbe	56.8	B
		U80C-05329	Kwa-Malukaka	27.4	B
U8-2	II	U80E-05028	Mtwalume	74.6	C
		U80E-05212	Quha	35.8	B

IUA	Water Resource Class	Nodes	River	Length (Km)	Target EC
		U80F-05258	Mtwalume	9.0	B
		U80F-05301	uMgeni	20.1	B

Table 13.5 Mvoti to Umzimkulu WMA: Recommended ECs and Water Resource Classes for the estuary dominated IUAs

IUA	Water Resource Class	Nodes/ Estuaries	River	Length /* hectares (km/ha)	Target EC
SC.1	I	T40F-05666	Mbizana	6.7	B
		T40G-05616	Vungu	7.5	B
		Mtamvuma		54.15	A/B
		Zolwane		0.44	B
		Sandhlunlu		4.73	C
		Kuboyoyi		0.73	B
		Tongazi		0.73	B/C
		Kandanhlovu		1.29	B
		Mpenjati		14.90	B
		Umhlangankulu		5.61	C
		Kaba		2.42	C
		Mbizana		13.41	B
		Mvuthsini		0.63	B/C
		Bilanhlolo		2.01	C
		Umvazana		0.36	C
		Kongweni		1.52	EF
		Vungu		0.28	B
		Mhlangeni		5.85	C
		Zotsha		8.54	B
		Boboyi		1.83	B/C
		Mbango		0.37	EF
		Umzimkulu		107.03	B
SC.2	II	U80G-05097	Fafa	14.68	B
		U80H-05109	Mzinto	7.66	C
		U80H-05120	Mzimayi	0.23	C
		U80H-05186	Mkhumbane	0.23	C
		U80H-05202	Sezela	0.23	C
		U80H-05229	Mdesingane	0.23	C
		U80J-04979	Mpambanyoni	8.36	B
		U80J-05043	Ndonyane	4.14	B/C
		U80K-04952	Mpambanyoni	15.46	C
		Mtentwini		7.76	C
		Mhlangamkulo		2.78	C
		Domba		3.57	D

IUA	Water Resource Class	Nodes/ Estuaries	River	Length /* hectares (km/ha)	Target EC
		Koshwani		1.01	C
		Inhshambili		0.68	C
		Mzumbe		6.68	C/D
		Mhlabatshane		3.00	B
		Mhlungwa		5.94	C
		Mfazazana		1.08	C
		KwaMakozi		2.46	B
		Mnamfu		1.31	C
		Mtwalume		5.01	C
		Mvuzi		0.92	C
		Fafa		14.30	C
		Mdesingane		0.17	D
		Sezela		6.58	C
		Mkumbane		1.08	C
		Mzinto		5.76	C/D
		Nkomba		0.07	C
		Mzimayi		0.50	C/D
		Mpambanyoni		2.92	C
CC	III	U80L-05020	aMahlongwa	7.26	B/C
		U70E-04942	Umsimbazi	2.39	C
		U70E-04974	uMgababa	29.38	C
		U70F-04845	aManzimtoti	30.08	C
		U70F-04893	Little Manzimtoti	16.51	C
		AMahlongwa		7.64	B
		Mahlangwana		6.53	B
		Mkomazi		70.33	B/C
		Ngane		1.86	C
		Umgababa		17.08	B/C
		Msimbazi		20.42	B
		Lovu		35.62	B/C
		Little Manzimtoti		2.58	EF
		aManzimtoti		5.20	D
		Mmbokotwini		8.75	EF
		Sipingo		0.00	EF
		Durban Bay		0.00	EF
		Durban Bay Shallow Zone		--	D
		Mgeni		84.54	D
		Mhlanga		11.21	B
		Mdloti		28.46	D

IUA	Water Resource Class	Nodes/ Estuaries	River	Length /* hectares (km/ha)	Target EC
		uThongathi		3.66	D
NC	III	U30E-04207	Mhlali	25.55	C
		U50A-04018	Zinkwazi	12.64	B/C
		U50A-04021	Nonoti	46.17	B/C
		U50A-04141	Mdlotane	5.32	B/C
		Mhlali		19.26	D
		Bobs Stream		0.38	B/C
		Seteni		0.89	B/C
		Mvoti		28.33	C/D
		Mdlotane		8.97	A/B
		Nonoti		12.13	C
		Zinkwazi		32.22	B

* Note that there are short rivers which are included in the IUAs. The numbers in these columns refer to river length (km) whereas the numbers for estuaries refer to area (ha). This information is used to calculate the Water Resource Class.

Table 13.6 River System nodes requiring improvements to meet the TEC

IUA	Node	River	PES	REC	REC Comment	TEC
T4-Mtamvuna						
T4-1	T40A-05487	Goxe	**B/C**	**B**	Catchment management of informal agriculture and overgrazing will be required.	**B**
	T40C-05510	Mtamvuna	**B/C**	**B**	Catchment management of informal agriculture and overgrazing will be required. Alien vegetation can be removed.	**B**
	T40E-05767	Hlolweni	**B/C**	**B**	Catchment management of informal agriculture and overgrazing will be required. Alien vegetation can be removed.	**B**
T5-Umzimkulu						
T5-1	T51A-04551	Mzimude	**B/C**	**B**	Flow modification needs to improve from a 1.5 to a 1	**B**
T5-2	T51H-04923	Malenge	**B/C**	**B**	Riparian buffer reinstatement.	**B**
	T52D-05024	Ncalu	**B/C**	**B**	Reduce sedimentation and establish buffer zone (forestry area)	**B**
	T52D-05061	Mgodi	**B/C**	**B**	Reduce sedimentation and establish buffer zone (forestry area)	**B**
	T52E-05053	Upper Bisi	**B/C**	**B**	Buffer zone reinstatement in forestry and other areas and alien veg removal	**B**
U1-uMkhomazi						
U1-1	U10D-04298	Nzinga	**B/C**	**B**	Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.	**B**
U1-1	U10D-04349	uMkhomazi	**B/C**	**B**	Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.	**B**
U1-1	U10D-04434	uMkhomazi	**B/C**	**B**	Difficult to achieve the REC as catchment management would be required to amongst others manage sedimentation.	**B**
U1-2	U10G-04388	Elands	**C**	**B**	Target improvement especially in the lower reach. Buffer zone, alien removal, water quality practices. As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.	**B**
U1-2	U10G-04473	Elands	**C**	**B**	Target improvement especially in the upper reach. Buffer zone, alien removal, water quality practices. Also flow improvements but should be able to reach at least	**B**

IUA	Node	River	PES	REC	REC Comment	TEC
					a B/C without any improvement in flow.	
U1-3	U10H-04666	Ngudwini	B/C	B	Address erosion to reduce sedimentation (overgrazing, forestry, informal agriculture). As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.	B
U1-4	U10J-04713	Mkobeni	C	B	Riparian buffer zone in forestry and agricultural areas. Also alien removal. As none of the scenarios are relevant to this SQ, the improvement is valid irrespective of the recommended scenario.	B
U1-4	U10J-04820	Lufafa	B/C	B	Erosion control, riparian buffer. Due to the catchment scale of the problem, this is deemed to be difficult and the PES must be maintained.	B/C
U1-5	U10M-04746	uMkhomazi Estuary	C	B	Remove sand mining from the upper reaches to increase natural function, i.e. restore intertidal area. Restoration of vegetation in the upper reaches and along the northern bank in the middle and lower reaches, e.g. remove alien vegetation and allow disturbed land to revert to natural land cover (is already on upwards trajectory). Curb recreational activities in the lower reaches through zonation and improved compliance. Reduce/remove cast netting in the mouth area through estuary zonation or increased compliance.	B/C
U2-uMngeni						
U2-1	U20B-04074	Ndiza	B/C	B	Reinstate riparian zone in forestry.	B
	U20B-04173	Lions	C	B	Reinstate riparian zone in forestry and wetland buffers. Address irrigation return flows (wq) & town runoff	B
	U20C-04190	Lions	B/C	B	IBT a given - constant flows, no seasonality, but reinstating wetland buffers (off channel) and riparian river zones	B
	U20C-04332	Gqishi	B/C	B	Riparian zone buffer to be improved.	B
U2-2	U20D-04029	Yarrow	B/C	B	Agricultural area - wetland buffers,	B
	U20D-04151	Karkloof	B/C	B	Reinstate riparian buffer zone and wetland buffers.	B
U2-4	Mg_R_EWR 4	uMnsunduze	D/E	D	Water quality improvement	D
	U20J-04452	Mpushini	B/C	B	Water quality from Ashburton and other aspects	B
	U20J-04488	Mshwati	B/C	B	Lower section in worse state. Reinstate riparian zone, address erosion.	B
U2-5	U20K-04296	Tholeni	C	B/C	Riparian zone buffer to be improved.	B/C
	U20K-04411	Mqeku	B/C	B	Riparian zone buffer to be improved.	B
U3: uMdloti and uThongathi						
U3-1	U30A-04228	Mdloti	B/C	B	Improve riparian buffer zone, erosion control	B
	U30A-04363	Mwangala	B/C	B	Improve riparian buffer zone, erosion control	B
U3-3	U30C-04272	Mona	B/C	B	Riparian buffer zone improvement	B
U4-Mvoti						
U4-1	U40A-03869	Mvoti	B/C	B	Improve riparian buffer in forestry and agriculture areas.	B
U4-1	U40C-03982	Khamanzi	B/C	B	Improve riparian buffer in forestry and agriculture areas.	B
U4-3	U40H-04091	Pambela	B/C	B	Reinstate riparian zone.	B
U4-3	U40H-04117	Nsuze	B/C	B	Reinstate riparian zone.	B
U4-3	U40H-04133	Nsuze	B/C	B	Reinstate riparian zone, erosion control.	B
U4-4	U40J-03998	Mvoti Estuary	D	C	Improvement of oxygen levels in the estuary, through for example, removal of the high organic content from the Sappi Stanger effluent. Reduce the nutrient input from the catchment by 20%. Remove the sugarcane from the Estuary Functional Zone.*	C
U6: uMlazi						
U6-1	U30C-04272	Mona	B/C	B	Riparian buffer zone improvement	B
U6-3	U60E-04795	Bivane	B/C	B	Erosion control, riparian buffer, agricultural practices	B

IUA	Node	River	PES	REC	REC Comment	TEC
U8: Mtwalume and Mzumbe						
U8-2	U80F-05258	Mtwalume	**B/C**	**B**	Improve water quality of return flows	**B**
	U80F-05301	uMngeni	**B/C**	**B**	Improve water quality of return flows. Reinstate buffer zone	**B**

* This recommendation may require economic analysis and it is recommended that this be investigated.

All estuaries requiring improvement to achieve the REC is listed in Table 13.7 – 13.10. The improvements required is summarised, as well as the rationale on the attainability leading to the TEC. To provide implications on future development, the recommended future scenario (from the MCA model) has also been included in the table to indicate how the predicted EC will differ from the PES, REC and TEC.

Table 13.7 SC1 IUA: Estuary nodes requiring improvements to meet the REC and TEC rationale

Estuary	REC	PES	Sc C	Sc D	TEC motivation	TEC
Mtamvuna	A/B	B	B	B	Interventions required to achieve the REC of an A/B: ▪ Restoration of estuarine riparian habitat. ▪ Reduce/control fishing high pressure. ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. A/B TEC is immediately applicable.	**A/B**
Mpenjati	B	B/C	B/C	B/C	Interventions required to achieve the REC: ▪ Remove/reduce impact of sand mining. ▪ Improve water quality. ▪ Restore estuarine riparian habitat. The B TEC is immediately applicable if the above non-flow related activities are addressed. Water quality should also be improved and standards for existing situation and future scenarios should be investigated to allow for improvement.	**B**
Kongweni	D	E	E	E	Interventions required to achieve the REC: ▪ Restoration of estuarine riparian habitat. ▪ Improve water quality. ▪ Reduce baseflows to estuary to maintain mouth state and salinity profile. The D can be achieved under the current situation by removing half the waste and flow of current discharges. This has socio-economic implications and will be difficult to do. Therefore, the TEC is set to maintain the PES below a D. The system should not become a health hazard.	**E/F**
Zotsha	B	B/C	B/C	B/C	Interventions required to achieve the REC: ▪ Restoration of estuarine riparian habitat. ▪ Improve water quality. TEC set to achieve the REC and is immediately applicable. No future waste scenarios should be considered for this system.	**B**
Mbango	D	E	E	E	Interventions required to maintain the REC: ▪ Restore baseflows to estuary to maintain mouth state and salinity profile. ▪ Maintain water quality; and ▪ Partial restoration of estuarine habitat. The D can be achieved under current situation by removing half the waste and flow of current discharges. This has socio-economic implications and will be difficult to do. Therefore, the TEC is set to maintain the PES below a D. The system should not become a health hazard.	**EF**
Umzimkulu	B	B	B	B	Interventions required to counteract the downward trajectory and to meet the REC/TEC: ▪ Eradicate invasive alien vegetation. ▪ Remove derelict, redundant and old quays, jetties, wharfs and revetments; and rehabilitate banks. ▪ Prohibit dredge spoil dumping in inappropriate areas.	**B**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						▪ Manage agricultural and industrial practices in the catchment.	

Table 13.8 SC2 IUA: Estuary nodes requiring improvements to meet the REC and TEC rationale

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
Domba	C	D		D	D	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to maintain mouth state and salinity profile. ▪ Maintain water quality; and ▪ Partial restoration of estuarine habitat. The PES is to be maintained as the TEC in the short term as restoration of baseflows have potential socio-economic implications. Further investigations can be undertaken as part of the estuarine management plan to determine whether improvement is possible even to a C/D by addressing non-flow measurements. No further scenarios should be considered as this could compromise potential improvement and as water quality must be maintained in its present state.	**D**
Koshwana	B	C/D		C/D	C/D	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to increase mouth state and salinity profile. ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. There is uncertainty regarding the capacity and discharge of the waste and waste water mixing works. To improve the estuary would either require removal of waste water and/or improvement of the treatment work to the required standard. Due to these uncertainties and the uncertainty around the implications of improvement, the TEC has been set at a C only. Once more information is available, the TEC can be reviewed.	**C**
Intshambili	B	C		C	C	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. The PES is to be maintained as the TEC in the short term as information is unavailable on the increased baseflows required. Restoration of base flows is the key parameter which requires improvement. Further investigations can be undertaken as part of the estuarine management plan to determine whether improvement is possible even to a B/C by addressing non-flow measurements. No scenarios should be considered.	**C**
Mzumbe	C	C/D		C/D	C/D	Interventions required to achieve the REC: Restore estuarine riparian habitat.	**C**
Mhlabatshane	A/B	B/C		B/C	B/C	Interventions required to achieve the REC: ▪ Catchment water quality; and ▪ Restoration of estuarine habitat (riparian). As it is assumed that addressing catchment water quality may be difficult and not possible on the short term, it was evaluated whether only addressing the estuarine habitat will achieve an improvement. Improvement will be to a B which is set as the TEC and immediately applicable. The TEC therefore represents an improvement, but not to the REC.	**B**
Mfazazana	B	C		C	C	Interventions required to achieve the REC: ▪ Improve baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality; and ▪ Partial restoration of estuarine riparian habitat. The PES is to be maintained as the TEC in the short term as restoration of baseflows have potential socio-economic implications. Further investigations can be undertaken as	**C**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						part of the estuarine management plans to determine whether improvement is possible even to a B/C by addressing non-flow measurements.	
Kwa-Makosi	B	B/C		B/C	B/C	Interventions required to achieve the REC/TEC: ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. The TEC is set to improve to a B.	**B**
Fafa	C	C/D		C/D	C/D	Interventions required to achieve the REC: ▪ Restore estuarine riparian habitat. The C TEC is immediately applicable if the above non-flow related activities are addressed.	**C**

Table 13.9 CC IUA: Estuary nodes requiring improvements to meet the REC and TEC rationale

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
Amahlongwa	B	C		C	C	Interventions required to achieve the REC: ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality. ▪ Partial restoration estuarine riparian habitat. ▪ Control and reduce fishing pressure. B TEC is immediately applicable.	**B**
Mahlongwana	B	C		C	C	Interventions required to achieve the REC: ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality. ▪ Partial restoration estuarine riparian habitat. B TEC is immediately applicable.	**B**
uMkhomazi	B	C		C	C	Interventions required to achieve the REC: ▪ Remove sandmining from the upper reaches below the Sappi Weir. ▪ Restoration of vegetation in the upper reaches and along the northern bank in the middle and lower reaches. ▪ Curb recreational activities in lower reaches. ▪ Reduce/remove cast netting in the mouth area. ▪ Relocate upstream, or remove, the Sappi Weir. ▪ Restore baseflows to estuary to maintain mouth state and salinity profile. The TEC of a B/C is immediately applicable and excludes the relocation of the SAPPI weir (as it may have economic consequences) and restoration of baseflows (difficult without a dam). The same anthropogenic measures under medium to long term option Sc 21 (includes the dam) as well as Sc Ci and Di, will also achieve the B/C. However, putting any additional waste whatsoever in the uMkhomazi should be avoided due to the risk of mouth closure (especially pre-dam) and other options should be sought.	**B/C**
Umgababa	B	C		C	C	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. Without information on the baseflow requirements (and a way to supply it), the REC cannot be achieved in the short term. The TEC therefore represents an improvement, but not to the REC. Water quality and estuarine habitat must be improved to achieve the TEC which is immediately applicable. Once higher confidence information is available on this estuary, the TEC can be improved to a B. No waste water must be put into this system as it will then not make it possible to improve to the REC in the long term.	**B/C**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
Msimbazi	A	B		B	B	Interventions required to achieve the REC: ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality. ▪ Partial restoration of estuarine habitat. The TEC is set to maintain the PES. Improvement to the A EC will be difficult as one would have to remove some development in the catchment.	**B**
Lovu	B	C/D		C/D	C/D	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to improve mouth state and salinity profile (Sc L4). ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. Sc L4 (significant decrease in forestry and irrigation) may meet REC. Socio economic implications of this scenario are significant and immediately applicable. TEC is set at a B/C by applying non-flow related measures. Further improvement may require measurements that have significant socio-economic consequences.	**B/C**
Little Manzimtoti	D	E		E	E	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to improve mouth state and salinity profile. ▪ Significant improvement in water quality; and ▪ Partial restoration of estuarine habitat. Immediate applicable maintain PES, as it is very difficult (costly) to achieve the D as this would require removing all waste. Further waste water scenarios can therefore be considered as long as the estuary does not become a health hazard and there is compliance to other relevant legal requirements.	**EF**
aManzimtoti	D	D/E		D/E	D/E	Interventions required to achieve the REC: ▪ Catchment water quality. ▪ Riparian habitat. REC of a D is immediately applicable.	**D**
Mbokotweni	D	E		E	E	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to improve mouth state and salinity profile. ▪ Significant improvement in water quality; and ▪ Partial restoration of estuarine habitat. Immediately applicable - maintain PES, as it is very difficult (costly) to achieve the D EC as this would require removing all waste. Further waste water scenarios can therefore be considered as long as the estuary does not become a health hazard and there is compliance to other relevant legal requirements.	**EF**
Sipingo	D	F		F	F	Interventions required to achieve the REC: ▪ Restore as much as possible baseflows to estuary to improve mouth state and salinity profile. ▪ A significant improvement in water quality (storm water) needed. ▪ Partial restoration of estuarine habitat. It is not possible to improve the estuary to a D EC as there is limited restoration potential. It must be noted that the mangrove habitat should not be compromised within the estuary. Stormwater is the overriding problem.	**EF**
Durban Bay	D	E		E	E	It is not possible to improve the estuary to a D EC as there is limited restoration potential. It must be noted that the white mangrove habitat should not be compromised within the estuary.	**EF**
Durban Bay Shallow water and intertidal zone	D	E				Interventions required to restore functionality to Durban Bay applicable to the specific important areas within the bay: ▪ Protect baseflows to estuary to maintain mouth state and salinity profile. ▪ Improve water quality (storm water management). ▪ Reduce fishing effort, and ▪ Partial restoration of estuarine habitat in upper reaches.	**D**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
	🟩	🟨				The restoration of this area requires a TEC of a D and is immediately applicable.	🟩
uMngeni	D	D/E		D	D	Interventions required to achieve the REC/TEC: ▪ Restoration of macrophytes: removal of alien plant species, replanting/ reintroduction with indigenous species (some of which is already occurring). ▪ Wetland engineering (creation of new wetland habitats in close proximity to the uMngeni River banks. ▪ Implement flow allocation in an estuary friendly manner. ▪ Review the current breaching policy that only requires breaching after 2 - 3 weeks, this poses a risk to plant communities and birds. ▪ Develop an Estuary Management Plan. The above interventions can achieve the TEC which is immediately applicable. Any scenarios that result in a D TEC are acceptable.	**D**
Mhlanga	B	D		D	D	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to improve mouth state and salinity profile. ▪ A significant improvement in water quality needed. ▪ Partial restoration of estuarine habitat. If the existing pumping scheme comes into operation, it should achieve REC. The TEC is therefore set as the REC and is immediately applicable.	**B**
uMdloti	C	D		D	D/E	Interventions required to achieve the REC: ▪ Restore baseflows to estuary to improve mouth state and salinity profile. ▪ A significant improvement in water quality needed; and ▪ Partial restoration of estuarine habitat. Further investigation should be conducted to see to what extend the catchment quality can be improved to meet the REC. The importance rating should also be reviewed as it is likely that improvement to a C may not be required. The TEC that is therefore immediately applicable is set to maintain the PES. A scenario that includes more waste water to a specific limit must be investigated as this could achieve the TEC.	**D**
uThongathi	C	D		E	E/F	Improvement is based on low confidence importance which cannot be refined (1 point). Based on this, the immediate applicable TEC is set as a D and all scenarios apart from Sc Aiii will maintain the present state.	**D**

Table 13.10 NC IUA: Estuary nodes requiring improvements to meet the REC and TEC rationale

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
Mhlali	B/C	C/D		D	D	Interventions required to achieve the REC: ▪ Reduce the nutrient input from the WWTW and catchment to control growth of reeds and aquatic invasive plants. ▪ Remove the sugarcane from the Estuary Functional Zone (below 5 m contour). ▪ Removal of vegetation from main river channel in upper reaches, including invasive alien plants. ▪ Ensure that the estuary is not artificially breached; and ▪ Remove the old saltwater weir from middle reaches of system. Intervention without removal of waste water will achieve a C, but not the REC. However, infrastructure has already been constructed and licenses awarded for an increases in waste (from 0.8 to 6 Ml/D) (Sc D). Any increase of waste from current is likely to result in a decreased (from PES) state as nutrients are the key factor in this estuary.	**D**
Mvoti	C	D		D	D	Interventions required to achieve the REC: ▪ Improvement of oxygen levels in the estuary, through e.g., removal of the high organic content from the Sappi Stanger effluent. ▪ Reduce the nutrient input from the catchment by 20%.	**C/D**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						▪ Remove the sugarcane from the Estuary Functional Zone (below 5 m contour). If the Sappi effluent is retained, but other interventions applied TEC = C/D. Sc 21, 22, 41, 42 and 43 (which includes a proposed dam) will also achieve the TEC with the above measures. Limited increase in waste water to this system is not likely to degrade it below a D as long as the system remains open. The TEC is set as a C/D which can be maintained with a new dam, possibly limited increases in waste water, and by addressing the interventions above without the removal or organic content from the SAPPI effluent.	
Mdlotane	A/B	B		B	B	Interventions required to achieve the REC: ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. The TEC is set as an A/B.	**A/B**
Zinkwazi	A/B	B/C		B/C	B/C	Interventions required to achieve the REC/TEC: ▪ Protect baseflows to estuary to ensure mouth state and salinity regime. ▪ Improve water quality; and ▪ Partial restoration of estuarine habitat. Measures should be put in place to improve to a B EC and the TEC of a B is immediately applicable. It is felt that achieving an A/B EC will require a scale of interventions that is difficult and is associated with negative socio-economic implications.	**B**

It is proposed to gazette the Water Resource Classes and catchment configuration for the immediate applicable TECs.

13.6 CONCLUSIONS

13.6.1 Mtamvuna system (IUA T4-1 & SC1)

- Improve (i.e addressing catchment management of informal agriculture) in Goze and Hlolweni tributaries of the main river and in one reach of the upper Mtamvuna River.
- The current state is recommended for the rivers in the rest of the IUA.
- Improve the estuary by restoring riparian habitat and reducing or controlling recreational fishing.

13.6.2 Umzimkulu system (IUA T5-1, 2, 3 and SC1)

- The current state is recommended for the main Umzimkulu River.
- Institute measures (addressing flow in the Mzimude River and non-flow interventions such as riparian buffer reinstatement, reducing sedimentation etc. in Malenge, Ncalu, Mgodi and Upper Bisi tributaries) to achieve the recommended ecological improvement. These measures focus mainly on establishing and maintaining the riparian buffer.
- Institute non-flow related measures in the estuary to counteract the downward trajectory.

13.6.3 uMkomazi system (IUA U1-1, 2, 3, 4 and CC)

- Institute measures (non flow-related, i.e. manage sedimentation, overgrazing, alien vegetation removal etc) to achieve the recommended ecological improvement in Nzinga, Elands, Ngudwini, Mkobeni tributaries of the main river and in two reaches of the upper uMkhomazi River.
- The current state is recommended for the rivers in the rest of the IUA.
- Improve the estuary through various non-flow related interventions.

Implications:

- A dam such as Smithfield Dam with specific EWR releases can be developed. This will have no impact on the Class and Catchment Configuration. Specific riverine components (geomorphology, fish, and invertebrates) will be degraded from present state.
- There will be no impacts on the socio-economics. If Smithfield Dam is implemented and operated according to the recommended scenario, the GDP and jobs will improve.
- Although the estuary will improve, the required degree of improvement will not be achieved as this will require the removal or relocation of the SAPPI weir.
- No further waste can be discharged into the estuary in the future.

13.6.4 uMngeni system (IUA U2-1, 2, 3, 4, 5, 6 and CC)

- The current state is recommended for the main uMngeni River.
- Improve (addressing the riparian buffer zone and water quality in the Ndiza, Lions, Gqishi, Yarrow, Karkloof, uMnsunduze, Mpushini, Mshwati, Tholeni, Mqeku, Mdloti, Mwangala, and Mona tributary reaches.
- The estuary improvement requires implementation of the EWR flow release from Inanda Dam as well as various non-flow related improvements.

Implications:

- Increased waste (to a certain level) can be accommodated in the uMngeni estuary.
- Scenarios that include the ultimate developed demands and return flows, and the Mooi Mgeni Transfer Scheme Phase 2 can be implemented in the future.
- There is no impact on the socio-economics implications of the Water Resource Class and catchment configuration. The future scenarios will have a positive impact on GDP and jobs.

13.6.5 uMdloti and uThongathi systems (IUA U3-1, 2, 3, and CC)

- Improve (addressing non flow-related, i.e. riparian buffer zone issues) Mwangala and Mona tributaries of the main river and the Mdloti River.
- The current state is recommended for the rivers in the rest of the IUA.
- Maintain and/or improve the current state of the estuaries over the long term.

Implications:

- Increased waste in the short term in the estuaries can be accommodated and this may decrease the condition of the estuaries.
- In the long term, all waste must be removed and other options such as indirect re-use must be implemented. The estuaries will return to the present state and may even improve.
- Despite the benefit of reuse, the cost exceeds the benefit; i.e. there are economic implications.

13.6.6 Mvoti systems (IUA U4-1, 2, 3, and CC)

- The current state is recommended for the main Mvoti River.
- Improve (mostly addressing informal agriculture and over grazing) in Khamanzi, Pambela and Nsuze tributary reaches.
- Improve the estuary through various non-flow related interventions.

Implications:

- The proposed Isithundu Dam with specific EWR releases can be developed in the Mvoti River. This will have no impact on the Class. Specific riverine components (geomorphology, fish) will be degraded from present state.
- If the dam is implemented and operated according to the recommended scenario, the GDP and jobs will improve.

- Although the estuary will improve, it will not achieve the required degree of improvement without significant improvement of oxygen levels in the estuary.
- Limited increased waste can be accommodated as long as the estuary remains open.

13.6.7 uMlazi system (IUA U6-1, 2)

- The current river state is recommended apart from Mona and Bivane River reaches which require improvement (mostly addressing informal agriculture and over grazing).
- There is no estuary anymore as it has been canalysed.

13.6.8 Lovu system (IUA U7-1 and CC)

- The current river state is recommended.
- Improve the estuary through various non-flow related interventions.

Implications:

- Although the estuary can improve, the required degree of improvement cannot be met without improving baseflows. This has significant economic implications in terms of los of GDP and jobs.

13.6.9 Mtwalume and Mzumbe (IUA U8-1, 2 and SC2)

- The Mtwalume and Mzumbe Rivers are in a good ecological condition which needs to be maintained.

13.6.10 Southern Cluster 1 IUA (Umzimkulu to Mtamvuna Estuaries)

- Improved estuarine states are recommended at the Zotsha, Mpenjati and Mtamvuna through non-flow related interventions such as managing sedimentation etc.
- Improve the Mtamvuna estuary by restoring riparian habitat and reducing or controlling recreational fishing.
- Institute non-flow related measures (i.e. manage sedimentation, overgrazing, alien vegetation removal etc.) in the uMzimkulu estuary to prevent further degradation.

Implications:

- No waste must be discharged in the Vungu and Zotsha Estuaries.
- Scenarios that allow some increase in waste can be allowed in the Zolwane, Mvutshini and Tongazi estuaries.

13.6.11 Southern Cluster 2 IUA (Mtentweni to Mpambanyoni Estuaries)

- The current estuarine states are recommended at the Mpambanyoni, Mzimayi, Nkomba, Mzinto, Mkumbane, Sezela, Mdesingane, Mvuzi, Mtwalume, Mnamfu, Mhlungwa, Mzumbe, Mhlangamkulu and Mtentweni estuaries.
- Improved estuarine states are recommended at the Fafa, Kwa-Makosi, Mhlabatsjane, and Koshwna estuaries through non-flow related interventions such as addressing riparian buffer zone issues etc.

Implications:

- Although the Mhlabatshane and Koshwana Estuaries will improve, they will not achieve the required degree of improvement.
- No further waste must be discharged in the Intshambili estuary.
- Limited additional waste can be allowed in the Sezela estuary.

13.6.12 Central Cluster IUA (uThongathi to Mahlongwa Estuaries)

Note: The uThongathi, uMdloti, uMngeni, Lovu, uMkhomazi, Mahlongwana and Mahlongwa estuaries have been dealt with as part of the river systems discussed above.

- Improved estuarine states are recommended at the Umhlanga, Durban Bay zone, aMmanzimtoi, and Umgababa estuaries through non-flow related interventions (i.e. manage sedimentation, overgrazing, alien vegetation removal etc.).

Implications:

- The Isipingo estuary is in a very degraded state due to airport developments and further degradation should be prevented. In the Umgababa estuary, partial improvement has been met through non-flow interventions (i.e. manage sedimentation, overgrazing, alien vegetation removal etc.).

13.6.13 Northern Cluster IUA (uThongati to Mahlongwani Estuaries)

Note: The Mvoti estuary has been dealt with as part of the river system discussed in f) above.

- The current estuarine states are recommended at the Nonoti, Seteni and Bobs Stream estuaries.
- Improved estuarine states are recommended at the Zinkwazi and Mdlotane estuaries through non-flow related interventions.
- A predicted new state based on newly built Waste Water Treatment Works (WWTW) is recommended for the Mhlali River. This is lower than the present ecological state.

Implications:

- Although the estuaries improve, the required degree of improvement could not be met at the Zinkwazi Estuary.
- Increased waste water discharges can be accommodated in the short term in the Nonoti Estuary.

14 RESOURCE QUALITY OBJECTIVES

This chapter is an extract from the following reports:
Department of Water and Sanitation (DWS), South Africa. 2015e. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 1: River Resource Quality Objectives. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. April 2015. DWS Report: RDM/WMA11/00/CON/CLA/0315.

Department of Water and Sanitation (DWS), South Africa. 2015f. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 4: Estuary Resource Quality Objectives. Prepared by: Van Niekerk, Adams, Taljaard, Weerts. September 2015. DWS Report: RDM/WMA11/00/CON/CLA/0615.

14.1 BACKGROUND

Within the integrated water resource management process outlined in Table 14.1, integrated step 6 refers to: The development of RQOs and provision of numerical limits. This step is closely linked to the next step where the class configuration and RQOs are gazetted and implemented. The results of Step 6 are documented in this Chapter.

Table 14.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s)
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the EWRs and changes in non-water quality ecosystem goods, services and attributes.
4	Identify and evaluate scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	**Develop draft RQOs and numerical limits.**
7	Gazette and implement the class configuration and RQOs.

14.2 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) therefore 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 to inform the Water Resource Class and RQOs define and/or describe the Water Resource Class (Figure 14.1).

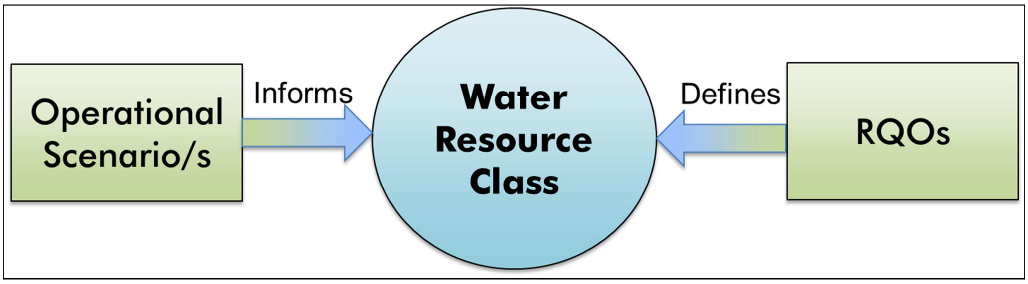


Figure 14.1 Links between RQOs and the Water Resource Class and operational scenarios

14.3 RIVERS

14.3.1 River RUs

RUs are delineated as follows:

- SQ reaches have been identified (DWA, 2013a) for the study area. These are surrogates for RUs in areas where further detailed RU determination will not be undertaken. These RUs are represented by DBNs (DWA, 2013a).
- For the purposes of RQOs, the SQs were combined to form RUs which represent a homogenous area of similar state and land use. This process was followed in tributaries and rivers with no EWR sites which are usually lower priority areas and therefore do not include hotspots.
- In key rivers which include hotspots (DWA, 2013a), a detailed RU assessment was undertaken to determine MRU. These also consist of a range of SQs, but the process and criteria used are more detailed than for the lower priority rivers. These MRUs were identified during Reserve studies. Most MRUs are represented by key biophysical nodes (EWR sites).

RU priority is based on the outcome of the hotspot assessment (Step 1 of the integrated steps for the NWRC and RQO determination) as well as available information and confidence in the information.

There are three main priority levels each with the broad type and detail of RQOs indicated:

RU priority level	RU priority level	Associated RQO
Low (1)	**1a**	Flow RQO. Habitat RQO in terms of Present Ecological State (PES) and Recommended Ecological Category (REC) (EcoStatus).
	1b	Habitat RQO in terms of PES and REC (EcoStatus) (total river length usually in declared conservation areas).
Moderate (2)	**2**	Flow RQO. Habitat and biota RQO (broad).
High (3)	**3a**	Forms part of RU represented by an EWR site.
	3b	EWR site. Flow RQO related to preferred scenario. Detailed habitat and biota RQO (EcoSpecs).
	3WQ	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.

14.3.2 Hydrology RQOs at High Priority River RUs (EWR sites)

Table 14.2 provides 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 90% (representative of drought conditions) and 60%.

Table 14.2 RIVERS: Summary of key hydrological RQOs

RU	Biophysical node and EWR site	River	Target EC	nMAR^1 (MCM)	Low flows (% nMAR)^2	Total flows (%nMAR)^3	Sep		Feb	
							(m^2/s)		(m^2/s)	
							90%	60%	90%	60%
MTAMVUNA (T4): IUA T4-1										
MRU MT B	T40E-05601 Mt_R_EWR1	Mtamvuna	C	79.22	19.1	32.1	0.332	0.525	1.157	1.606
uMKHOMAZI (U1): IUA U1-2										
MRU uMKHOMAZI B.3	U10E-04380 Mk_I_EWR1	uMkhomazi	C	683.17	18.1	27.2	0.890	1.458	4.130	5.542
uMKHOMAZI (U1): IUA U1-3										
MRU uMKHOMAZI C	U10J-04679 Mk_I_EWR2	uMkhomazi	B	890.91	14.2	35.8	1.551	2.869	5.991	10.488
uMKHOMAZI (U1): IUA U1-4										
MRU uMKHOMAZI D	U10M-04746 Mk_I_EWR3	uMkhomazi	C	1068.6	21.2	31.1	1.532	2.203	5.589	7.668
uMNGENI (U2): IUA U2-1										
MRU uMnA	U20A-04253 Mg_R_EWR1	uMngeni	C/D	79.22	10.1	21.7	0.016	0.098	0.179	0.327
uMNGENI (U2): IUA U2-2										
M KAR C	U20E-04170 Mg_R_EWR3	uMngeni	B	70.11	27.3	43.5	0.032	0.245	0.203	0.758
MRU uMnB	U20E-04243 Mg_I_EWR2	uMngeni	C	228.19	14.7	20	0.460	0.810	0.450	0.990
uMNGENI (U2): IUA U2-5										
MRU uMn D	U20L-04435 Mg_I_EWR5	uMngeni	D	583.66	21.2	24.3	0.856	2.017	1.655	2.477
MVOTI (U4): IUA U4-1 and U4-2										
MRU HEYNS A	U40B-03770 Mv_I_EWR1	Mvoti	C	17.36	18.2	27.9	0.030	0.037	0.067	0.093
MVOTI (U4): IUA U4-3										
MRU MVOTI C	U40H-04064 Mv_I_EWR2	Mvoti	C	273.96	14.4	21.2	0.174	0.402	0.622	1.336
LOVU (U7): IUA U7-1										
MRU LOVU D	U40H-04064 Lo_R_EWR1	Lovu	B/C	87.76	22.8	37.9	0.142	0.189	0.359	0.533

1 nMAR is the natural Mean Annual Runoff in million cubic meters per annum.

2 % nMAR is flow required at the nodes expressed as a percentage of the natural Mean Annual Runoff, Low flows and Total flows.

3 Percentage points on the monthly low flow frequency distribution continuum at the nodes, expressed as the percentage of the months (90% and 60% for EWR sites) that the flow should equal or exceed the indicated minimum values.

14.3.3 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 (Table 14.3). A summary of key Water Quality RQOs in High Water Quality priority RUs of study area are provided in Table 14.4.

Table 14.3 RIVERS: Summary of key habitat, biota and water quality RQOs

Component/ Indicator	TEC	RQO
IUA T4-1: MTAMVUNA RU EWR MT_R-EWR1 (T40E-05601, T40C-05520, T40D-05537, 05584, 05707)		
Fish	B/C	Maintain the target EC (>78%). Fish species that are intolerant to alteration or with a high preference for specific habitat features are present in this unit. These species provide valuable indicators that should be used to monitor potential change. Primary indicator fish species for this reach is the semi-rheophilic Natal Scaly (BNAT).
Invertebrates	B	Maintain the target EC (>82%). Community should be representative of a medium foothill stream assemblage with perennial flows.
Riparian vegetation	C/D	Maintain the target EC (>58%). Agricultural activities shall not encroach into the riparian zone or floodplain and perennial invasive alien species shall be kept in check.
Water quality	A/B	Maintain the target EC (>88%). Ensure that **turbidity or clarity levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
IUA U1-2: MIDDLE uMKHOMAZI RU MK_I_ EWR1 DS (U10F-04528 DS)		
Fish	B	Maintain the target EC (>82%). Four indigenous species. Primary indicator fish species is the semi-rheophilic Natal mountain catfish (ANAT). FROC of ANAT and BNAT will decrease and result in the drop of a B/C for Sc 21.
Invertebrates	B/C	Maintain the target EC (>78%). Community should be representative of a medium-sized mountain stream assemblage with perennial flows. Maintain stones-in-current (SIC) with moderate marginal vegetation habitat, deep water with slow flows and rocky bottoms.
Riparian vegetation	C	Maintain the target EC (>62%). Perennial invasive alien species must be kept in check (especially wattle) to maintain the C EC. No increase of agricultural activities such as overgrazing and trampling
Water quality	A/B	Maintain the target EC (>88%). Ensure that **turbidity or clarity levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
IUA 1-3: uMKHOMAZI GORGE RU MK_I_ EWR2 (U10J-04679, U10JH-04638, 04675)		
Fish	B	Maintain the target EC (>82%). Seven indigenous species. Primary indicator fish species is the semi-rheophilic ANAT. The abundance and FROC of most species, especially ANAT and BNAT will decrease and result in the drop to a C for Sc 21.
Invertebrates	B	Maintain the target EC (>82%). Community should be representative of a lowland river assemblage with perennial flows. Maintain stones-incurrent with scanty marginal vegetation. Sediment scouring may impact on bottom dwelling taxa resulting in drop of category.
Riparian vegetation	B	Maintain the target EC (>82%). Perennial invasive alien species must be kept in check to maintain the category. Agricultural activities must not encroach into the riparian zone or floodplain.
Water quality	A/B	Maintain the target EC (>88%). Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
		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).
IUA U1-4: LOWER uMKHOMAZI RU MK_I_ EWR3 (U10M-04746, U10J-04807, 04799, 04833, U10K-04838)		
Fish	B	Maintain the target EC (>82%). 23 indigenous species. Primary indicator fish species is the semi-rheophilic BNAT. The abundance and FROC of especially BNAT will decrease and result in the drop to a B/C for Sc 21.
Invertebrates	B	Maintain the target EC (>82%). Community should be representative of a large lowland river assemblage with perennial flows. Maintain dominant alluvial run habitats with good SIC controls. The marginal vegetation habitat may become reduced during Sc 21, therefore the drop to a B/C.
Riparian vegetation	D	Maintain the target EC (>42%). Perennial invasive alien species must be kept in check to maintain the D.
Water quality	A/B	Maintain the target EC (>88%). Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
		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).

Component/ Indicator	TEC	RQO
IUA 2-1: uMNGENI UPSTREAM MIDMAR DAM RU Mg_R_ EWR1 (U20A-04253, U20C-04275)		
Fish	D (C)	Maintain the target EC (>42%). Alien fish major issue at site. Primary indicator species are ANAT and BNAT.
Invertebrates	C	Maintain the target EC (>62%). Community should be representative of a small foothill stream assemblage with perennial flows. Good SIC with scanty marginal vegetation. Deeper pools also important.
Riparian vegetation	C/D	Maintain the target EC (>58%). Perennial invasive alien species must be kept in check to maintain the C/D. Maintain the composition and diversity of the woody and non-woody species.
Water quality	B	Maintain the target EC (>82%). Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
		Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA 2-2: uMNGENI, MIDMAR TO ALBERT FALLS RU Mg_I_ EWR2 (U20E-04243, U20E-04221)		
Fish	D	Maintain the target EC (>42%). PES in E and must be improved to D – potential water quality issues. Alien fish major issue at site. Primary indicator species are ANAT and BNAT.
Invertebrates	C	Maintain the target EC (>62%). Community should be representative of a foothill slope river assemblage with perennial flows. Good SIC with moderate marginal vegetation. Deeper pools also important.
Riparian vegetation	C	Maintain the target EC (>62%). Perennial invasive alien species must be kept in check to maintain the C. Maintain the composition and diversity of the woody and non-woody species.
Water quality	C/D	Maintain the target EC (>58%). Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver).
		Ensure that **nutrient levels (Total Inorganic Nitrogen; TIN)** are within Acceptable limits: 50th percentile of the data must be less than 0.85 mg/L TIN-N (Aquatic ecosystems: driver).
		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).
		Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
		Ensure that other **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 (1996) and DWAF (2008).
RU Mg_R_ EWR3 (U20E-04170)		
Fish	B/C	Maintain the target EC (>78%) and 11 indigenous species. Primary indicator species is small ANAT and large BNAT.
Invertebrates	B	Maintain the target EC (>82%). Community should be representative of a medium-sized foothill stream assemblage with perennial flows. Good SIC with good marginal vegetation. Deeper pools also important.
Riparian vegetation	B	Maintain the target EC (>82%). Perennial invasive alien species must be kept in check to maintain the B category. Maintain the composition and diversity of the woody and non-woody species.
Water quality	B	Maintain the target EC (>82%). Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
IUA 2-4: uMNSUNDUZE RU Mg_R_ EWR4 (U20J-03464, U20E-04401)		
Fish	E	Maintain the target EC (>22%). The primary indicator fish species for this reach (especially in terms of flow-modification) is the large semi-rheophilic BNAT. This fish category needs to be improved to at least a D EC.
Invertebrates	E	Maintain the target EC (>22%). The macro-invertebrate community should be representative of a medium-sized foot-hill stream assemblage with perennial flow, and should be improved to at least a D Category.
Riparian vegetation	D/E	Maintain the target EC (>38%). The target EC for the site is to improve the EC to a Category D (>42%). Perennial invasive alien species must be removed and kept in check. Species composition within the riparian zone must reflect the target EC and maintain current levels of endemism.
Water quality	E/F	Maintain the target EC (>17%). Ensure that **nutrient levels (phosphate and Total**

Component/ Indicator	TEC	RQO
		Inorganic Nitrogen; TIN) are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver): 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver).
		Ensure that **periphyton chl-a levels** are within Tolerable limits: 50th percentile of the data must be less than or equal to 52.5 mg/m^2 periphyton chl-a (Aquatic ecosystems: driver).
		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 present with increased turbidity levels expected (Aquatic ecosystems: driver).
		Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
		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 (1996) and DWAF (2008).
		Ensure that **dissolved oxygen levels** are within Tolerable limits: 5th percentile of the data must be more than 5 mg/L dissolved oxygen (Aquatic ecosystems: driver).
IUA 2-5: uMNGENI DS uMNSUNDUZE CONFLUENCE TO INANDA DAM RU Mg_I_ EWR5 (U20L-04435, U20M-04396)		
Fish	**D**	Maintain the target EC (>42%) and 15 indigenous species. Primary indicator species is large BNAT.
Invertebrates	**C/D**	Maintain the target EC (>58%). Community should be representative of a large lowland river assemblage with perennial flows. Good SIC with adequate marginal vegetion. Deeper pools also important.
Riparian vegetation	**D**	Maintain the target EC (>42%). Perennial invasive alien species must be kept in check to maintain the very low D. Maintain the composition and diversity of the woody and non-woody species. No further removal of vegetation or bank disturbance should take place.
Water quality	**C/D**	Maintain the target EC (>58%). Ensure that **nutrient levels (phosphate and Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than or equal to 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). 50th percentile of the data must be less than or equal to 4.0 mg/L TIN-N (Aquatic ecosystems: driver).
		Ensure that **periphyton chl-a levels** are within Tolerable limits: 50th percentile of the data must be less than or equal to 21 mg/m^2 periphyton chl-a (Aquatic ecosystems: driver).
		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 **turbidity or clarity levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
		Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA 4-1 AND 4-2: MVOTI RU MV_I_ EWR1 (U40B-03770, HEINESSPRUIT)		
Fish	**C**	Maintain the target EC (>62%). Six indigenous species. Primary indicator species is BNAT.
Invertebrates	**C**	Maintain the target EC (>62%). Community should be representative of a small mountain stream assemblage with perennial flows. Good SIC with moderate marginal vegetation.
Riparian vegetation	**B/C**	Maintain the target EC (>78%). Perennial invasive alien species must be kept in check to maintain B/C. Maintain the composition and diversity of the woody and non-woody species.
Water quality	**C**	Maintain the target EC (>62%). Ensure that **nutrient levels (phosphate and Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than 0.125 mg/L PO_4-P (Aquatic ecosystems: driver). 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver).
		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).
		Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
		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 (1996) and DWAF (2008).
IUA 4-3: LOWER MVOTI RU MV_I_ EWR2 (U40H-04064)		
Fish	**B/C**	Maintain the target EC (>78%) and 16 indigenous species. Primary indicator species is large BNAT. Change in FROC will result in degradation to a C EC.

Component/ Indicator	TEC	RQO
Invertebrates	B/C	Maintain the target EC (>78%). Community should be representative of a large lowland river assemblage with perennial flows. Good SIC with adequate marginal vegetation and clean substrate in runs.
Riparian vegetation	C/D	Maintain the target EC (>58%). Perennial invasive alien species must be kept in check to maintain a C/D. Maintain the composition and diversity of the woody and non-woody species.
Water quality	C	Maintain the target EC (>62%). Ensure that **nutrient levels (phosphate)** 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 Acceptable limits: A small change from present with minor silting of habitats and turbidity loads (Aquatic ecosystems: driver).
IUA 7-1: LOVU RU LO_R_ EWR1 (U70C-04859)		
Fish	B/C	Maintain the target EC (>78%). Twelve indigenous fish species. Fish species that are intolerant to alteration or with a high preference for specific habitat features are present in this RU. These species provide valuable indicators that should be used to monitor potential change. Primary indicator fish species for this reach is the semi-rheophilic BNAT.
Invertebrates	B/C	Maintain the target EC (>78%). Community should be representative of a medium foothill stream assemblage with perennial flows. Maintain SIC with marginal vegetation habitat.
Riparian vegetation	B/C	Maintain the target EC (>78%). Perennial invasive alien species must be kept in check to maintain the B/C. Integrity of seep wetlands associated with the riparian zone must also be maintained.
Water quality	B/C	Maintain the target EC (>78%). Ensure that **turbidity or clarity levels** stay within Acceptable limits: A small change from present with minor silting of habitats and turbidity loads (Aquatic ecosystems: driver).

* Note that all river faecal coliform and *E. coli* targets for full and partial contact are presented in terms of SA NMMP guidelines and health risks in terms of counts/100 mL, as follows:

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.

Table 14.4 Summary of key WATER QUALITY RQOs in HIGH Water Quality priority RUs of study area

RU	SQ	Water quality RQOs
IUA T4-SC: MTAMVUNA		
RU SC1	T40G-05616	Ensure that **nutrient levels (phosphate)** 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 **electrical conductivity (salt) levels** are within Ideal (A/B) limits: 95th percentile of the data must be less than or equal to 45 mS/m (Aquatic ecosystems: driver). Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA T5-2: UMZIMKULU		
MRU MzA	MzEWR2i T51C-04760	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 **nutrient levels (phosphate)** 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/clarity or TSS levels** stay within Ideal limits: Vary by a small amount from the natural turbidity range; minor silting of instream habitats acceptable.
MRU MzB	MzEWR3i T52C-04960 T52D-04948 T52D-05137	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 **nutrient levels (phosphate)** 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/clarity or TSS levels** stay within Ideal limits: Vary by a small amount from the natural turbidity range; minor silting of instream habitats acceptable.
MRU MzD	T52K-05353 T52K-05475 MzEWR17i	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).

RU	SQ	Water quality RQOs
		Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P (Aquatic ecosystems: driver).
IUA T5-3: UMZIMKULU		
MRU MzC	MzEWR5i MzEWR6i T52J-05276 T52D-05155	Ensure that **nutrient levels (phosphate)** are within Acceptable limits: 50th percentile of the data must be less than 0.015 mg/L PO_4-P. 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 **turbidity/clarity or TSS levels** stay within Acceptable limits: Small to moderate change from present with temporary high sediment loads and turbidity during runoff events (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U2-1: UMNGENI		
RU uMn3	U20C-04332 U20C-04340	Ensure that **nutrient levels (phosphate)** 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/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U2-3: UMNGENI		
RU uMn7	U20F-04131 U20F-04204 U20F-04224 U20G-04194 U20G-04215	Ensure that **nutrient levels (phosphate)** 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/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
MRU uMnC	U20G-04240 U20G-04259 U20G-04385	Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA 2-4: UMNSUNDUZE		
RU uMn8	U20J-04461 U20J-04488	Ensure that **nutrient levels (phosphate + Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P. 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver). Ensure that **periphyton chl-a levels** are within Tolerable limits: 50th percentile of the data must be less than or equal to 52.5 mg/m^2 periphyton chl-a (Aquatic ecosystems: driver). Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
MRU Duze C	U20J-04391	Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.

RU	SQ	Water quality RQOs
MRU Duze D	U20J-04459	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U2-6: UMNGENI		
RU uMn10	U20M-04625 U20M-04639 U20M-04642 U20M-04649 U20M-04653 U20M-04659 U20M-04682	Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). Ensure that **periphyton chl-a levels** are within Tolerable limits: 50th percentile of the data must be less than or equal to 21 mg/m^2 periphyton chl-a (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U3-1: UMDLOTI		
RU U3.1	U30A-04228 U30A-04363 U30A-04360	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate)** 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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U3-2: BLACK MHLASHINI		
RU U3.2	U30B-04465	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA NCC		
RU NC.1	U30E-04207	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate)** 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*.
IUA U4-1 AND U4-2: MVOTI		
RU Mv1	U40B-03708 U30B-03740 U30B-03832	Ensure that **nutrient levels (phosphate)** 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 **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).
IUA U4-3: MVOTI		
MRU Mvoti C MRU Mvoti D	U40J-03998	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate)** 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 **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 **toxics** are within Ideal limits or A categories: 95th percentile of the data must be within the TWQR for toxics (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U6-1: UPPER UUMLAZI		
RU U6.1	U60A-04533 U60B-04614 U60C-04555	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data

RU	SQ	Water quality RQOs
		must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). Ensure that **electrical conductivity (salt) levels** are within Tolerable limits: 95th percentile of the data must be less than or equal to 85 mS/m (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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
RU U6.2	U60C-04556	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P (Aquatic ecosystems: driver). 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 **toxics** are within Ideal limits or A categories; particularly Hg and Sn: 95th percentile of the data must be within the TWQR for toxics (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
RU U6.3	U60C-04613	Ensure that **nutrient levels (phosphate)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008).
IUA U6-2: LOWER UUMLAZI		
RU U6.4	U60D-04661	Ensure that **turbidity/clarity or TSS levels** stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff event (Aquatic ecosystems: driver). Ensure that **nutrient levels (phosphate and Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P. 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver). Ensure that **electrical conductivity (salt) and toxics levels** are within appropriate limits for intended use, e.g. industrial use: Numerical limits can be found in DWAF (1996e) (Industrial use: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U6-3: MBOKODWENI		
RU U6.6	U60E-04792	Ensure that **electrical conductivity (salt) and toxics levels** are within appropriate limits for intended use, e.g. industrial use: Numerical limits can be found in DWAF (1996e) (Industrial use: driver). Ensure that **nutrient levels (phosphate and Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P. 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA U7-1: LOVU		
MRU Lovu B	U70B-04655	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 **nutrient levels (phosphate)** 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 (DWAF, 1996) or the upper limit of the A category in DWAF (2008). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact) use*.
IUA CC: COASTAL CLUSTER		
RU CC	U60F-04597 U60F-04632	Ensure that **electrical conductivity (salt) and toxics levels** are within appropriate limits for intended use, e.g. industrial use: Numerical limits can be found in DWAF (1996e) (Industrial use: driver). Ensure that **nutrient levels (phosphate and Total Inorganic Nitrogen; TIN)** are within Tolerable limits: 50th percentile of the data must be less than 0.075 mg/L PO_4-P. 50th percentile of the data must be less than 2.5 mg/L TIN-N (Aquatic ecosystems: driver). Meet **faecal coliform and *E. coli* targets** for recreational / other (full or partial contact)

RU	SQ	Water quality RQOs
		use*.
RU CC2	U70F-04845 U70F-04893	Ensure that **nutrient levels (phosphate)** 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*.

* Note that all river faecal coliform and *E. coli* targets for full and partial contact are presented in terms of SA NMMP guidelines and health risks in terms of counts/100 ml, as follows:

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.

14.4 ESTUARIES

14.4.1 Estuary RUs

Each estuary is sufficiently different in terms of state, functioning and management to form individual RUs. RU priority is based on the outcome of the hotspot assessment (DWA, 2013a) (Step 1 of the integrated steps for the NWRC; DWA (2007)) as well as available information. **All estuaries were prioritised for the development of RQOs. RQOs were developed as comprehensively as possible for all systems based on available information. The benefit of this is that it allows for alignment between legislation and the incorporation of the RQOs in the estuary management planning process under the Integrated Coastal Management Act.**

Priority estuaries for evaluating RQOs against monitoring results were identified as part of the estuary hotspot assessment and include (DWA, 2013a):

Zolwane	Mbango	Mzinto	Mgeni
Ku-Boboyi	Mzimkulu	Mahlongwa	Mhlanga
Tongazi	Koshwana	Mahlongwane	Mdloti
Kandandhlovu	Intshambili	Mkomazi	Tongati
Mpenjati	Mhlabatshane	Ngane	Mhlali
Kaba	Mfazazana	Umgababa	Bobs Stream
Mvutshini	Kwa-Makosi	Lovu	Seteni
Vungu	Mvuzi	Mbokodweni	Mvoti
Zotsha	Sezela	Sipingo	Mdlotane
Boboyi	Mkumbane	Durban Bay	Zinkwasi

14.4.2 Format of RQO components

RQOs are set for 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).

Hydrological RQOs are provided as a flow regime (described by means of a flow durarion table) associated with the TEC for Mvoti and uMkomazi Estuary. For the other systems the output is based on a hydrological time series generated for the PES with an indication if the various components of the flow regime (baseflows and floods) meet the EWR requirement.

Water quality RQOs were set for all estuaries 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.

Detailed RQOs were developed for the Mvoti, uMkhomazi and Mhlali estuaries for the TEC. For the remainder of the systems RQOs is described in terms of the PES. Where the PES does not meet the TEC a "↑" was used to indicate which individual components should improve to achieve the TEC. The EC limits applicable to Estuaries are provided in Table 14.5.

Table 14.5 EC limits applicable to Estuaries

EC Limits: Broad classes
A > 93
A/B > 87
B > 78
B/C > 72
C > 63
C/D> 57
D > 43
D/E > 37
E > 23
E/F > 17

14.4.3 Estuary RQOs

Table 14.6 provides an indication of the ECs and associated RQOs of Estuaries for water quality, geomorphology, vegetation, invertebrates, fish and birds, respectively to achieve the TEC listed in Table 13.11 for the uMkhomazi Estuary and Table 13.12 for the Mvoti Estuary. The configurations of EC, as well as quantification of RQOs are based on best available information at the time.

Table 14.6 ESTUARIES: RQOs for water quality, geomorphology, riparian vegetation, macro-invertebrates and fish in High priority RUs

Component/ Indicator	TEC	RQO
IUA SC2: MKOMAZI ESTUARY		
Hydrology	**C/D**	▪ Maintain the target EC (> 57%). Protection of estuarine ecosystem to achieve ECs and ROQs indicated for hydrodynamics, water quality, sediment dynamics and the various biotic components: River inflow distribution patterns differ by less than 5% from that of Scenario B (i.e. approved flow scenario for the Mkomazi). ▪ Monthly river inflow > 1.0 m^3/s. ▪ Monthly river inflow > 2.0 m^3/s persists for longer than three months in a row. ▪ Monthly river inflow > 5.0 m^3/s for more than 30% of the time.
Hydrodynamics	**A**	▪ Maintain the target EC (> 93%). Protection of estuarine ecosystem. ▪ Mouth closure occurs less than 2 - 3 weeks in a year. ▪ Mouth closure occurs for less than two years out of ten. ▪ Mouth closure does not occur between September and April.

Component/ Indicator	TEC	RQO
Water quality	C	Maintain the target EC (> 63%). ROQs for water quality in **river inflow** to protect estuarine ecosystem, that is achieving the EC and ROQs indicated for the various biotic components: ▪ pH: 7.5 - 8.5. ▪ DO > 6 mg/L. ▪ Turbidity (low flow < 5m^3/s): < 15 NTU. ▪ Turbidity (low flow > 5m^3/s): Naturally turbid. ▪ Dissolved nutrients (low flow < 5m^3/s): NO_x-N <150 µg/L; NH_3-N < 20 µg/L; PO_4-P < 10 µg/L. ▪ Dissolved nutrients (high flow > 5m^3/s): NO_x-N <200 µg/L; NH_3-N < 20 µg/L; PO_4-P < 20 µg/L. ▪ Trace metals (to be determined). ▪ Pesticides/herbicides (to be determined).
		Minimum requirement for recreational use (DEA, 2012): ▪ *Enterococci*: Ninety percentile (90%ile) over a 12 month running period ≤ 185 counts per 100 ml. ▪ *E. coli*: Ninety percentile (90%ile) over a 12 month running period ≤ 500 counts per 100 ml.
		ROQs for water quality in **estuary** to protect estuarine ecosystems, that is achieving the EC and ROQs indicated for the various biotic components: ▪ Salinity: 0 in the upper reaches; > 20 middle reaches during the low flow season; freshwater dominated for 70% of the time. ▪ Turbidity (low flow < 5m^3/s): Average < 10 NTU in any sampling survey. ▪ Turbidity (high flow > 5): Naturally turbid. ▪ pH: Average 7.0 - 8.5 in any sampling survey. ▪ Dissolved oxygen: Average >6 mg/L in any sampling survey. ▪ Dissolved nutrients (low flow < 5m^3/s): Average NO_x-N < 150 µg/L, NH_3-N < 20 µg/L and PO_4-P < 10 µg/L in any sampling survey. ▪ Dissolved nutrients (high flow > 5m^3/s): Average NO_x-N < 300 µg/L, NH_3-N < 20 µg/L and PO_4-P < 20 µg/L in any sampling survey. ▪ Total metal concentrations in water not to exceed target values as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995). ▪ Total metal concentration in sediment not to exceed target values as per WIO Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009).
Sediment dynamics	B	Maintain the target EC (> 78%). Ensure that turbidity or clarity levels stay within Acceptable limits: A moderate change from present with temporary high sediment loads and turbidity during runoff events (Aquatic ecosystems: driver).
		Flood regime to protect estuarine ecosystem's sediment distribution patterns and aquatic habitat (instream physical habitat: ▪ River inflow distribution patterns (flood components) differ by less than 20% (in terms of magnitude, timing and variability) from that of the Present State (2013). ▪ Suspended sediment concentration from river inflow deviates by less than 20% of the sediment load-discharge relationship to be determined as part of baseline studies (Present State 2013). ▪ Findings from the bathymetric surveys undertaken as part of a monitoring programme indicate that no changes in the sedimentation and erosion patterns in the estuary have occurred (± 0.5 m). ▪ Intertidal and subtidal habitat in upper reaches below the weir are available for estuarine species (increase by > 20% from present).
		Changes in sediment grain size distribution patterns to maintain benthic invertebrates. ▪ The median bed sediment diameter deviates by less than a factor of two from levels to be determined as part of baseline studies (Present State 2013). ▪ Sand/mud distribution in middle and upper reaches change by less than 20% from Present State (2013). ▪ Changes in tidal amplitude at the tidal gauge of less than 20% from Present State (2013).
Microalgae	B	▪ Maintain the target EC (> 78%). Maintain current microalgae assemblages, specifically > 5 diatom species at a frequency > 3% of the total population in saline reaches (i.e. Zone A in low flow). ▪ Medium phytoplankton: > 5µg/L for more than 50% of the stations. ▪ MPB: > 30 mg m^2 for more than 50% of the stations in the saline portion of the estuary. ▪ Observable bloom in the estuary.
Macrophytes	D	Maintain the target EC (> 43%). Maintain the 2015 distribution of macrophyte habitats: ▪ Maintain the integrity of the riparian zone particular where the sandmining no longer occurs. ▪ No invasive floating aquatic species present in the estuary e.g. water hyacinth. ▪ No sugarcane in the estuarine functional zone. ▪ No greater than 10 % change in the area covered by different macrophyte habitats. ▪ No canalisation of lower reaches.

Component/ Indicator	TEC	RQO
		- No invasive plants (e.g. syringa berry, Spanish reed, black wattle, Brazilian pepper tree) largely absent from the riparian zone. - No die-back of reeds and sedges in the lower reaches. - No unvegetated, cleared areas along the banks. - No floating invasive aquatics observed in the upper estuary reaches. - No Sugarcane is present in the estuarine functional zone.
Invertebrates	**B**	Maintain the target EC (> 78%). Maintain current levels of zoobenthic abundance (including seasonal variation). Retain an invertebrate community assemblage in the estuary based on species diversity and abundance that includes a variety of indigenous species. This include the following: - Species diversity (between 15 species in summer - 40 species in winter). - Polychaetes, amphipods and tanaeids should numerically dominate during all seasons. However, abundance of all taxon groups should be higher during summer high flow periods and lower during winter low flow period. - DOs should > 4 ppt in > 75% of the estuary. - Less than 20% change in the intertidal and subtidal habitats. - No occurrence of invertebrate alien species (e.g. *Tarebia granifera*). - No decrease in abundance of zooplankton (>20%) in terms of numbers per m^{-2} over entire estuarine area (three sample sites) over three years. - No decrease in abundance of benthic macroinvertebrates. - No occurrence of *Paratylodiplax blephariskios* in annual sample.
Fish	**D**	- Maintain the target EC (> 43%). The upper reaches below weir in its entirety acts as a nursery to a diversity of EDC2 species (EDC2a especially). An abundance (to be defined as an average with prediction limits) of EDC2a species as young juveniles occur in spring and early summer (*Solea bleekeri, Acanthopagrus vagus, Ponmadasys comerssonnii, Rhabdosargus holubi*). - A good trophic basis exists for predatory estuarine dependant marine species (e.g. *Agyrosomus japonicus, Carynx* spp.), i.e. mullet occur throughout the system represented by a full array of size classes. - Estuarine residents species represented by core group (*Glossogobius* spp., *Oligolepis* spp. *Ambassis* spp. and *Gilchistella aestuaria*) in two consecutive years. - *Oreochromis mossambicus* limited to the upper reaches of one C in the low flow period, i.e. do not extend into middle reaches for more than two consecutive years. - Species assemblage comprises indigenous species only, no alien fish species are caught in the system. - Connectivity to a healthy transitional marine-estuary waters is maintained. No decline in nearshore linefish catches (*A. japonicus*) (not related to gear changes or bag limit restrictions).
Birds	**C**	Maintain the target EC (> 63%). The estuary should contain a rich avifaunal waterbird community, occurring at high densities (relative to available shorelength) that includes representatives of all the major groups, i.e. aerial (e.g. kingfishers), swimming (e.g. cormorants) and large wading piscivores (e.g. herons), small invertebrate-feeding waders, including migratory Palaearctic sandpipers, herbivorous waterfowl (e.g. ducks and geese) and roosting terns and gulls. - The presence of a resident pair of African Fish Eagle that breed successfully. - Pied Kingfishers, White-breasted Cormorants or Reed Cormorants are recorded on more than three consecutive counts spanning a period of 18 months or more. - Numbers of waterbird species do drop below 10 for two consecutive counts.
MVOTI ESTUARY		
Hydrology	**C/D**	Maintain the target EC (> 57%). Protect the flow regime to create the required habitat for birds, fish, macrophytes, microalgae and water quality: - River inflow distribution patterns differ by more than 5% from that of Scenario A (i.e. the recommended flow scenario for the Mvoti Estuary). - Monthly river inflow > 1.0 m^3/s. - Monthly river inflow > 2.0 m^3/s persists for longer than three months in a row. - Monthly river inflow > 2.0 m^3/s for more than 50% of the time.
Hydrodynamics	**A**	Maintain the target EC (> 93%). Maintain a mouth conditions to protect estuarine ecosystems and the associated habitat for birds, fish, macrophytes, microalgae and water quality: - Mouth closure occurs less than two - three weeks in a year. - Mouth closure occurs for less than two years out of ten. - Mouth closure does not occur between November and June.
Water quality	**C/D**	Maintain the target EC (> 57%). RQOs for river inflow to protect estuarine ecosystem, that is achieving the EC and ROQs indicated for the various biotic components: - pH: 7.0 - 8.5. - DO > 4 mg/L. - Turbidity (low flow): <15 NTU.

Component/ Indicator	TEC	RQO
		▪ Turbidity (low flow): Naturally turbid. ▪ Dissolved nutrients: NO_x-N < 400 µg/L; NH_3-N < 30 µg/L; PO_4-P < 25 µg/L. ▪ Trace metals (to be determined). ▪ Pesticides/herbicides (to be determined).
		ROQs for water quality in **estuary** to protect estuarine ecosystem, that is achieving the EC and ROQs indicated for the various biotic components: ▪ Salinity: Salinity > 20 PSU one km from the mouth; Salinity <1 PSU for >50% of the time?? ▪ Turbidity (low flow): Average <10 NTU in any sampling survey. ▪ Turbidity (high flow): Naturally turbid. ▪ pH: Average 7.0 - 8.5 in any sampling survey. ▪ Dissolved oxygen: Average > 4 mg/L in any sampling survey. ▪ Dissolved nutrients: Average NO_x-N < 400 µg/L, NH_3-N < 30 µg/L and PO_4-P < 25 µg/L in any sampling survey. ▪ Total metal concentrations in water not to exceed target values as per SA Water Quality Guidelines for coastal marine waters (DWAF, 1995). ▪ Total metal concentration in sediment not to exceed target values as per WIO Region guidelines (UNEP/Nairobi Convention Secretariat and CSIR, 2009).
Sediment dynamics	**B/C**	Maintain the target EC (> 72%). Flood regime to protect estuarine ecosystems sediment distribution patterns and aquatic habitat (instream physical habitat): ▪ River inflow distribution patterns (flood components) differ by no more than 20% (in terms of magnitude, timing and variability) from that of the Present State (2013). ▪ Suspended sediment concentration from river inflow deviates by no more than 20% of the sediment load-discharge relationship to be determined as part of baseline studies (Present State 2013). ▪ Findings from the bathymetric surveys undertaken as part of a monitoring programme indicate no changes in the sedimentation and erosion patterns in the estuary have occurred (± 0.5 m). ▪ Changes in tidal amplitude at the tidal gauge of no more than 20% from Present State (2013).
		Changes in sediment grain size distribution patterns not to cause exceedance tolerance of benthic invertebrates. ▪ The median bed sediment diameter deviates by less than a factor of two from levels to be determined as part of baseline studies (Present State 2013). ▪ Sand/mud distribution in middle and upper reaches change by no more than 20% from Present State (2013).
Microalgae	**B**	Maintain the target EC (> 78%). Maintain current microalgae assemblages, specifically > five diatom species at a frequency >3% of the total population in lower saline reaches: ▪ Medium phytoplankton: > 3µg/L for more than 50% of the stations. ▪ MPB: > 20 mg m^2 for more than 50% of the stations in the saline portion of the estuary. ▪ Observable bloom in the estuary.
Macrophytes	**D**	▪ Maintain the target EC (> 43%). Maintain the distribution of macrophyte habitats, particularly the freshwater mangrove, *Barringtonia racemosa* stand at the mouth of the estuary so that there is no greater than 10% change in macrophyte habitat. ▪ Control the spread of hygrophilous grasses into open water area, i.e. no decrease in open water habitat to less than 16 ha. No increase in reeds and sedges and encroachment into main water channel due to nutrient enrichment, sedimentation and infilling of intertidal habitat. ▪ Prevent the spread of invasive plants, trees and shrubs as well as aquatic invasive plants. No invasive plants (e.g. syringa berry, Brazilian pepper tree) and aquatic invasives (e.g. water hyacinth) cover > 5% of total macrophyte area. ▪ No sugarcane in the estuarine functional zone.
Invertebrates	**E**	N/A
Fish	**D**	Maintain the target EC (> 43%). Protect the estuarine ecosystems functioning as: ▪ A nursery for a limited diversity and abundance of estuarine dependant marine fishes, which use the system through to their late juvenile and adult life stages. ▪ Habitat for a limited diversity and abundance of estuarine resident fishes which complete their life cycles in the estuary. ▪ Habitat for a limited diversity and abundance of freshwater fishes. ▪ A migration corridor for facultative catadromous eels. This will require that there be no loss of the following: ▪ Any one of the following species *Mugil cephalus*, *Myxus capensis* from Zones A, B and C. ▪ Any two of the following species *Gilchristella aestuaria*, *Ambassis* spp., *Glossogobius* spp. from the estuary. ▪ Any one of the following species *Barbus* spp, *O. mossambicus* from Zones A, B and C. ▪ *Anguilla* spp. from upstream river habitats (this should be noted in ecological

Component/ Indicator	**TEC**	**RQO**
		specifications in documentation pertaining to the EWR (river EcoSpecs and monitoring).
Birds	**E**	Maintain the target EC (> 23%). The estuary should contain a rich avifaunal waterbird community, occurring at high densities (relative to available shorelength) that includes representatives of all the major groups, i.e. aerial (e.g. kingfishers), swimming (e.g. cormorants) and large wading piscivores (e.g. herons), small invertebrate-feeding waders, including migratory Palaearctic sandpipers, herbivorous waterfowl (e.g. ducks and geese) and roosting terns and gulls. This means that the following will be observed: ▪ Presence of successful breeding by Collared Pratincoles and the resident pair of African. ▪ Fish Eagles. ▪ Numbers of bird species do not drops below 30 for three consecutive counts. ▪ Number of roosting terns recorded in mid-summer no fewer than 2000.

15 GROUNDWATER RESOURCE QUALITY OBJECTIVES

This chapter is an extract from report:
Department of Water and Sanitation (DWS), South Africa. 2015g. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 3: Groundwater Resource Quality Objectives. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Sami, K. March 2015. DWS Report: RDM/WMA11/00/CON/CLA/0515.

15.1 BACKGROUND

The purpose of this Chapter is to provide a summary of the narrative and numerical RQOs for the Groundwater Resource Units (GRUs) situated in the Mvoti to Umzimkulu WMA.

15.2 GROUNDWATER RESOURCE UNITS

The study area was subdivided into GRUs) by catchment areas, topograpy and geology. These are described below and summarised in Table 15.1:

- Drakensberg Escarpment: (GRUs 4 and 10): This region consists of predominantly argillaceous rocks of the Tarkastad Subgroup, and the Molteno and Elliot Formations of the Karoo Supergroup, capped by Clarens sandstones and Drakensberg Basalt. The basal sandstones of the Tarkastad Subgroup often form an escarpment of higher elevation than the underlying Adelaide Subgroup. On the high lying Drakensberg Escarpment, springs are common, especially along the Clarens/Drakensberg contact.
- Middelveld Karoo: (GRUs 1, 5, 6, 11, 14, 22, 27, and 30): This region consists of predominantly argillaceous rocks of the Ecca Group (Pietermaritzburg and Volksrust Formations) and Adelaide Subgroup, and arenaceous rocks of the Vryheid Formation, which lies in between the Volksrust and Pietermaritzburg Formations. It lies at a lower elevation than the Drakensberg Escarpment region. The Vryheid Formation forms an escarpment within this region. The median yield in the Vryheid Formation is slightly higher, 1.2 l/s compared to 0.9 l/s in the rest of the region. Fractures within the mudstones and shales tend to close once they are dewatered due to the ductility of the rock, making them prone to over exploitation. Fractures also tend to close up due to the oxidation of iron pyrite. Higher yields are associated with dolerite intrusions.
- Dwyka Tillites: (GRUs 2, 7, 12, 16, 28, 31, and 36): This region is underlain by fractured rocks of the Dwyka Group. The median yield is only 0.15 l/s and at least 40% of boreholes are dry, consequently, this is the poorest aquifer in the study area.
- Natal Group: (GRUs 8, 15, 20, 23, 29, and 33): This region is underlain by fractured aquifers with well-developed jointing and faulting. Fault zones are of high importance for establishing high yielding boreholes. The median yield is 0.5 l/s and 80 - 90% of boreholes are successful. The Natal Group forms elevated plateaux and sheer cliffs and deep incised ravines. Many of the outcrops are fault bounded. Springs often occur at the contact between the Natal Group and the underlying Natal Metamorphic Province.
- Natal Metamorphic Province: (GRUs 3, 9, 13, 17, 19, 24, 32, and 35): This aquifer forms a crystalline basement and consists of fractured overlain by a saturated clayey weathered zone. The region is also highly faulted. The median yield is 0.4 l/s and success rates are 70%.
- Coastal Karoo: (GRUs 18, 21, 25, 26, and 34): This region consists of varied Ecca and Dwyka lithologies from the Dwyka tillites to Pietermaritzburg shales and Vryheid Formation sandstones. These are faulted against Natal Group sandstones. Borehole yields are higher

than inland due to the density of block faulting. On the coast, the rocks are overlain by unconsolidated Quaternary sediments of the Berea red sands.

Table 15.1 Summary of Groundwater Resource Units

GRU	Primary Geology	Catchment	Quat[1]	Description
1	Volksrust, Vryheid	Mtamvuna	T40A, T40B, T40C	Upper Mtamvuna
2	Dwyka, Natal Group sandstone		T40D, T40E	Lower Mtamvuna
3	Natal Metamorphic Province,	South coast rivers	T40F, T40G	South coast
4	Drakensberg, Clarens, Elliot, Molteno, Tarkastad	Umzimkulu	T51A-B, T51D-E, T51F-G	Upper Umzimkulu escarpment zone
5	Adelaide, Volksrust		T51C, T51H, T51J	Upper Umzimkulu middelveld zone
6	Volksrust, Vryheid, Pietermaritzburg		T52A-C, T52E-G	Middle Umzimkulu
7	Dwyka		T52D, T52H-K	Middle Umzimkulu
8	Natal Group		T52L	Lower Umzimkulu
9	Natal Metamorphic Province		T52M	
10	Drakensberg, Ellliot, Molteno, Tarkastad	uMkhomazi	U10A-D	Mkomazi Drakensberg Escarpment
11	Adelaide, Volksrust, Vryheid, Pietermaritzburg		U10E-K	Mkomazi middelveld
12	Dwyka		U10L	Lower Mkomazi
13	Natal Metamorphic Province		U10M	
14	Adelaide, Volksrust, Vryheid	uMngeni and Msunduze	U20A-E, U20H	uMngeni to Albert Falls, and upper uMnsunduze
15	Natal Group		U20F-G, U20K	uMngeni- uMnsunduze
16	Pietermaritzburg, Dwyka	Msunduze	U20J	Lower uMnsunduze
17	Natal metamorphic Province	uMngeni	U20L	uMngeni to Inanda dam
18	Natal Group, faulted coastal Karoo		U20M	Lower uMngeni
19	Natal Metamorphic Province, Natal group	uMdloti	U30A	Upper Mdloti
20	Natal Metamorphic Province, Natal group	uThongati	U30C	Upper Tongati
21	Coastal faulted Karoo	uThongati and uMdloti, north coast rivers	U30B, U30D-E	Lower Mdloti and Tongati
22	Vryheid, Pietermaritzburg	Mvoti	U40A-B	Upper Mvoti
23	Natal Metamorphic Province, Natal Group		U40C-F	Middle Mvoti
24	Natal Metamorphic Province		U40G-H	
25	Natal Group, faulted coastal Karoo		U40J	Lower Mvoti
26	faulted coastal Karoo	North coast rivers	U50A	North coast
27	Volksrust, Vryheid, Pietermaritzburg	uMlaza	U60A	Upper uMlazi
28	Pietermaritzburg, Dwyka		U60B	
29	Natal Group, Dwyka		U60C-F	Lower uMlazi and central coast
30	Volksrust, Vryheid, Pietermaritzburg	Lovu	U70A	Upper Lovu
31	Pietermaritzburg, Natal Group		U70B	Middle Lovu
32	Natal Group, Natal		U70C	

GRU	Primary Geology	Catchment	Quat[1]	Description
	Metamorphic Province			
33	Natal Group, Dwyka		U70D	Lower Lovu
34	Pietermaritzburg, Dwyka	Central coast rivers	U70E-F	Central coast
35	Natal Metamorphic Province	South and central coast rivers	U80A-K	South and Central coast rivers
36	Dwyka		U80L	

1 Quaternary catchment.

GRUs are shown in Figure 15.1.

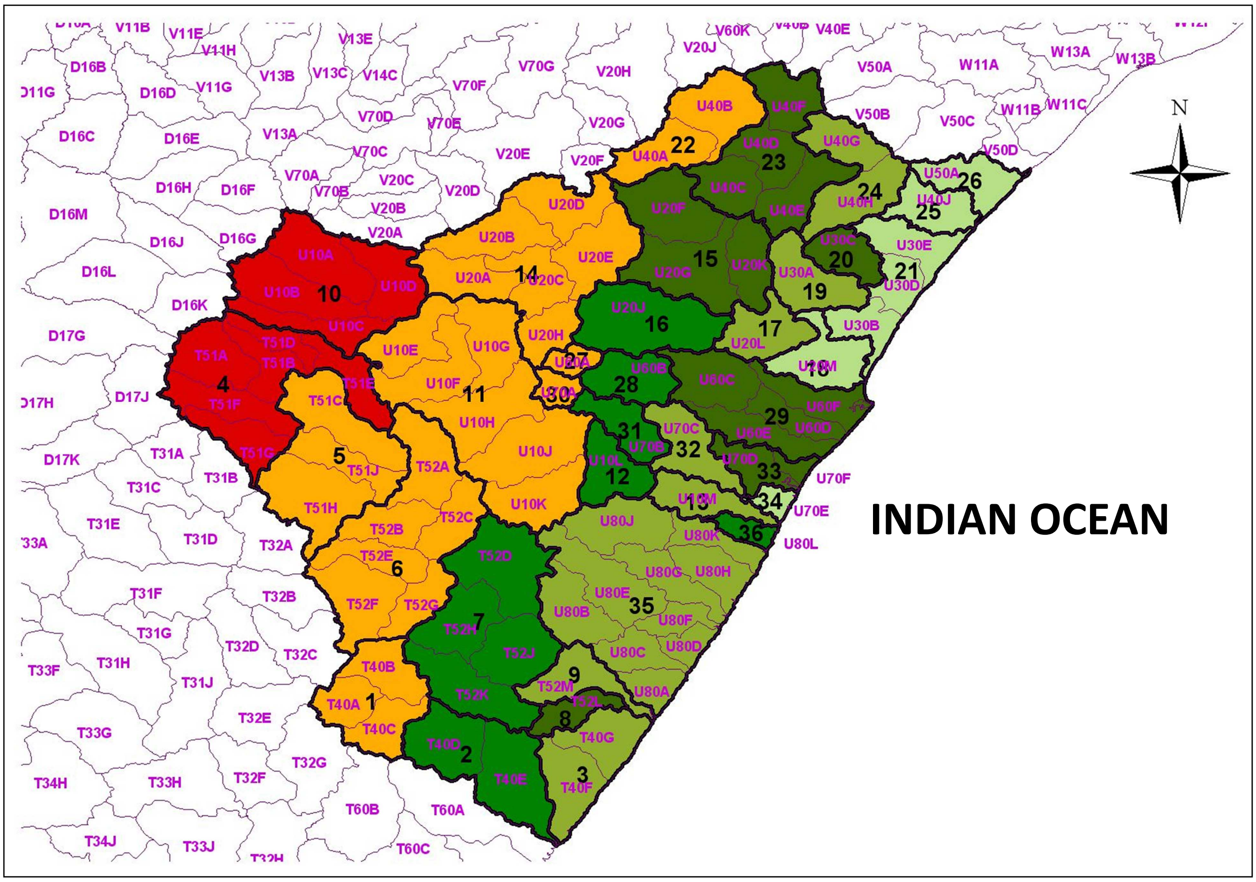


Figure 15.1 Groundwater Resource Units in WMA 11

15.3 RESOURCE QUALITY OBJECTIVES

Groundwater narrative and numerical RQOs were set for each IUA and GRU which is provided below.

Table 15.2 GRUs: Narrative and Numerical RQOs

GRU1: T40A-C: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual licence conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low yields, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU1: T40A-C: Numerical RQO	
Low flows at T4H001 should be maintained at a minimum of 35.78 Mm^3/a.	

GRU2: T40D-E: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low yields, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU2: T40D-E: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU4: T51A-B; T51D-G: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU4: T51A-B; T51D-G: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU5: T51C; T51H-J: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low yields, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU5: T51C; T51H-J: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU6: T52A-C; T52E-G: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU6: T52A-C; T52E-G: Numerical RQO	
Low flows at T5H002 should be maintained at a minimum of 72.75 Mm^3/a. Low flows at T5H007 should be maintained at a minimum of 131.7 Mm^3/a. Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU7: T52D; T52H: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low yields, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU7: T52D; T52H: Numerical RQO	

Due to the low groundwater use, numerical RQOs have not been set.	
GRU7: T52K: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU7: T52K: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU8: T52L: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU8: T52L: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU9: T52M: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU9: T52M: Narrative RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU10: U10A-D: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU10: U10A-D: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU11: U10E-F: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.

GRU11: U10E-F: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU11: U10G-K: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU11: U10G-K: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU12: U10L: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and/or nitrates. Fluoride and nitrates need to be tested for domestic boreholes.
GRU12: U10L: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l and nitrates below 20 mg/l.	
GRU13: U10M: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and/or nitrates. Fluoride and nitrates need to be tested for domestic boreholes.
GRU13: U10M: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l and nitrates below 20 mg/l.	
GRU14: U20A-C: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU14: U20A-C: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU14: U20D-E: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not

	required.
Water Quality	No regional groundwater quality issues exist.
GRU14: U20D-E: Numerical RQO	
Low flows at U2R002 should be maintained at a minimum of 69.53 Mm^3/a.	
GRU14: U20F-G: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU14: U20F-G: Numerical RQO	
Low flows at U2H012 should be monitored but an EWR has not been set.	
GRU14: U20H: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	No regional groundwater quality issues exist.
Water Quality	Some boreholes have elevated natural fluorides levels and/or nitrates. Fluoride and nitrates need to be tested for domestic boreholes.
GRU14: U20H: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU16: U20J: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Natural water quality problems exist in the catchment and boreholes for domestic use should be tested for compliance to drinking water standards
GRU16: U20J: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU15: U20K: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU15: U20K: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU17: U20L: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.

Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU17: U20L: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU18: U20A-M: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU18: U20A-M: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU19: U30A: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	No regional groundwater quality issues exist.
Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU19: U30A: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU21: U30A-B: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU21: U30A-B: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU20: U30C: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU20: U30C: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU21: U30D: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.

Water Quality	No regional groundwater quality issues exist.
GRU21: U30D: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU22: U40A-B: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU22: U40A-B: Numerical RQO	
Low flows at U4H002 should be maintained at a minimum of 6.41 Mm^3/a.	
GRU23: U40C: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU23: U40C: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU24: U40D: T52M: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU24: U40D: Narrative RQO	
Due to the low groundwater use, numerical RQOs have not been set	
GRU23: U40F: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU23: U40F: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU24: U40E and G: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.

Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU24: U40E and G: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU24: U40H: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural fluorides levels and need to be tested for domestic boreholes.
GRU24: U40H: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU25: U40J: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU25: U40J: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU21: U30E: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU21: U30E: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU26: U50A: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Monitoring not required as the aquifer discharges to the sea.
Water Level	Due to the moderate groundwater use, monitoring is required.
Water Quality	Some boreholes have elevated natural salinity and Fluoride levels which need to be tested for domestic boreholes.
GRU26: U50A: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU27: U60A: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.

Water Quality	No regional groundwater quality issues exist.
GRU27: U60A: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU28: U60B: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU28: U60B: Numerical RQO	
Low flows at U6H003 should be maintained at a minimum of 5.92 Mm^3/a.	
GRU29: U60C: T52M: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU29: U60C: Narrative RQO	
Due to the low groundwater use, numerical RQOs have not been set	
GRU29: U60D: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural salinity and Fluoride levels and Fluoride needs to be tested for domestic boreholes.
GRU29: U60D: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU21: U30D: Narrative RQO	
Abstraction	All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	No regional groundwater quality issues exist.
GRU21: U30D: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU30 and GRU 31: U70A-B: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the impacts of afforestation, sugar cane and AIPs, monitoring of baseflow is required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.

Water Quality	No regional groundwater quality issues exist.
GRU30 and GRU 31: U70A-B: Numerical RQO	
Low flows at U7H001 should be maintained at a minimum of 2.75 Mm^3/a.	
GRU32 and GRU33: U70C-D: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels and needs to be tested for domestic boreholes.
GRU32 and GRU33: U70C-D: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU29: U60F: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Groundwater quality needs to be monitored for salinity levels.
GRU29: U60F: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU33 and GRU34: U70E-F: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the confirmed Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Insufficient data exists.
GRU32 and GRU33: U70C-D: Numerical RQO	
Due to the low groundwater use, numerical RQOs have not been set.	
GRU35: U80B-C: Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.
Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU35: U80B-C: Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	
GRU3 (T40F-G), GRU35 (U80A, D, G-K), and GRU36 (U80L): Narrative RQO	
Abstraction	Significant ground water abstraction within 200 m of a perennial channel should be restricted. All users to comply with existing allocation schedules and individual license conditions within the Harvest Potential.
Baseflow	Due to the low groundwater use, monitoring not required.

Water Level	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.
Water Quality	Some boreholes have elevated natural Fluoride levels which need to be tested for domestic boreholes.
GRU3 (T40F-G), GRU35 (U80A, D, G-K), and GRU36 (U80L): Numerical RQO	
Boreholes used for long term primary water supply should have a Fluoride concentration of below 1.5 mg/l.	

16 IMPLEMENTATION CONSIDERATIONS

This chapter is an extract from report:
Department of Water and Sanitation (DWS), South Africa. 2015h. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Implementation report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. Authored by Pieter van Rooyen, Delana Louw, Patsy Scherman, Lara van Niekerk, Susan Taljaard, Shael Koekemoer, Piet Kotze, James Mackenzie, Karim Sami. September 2015. DWS Report: RDM/WMA11/00/CON/CLA/0715.

16.1 BACKGROUND

This task is associated with step 5 and 6 of the Water Resource Classification System. The report focuses on describing the principles of an implementation plan as part of National Water Resource Classification (NWRC), the actions required as well as a timeline for the implementation of the RQOs. Monitoring to measure whether the RQOs are being achieved is also provided.

Table 16.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and RUs, and describe the status quo of the water resource(s).
2	Initiation of stakeholder process and catchment visioning.
3	Quantify the EWRs and changes in non-water quality ecosystem.
4	Identification and evaluation of scenarios within the Integrated Water Resource Management process.
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	**Develop draft RQOs and numerical limits.**
7	**Gazette and implement the class configuration and RQOs**.

16.2 IMPLEMENTATION BUILDING BLOCKS AND COMPONENTS

The RQO implementation plan consists of three components:

- Firstly activities ensuring that the RQOs determined are adhered too (e.g. releasing or transferring water usually from storage).
- Secondly, monitoring (measuring) various aspects in order to determine whether or not the required RQOs are met or the resulting ecological health objectives are achieved.
- Lastly, if the intended outcomes are not observed from the monitoring process, adaptive management needs to take place in order to rectify the situation such that the desired RQOs are met. Figure 16.1 presents a simplified schematic of these three components, indicating a circular flow of information.

This is best demonstrated through what is needed for the flow RQOs:

- Activity: Release flow from a dam according to set rules.
- Monitoring: Record the flow at flow gauges and compare against EWR flow EWR at a downstream site as well as monitoring related to wastewater discharges affecting the estuaries.
- Adaptive Management: Inform operator to increase flow if target levels are not achieved.

Where the above cycle would typically be carried out at weekly or monthly frequencies a similar process would be followed for ecological variables, however, the cycle period could be annually of once every three years.

Important aspects that should be managed as part of this cycle are the flow of information including recorded (raw) data and information such as reports, meeting proceedings and decisions. This is to build up a history (record) of the implementation process as well as identify “lessons learned” to strengthen success and improve or adjust activities to achieve the desired results.

Some of the activities needed to fulfil the requirements of the RQO implementation plan relate to functions that are currently performed by different Directorates in DWS or even other institutions. Coordination among these institutions is essential and the uptake of particular responsibilities relating to these actions need to be formalised and added to their respective business plans. For example, institutions that will typically be involved are water users (e.g. Water Authority Associations and Municipalities) and DWS water resource operating personnel and active conservation bodies. This coordination may be formalised in an appropriate structure similar to a System Operating Forum (SOF) (as set up by DWS in various catchments across the country). All these role players need to contribute to the plan by, for example, sharing information and executing their assigned activities.

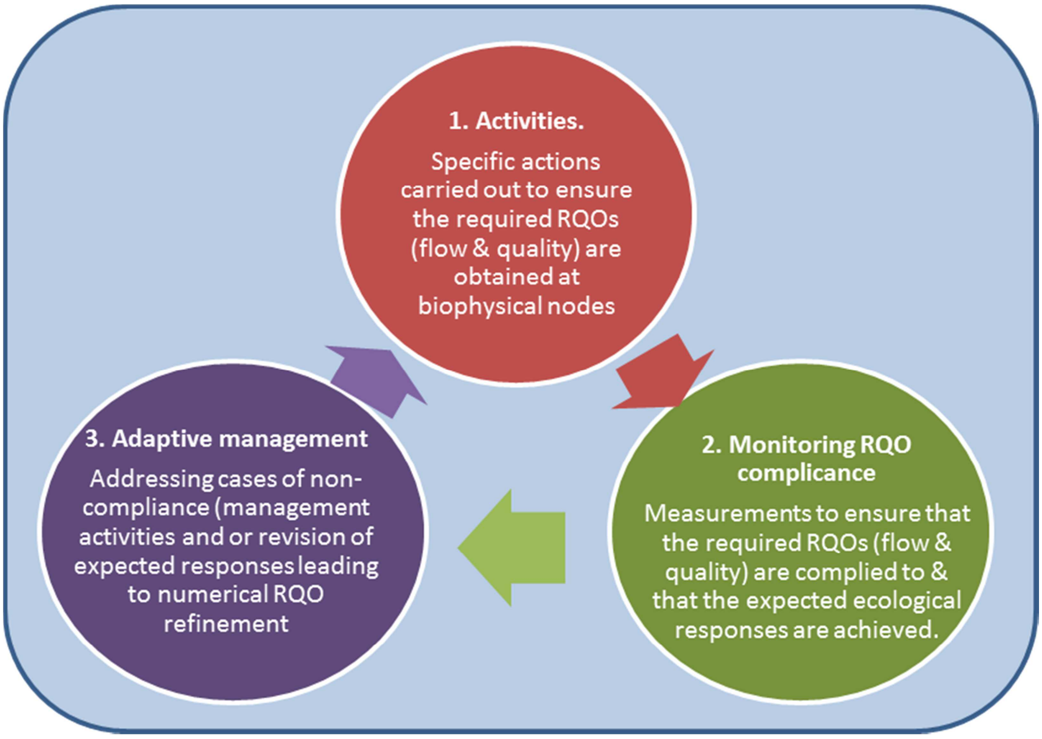


Figure 16.1 Core building blocks of the implementation plan

A RQO implementation plan must function within the existing environment of water resource management as well as existing monitoring programmes. While the regulation and control of the required RQOs are the responsibility of DWS’s CD: WE, certain aspects that could cause violations of the required RQOs may relate to legislation managed and implemented by other Directorates within DWS, or even other government departments. Examples of this are pollution, fisheries management, abstraction and erosion control. It is not the intention of the implementation plan to either duplicate or replace existing legislation and/or institutions that already manage aspects affecting the RQOs, but to rather harness these and inform the relevant authorities that can take action using existing Acts and legislation. The plan should therefore allow for the linkages that will initiate the appropriate actions to enforce compliance in accordance with procedures already in place. An example of an important links is with the Estuarine Management Plans.

Implementation of the RQOs to achieve the Water Resource Class (hereafter referred to as the Class) consists of the following primary components:

- Implementing the operating rules in terms of the key driver (hydrology) to ensure that the releases required by users and the ecology are met in time and place. This may consist of operation of dams, abstractions and other infrastructure as well as management through licensing and implementation of restrictions amongst other measures.
- Compliance hydrological monitoring based largely on the continuous monitoring at a network of flow and water level gauges.
- Compliance geohydrological monitoring based on monitoring low flow flows and water levels at gauging weirs and boreholes.
- Implementing water quality source control measures through operation and management of WWTW and monitoring of effluent quality and volume entering rivers and estuaries, for example. If dam releases are relevant, factors such as releases through multi-level outlets to maintain water quality would be relevant.
- Compliance water quality monitoring based largely on monitoring at gauges and other key points as well as monitoring through implementing agents and municipalities (often by the developers themselves as part of license conditions) amongst others. Water quality RQOs at EWR sites and associated RUs are described through Ecological Specifications (EcoSpecs) and Thresholds of Potential Concern (TPCs) for rivers. For estuaries, EcoSpecs and TPCs for water quality are set for river inflow into the estuary, as well as for zones in the estuary.
- Implementation of catchment and non-flow related measures to achieve the Class: In some cases, non-flow (other than quality) related measures are required to achieve the Class's catchment configuration. As these measures may not be the responsibility of DWS to implement and manage, RQOs are provided at a broad level. These measures most often relate to protection of the riparian buffer zone, alien vegetation control and control of erosion and sedimentation.
- Response monitoring (also called resource monitoring in Estuary Management framework) of biota and habitat to determine whether the expected responses described as part of the Reserve and Classification assessments are being achieved. The responses are described at different levels of detail depending on the available information and priority level of the different river reaches. Generally the biota and habitat RQOs are described through EcoSpecs and TPCs where detailed numerical information is available at high priority river reaches (RUs) which contain EWR sites. In the case of estuaries, EcoSpecs and TPC are usually set for all estuaries in a WMA, albeit at different levels of confidence (e.g. EcoSpecs and TPCs set as part of desktop or rapid level assessments are usually of low confidence, while EcoSpecs and TPCs set as part of intermediate or comprehensive level assessments are of medium to high confidence). Where insufficient data is available to set EcoSpecs and TPCs, it is indicated as such. Also note that the response monitoring is dependant on information on the hydrology and water quality compliance monitoring.

Note that the Reserve is encapsulated within the Class and RQOs. The Class and catchment configuration provides the associated EcoStatus for every river reach in the system. The EWRs associated with the accepted Class become the Ecological Reserve. The hydrology, water quality, habitat and biota RQOs therefore include the Reserve requirements. The response monitoring above directly refers to the monitoring of the EcoStatus and therefore by default the Ecological Reserve.

16.3 PROPOSED IMPLEMENTATION PLAN TO GIVE AFFECT TO THE RQOs

In its most basic form the implementation information tries to answer the following three questions:

- **What** activities are required? i.e. the actions and work that has to be performed and at what intensity or level of detail these should be carried out at;
- **When** should the activities take place? i.e. the frequency of work of activity.
- **Who** is responsible for ensuring the work or activity are carried out?

It was recognised that the implementation information should take account of the varying characteristics of the river reaches across the Study Area, availability and need for monitoring information, the ability (currently and in the future) to regulate flow in the river reaches as well as the existing water resource management activities taking place or being planned.

The overarching approach to be followed in the execution of the implementation is that a sequence of activities needs to be introduced to accommodate proposed future infrastructure developments, rollout of ongoing water resource management activities such as the verification of the lawful water use as well as seeking alignment with the progressive implementation of the DWS Reconciliation Strategy and the strategies of the Provincial and Local Authorities.

The tables below lists all the activities required for RQO implementation.

Table 16.2 Activities milestones and related processes

ID	Activity	Description
1	**Resource Quality Objectives and Class**	
2	Legal Notice.	Published in Gazette and comment period.
3	Promulgation.	Approved by Minister of Water and Sanitation.
4	**Monitoring**	
5	Flow (continuous recordings).	Maintain flow gauges.
6	Water quality (continuous from current activities).	▪ Maintain current DWS and other (e.g. Umgeni Water) water quality monitoring activities. ▪ Identify and maintain monitoring programmes other than DWS and that of Umgeni Water. Ensure that all data are captured in the DWS Water Management System (WMS) database, including microbial data. ▪ Link with the DWS NMMP and ensure that faecal coliform and *E.coli* data can be sourced by the programme.
7	Water quality.	Initiate and maintain additional water quality monitoring points as specified.
8	Fish and macro-invertebrates (every 2 - 3 years).	Standard fish and macro-invertebrate surveys and an update of the Fish Response Assessment Index (FRAI) and Macro Invertebrate Response Assessment Index (MIRAI) to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.
9	Diatoms (twice a year).	Diatom analysis to feed into the water quality monitoring programme.
10	Riparian vegetation (every 3rd year).	Specific surveys to determine whether TPCs have been exceeded as well as an update of the Vegetation Response Assessment Index (VEGRAI) to determine any changes in EC. If TPCs are triggered, the required actions must be undertaken.

ID	Activity	Description
11	Groundwater monitoring.	▪ Water level monitoring: Monthly to quarterly at existing and (new) monitoring boreholes. ▪ Abstraction monitoring (for large groundwater users): Continuous or aggregated monthly to annually. ▪ Baseflow monitoring continuously at gauging stations and aggregated monthly to provide annual volumes. ▪ Groundwater quality monitoring: quarterly at existing and (new) monitoring sites.
12	**Institutional arrangements**	
13	Establish RQO implementation structures (committee).	Design and establish the institutional structures. This could be in the form of a standalone committee or may be linked to other initiatives.
14	Develop reporting procedures, method and communication products.	This must be linked to the monitoring information and should be concise focussing on reporting compliance with meeting the RQOs.
15	Meetings / compliance reports / adaptive measures.	Application of what is defined in Item 19.
16	**Review RQO and Implementation Plan**	
17	Evaluate effectiveness of activities and monitoring.	Key activity to ensure the RQO implementation remains relevant.
18	Review RQOs and recommend changes	Recommend when RQOs need to be revised.
19	**Related Parallel Water Resource Management Processes**	
20	Operating Analysis.	
21	Update: Water requirements, maintenance schedules, operational risk analysis.	The information must feed into the water resource model.
22	System Operating Forum – uMngeni System and stand-alone systems.	DWS to continue with forums for operational planning including drought management.
23	Continuation and maintenance of the Reconciliation Strategy.	Revise the timeframes for implementation of water resource development interventions to account for prevailing water balances.

Note: Blue shaded activities are in progress or have been completed for the study area.

16.4 DOCUMENTATION

It is necessary to keep record of the implemented actions, monitoring and adaptive management and it is suggested that this take place on an annual basis. The annual implementation plan document will typically include a summary of the previous years' monitoring results. Where deviations occurred, explanations of the adaptive management or corrective measurements should be given. System changes that took place in the previous year should also be documented, as well as specific system operational aspects.

16.5 MONITORING

Effective implementation of the Classes and RQOs relies on the availability of relevant monitoring information for tracking progress, evaluating compliance and to identify if and when revisions of the specified stipulation (target criteria) need to be considered. Monitoring requirements are therefore a key component of the plan

16.6 MONITORING PROGRAMME FOR THE STUDY AREA

16.6.1 Hydrological compliance monitoring

The DWS has approximately 43 functional flow gauges on the online HYDSTRA database for the study area. There are also numerous flow gauges which have been closed over the years. It is important that flow monitoring takes place at the EWR sites. Where applicable, gauges that are no longer monitored should be reinstated. Monitoring exists for two main purposes namely:

- Monitoring to confirm whether the required flows at a certain point are being achieved.
- Monitoring to activate a specific action (request for release) should the flows be non-compliant.

16.6.2 Water level monitoring at estuaries

The DWS has eight functional estuary water level recorders on the online HYDSTRA database for the study area. It is important that were water levels are being monitored flow gauging also takes place above the estuary. This is only the case for about four of the systems at present. Monitoring exists for three main purposes namely:

- Gather information on estuary mouth behaviour and increase confidence in/ the mouth state-flow relationship.
- The monitoring of estuary mouth state to confirm whether the required volume of freshwater inflow is entering the estuary.
- Verify artificial breaching levels.

16.6.3 Groundwater monitoring

Groundwater monitoring timing is as follows:

- Water level monitoring: Water level monitoring is required monthly to quarterly.
- Abstraction monitoring: Abstraction monitoring is by nature continuous, or aggregated monthly to annually.
- Baseflow monitoring: Baseflow monitoring is undertaken continuously at gauging stations and aggregated monthly to provide annual volumes. During wet periods, baseflow can be derived from hydrograph separations.
- Groundwater quality monitoring: Water quality is required quarterly.

A groundwater monitoring plan has been provided that indicates what type of monitoring is essential and the priority.

16.6.4 Water quality compliance monitoring

Water quality monitoring is undertaken monthly or as specified by the current DWS or other (e.g. Umgeni Water) monitoring programme. Monitoring focussing on water quality and diatoms are specific to High Priority river sites (EWR and 3WQ sites for water quality monitoring) and estuaries, but could be applied at any of the RUs or estuaries with lower Priority Ratings (2) where water quality has been identified as an indicator.

Monitoring details for water quality and diatom sampling providing the actions, temporal and spatial scales have been provided below.

Table 16.3 Water quality and diatom monitoring programme

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
All variables measured as standard by DWS as a minimum requirement. Umgeni Water sties to continue as current, as a broader range of variables are monitored as compared to DWS sites. Note that temperature and dissolved oxygen should be monitored at all EWR sites as no baseline currently exists for these parameters and they are strongly linked to biotic responses. No data or numeric DWS guidelines exist for turbidity, although Umgeni Water routinely monitors turbidity. Turbidity should be measured where specified and a turbidity database developed. Although *E. coli* and faecal coliforms are not strictly part of ecological monitoring, data should be collected where specified due to current and potential impacts on users. This variable is again monitored by Umgeni Water.	Include additional variables in the formal DWS and other monitoring programmes as indicated by water quality RQOs, specifically periphyton chlorophyll-a and diatoms. Include toxics monitoring if specifically mentioned; otherwise cover only if indicated by biotic responses. Include *E. coli* and faecal coliform monitoring as part of the NMMP or other health monitoring programmes, as required and indicated in the Implementation Report.	1. Monthly, or as determined by current DWS or other monitoring programme per monitoring point. 2. Institute bi-monthly (i.e. twice a month) monitoring if required at High Priority water quality sites with no water quality gauging weir or other monitoring point in place. 3. Institute monthly monitoring of the standard suite of DWS variables, if specified in the Implementation Report, at Moderate Priority RUs where water quality has been identified as an indicator and an existing water quality gauging weir or monitoring point is in place. If not, institute bi-monthly (i.e. twice a month) monitoring as outlined in point 2. 4. *E. coli* and faecal coliform monitoring must be conducted at the frequency required by the NMMP.	1. Relevant water quality monitoring point or gauging weir. 2. Institute a monitoring point downstream of a High Priority water quality site or at the lower end of a Moderate Priority RU where water quality has been identified as an indicator, if no water quality gauging weir or monitoring point is in place for use. 3. Institute a monitoring point just upstream of estuaries (where this is not covered by an existing monitoring point or where the monitoring point is too far upstream from the estuary.
Diatoms	Collect baseline data to develop EcoSpecs and TPCs.	Six monthly.	All EWR sites and sites were WQ hotspots have been identified where there are potential nutrient problems.

Although it is recommended that monitoring activities outlined above be conducted at all High Priority and EWR sites as specified, it is understood that the pressure on resources may require prioritization of sites for monitoring purposes. This is particularly important if an information database has to be built before the implementation of RQOs can take place.

16.6.5 Habitat and biota monitoring for estuaries

This monitoring is at lower frequency and usually requires field work. The focus for this monitoring will be at the EWR sites and the high priority estuaries

In the table below, a monitoring programme for these actives is provided.

Table 16.4 Habitat and biota Level 2 monitoring programme

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
Sediment dynamics (Estuary)			
Bathymetric surveys:	Series of cross-section profiles and a longitudinal profile collected at fixed 200 - 500 m intervals, but in more detail in the mouth (every 100 m). The vertical accuracy should be about 5 cm.	Every 3 years	Entire estuary
Sediment grab samples	Set sediment grab samples (at cross section profiles) for analysis of Particle Size Distribution (PSD) and origin (i.e. using microscopic observations)	Every 3 years (with invert sampling)	Entire estuary
Water quality (Estuary)			
Longitudinal salinity and temperature profiles (in situ)	Collected over a spring and neap tide during high and low tide at: ▪ End of low flow season (i.e. period of maximum seawater intrusion). ▪ Peak of high flow season (i.e. period of maximum flushing by river water).	Seasonally every year	Entire estuary (3 - 10 stations)
Water quality measurements (i.e. system variables, and nutrients)	Take measurements along the length of the estuary (surface and bottom samples).	Seasonal surveys, every 3 years or when significant change in water inflows or quality expected	Entire estuary (3 - 10 stations)
Organic content and toxic substances (e.g. trace metals and hydrocarbons) in sediments	Measurements along length of the estuary, where considered an issue.	Every 3 - 5 years	Focus on sheltered, depositional areas
Water quality (e.g. system variables, nutrients and toxic substances)	Measurements on near-shore seawater.	Use available literature	Seawater adjacent to estuary mouth at salinity 35
Microalgae (Estuary)			
Phytoplankton Benthic microalgae	Conduct water column chl-a measurements and counts of dominant phytoplankton groups (incl. flagellates, diatoms, dinoflagellates, chlorophytes and cyanobacteria). Conduct intertidal and subtidal benthic chl-a measurements.	Summer and winter survey every 3 years	Entire estuary (3 - 10 stations)
Macrophytes (Estuary)			
Plant community types, identification and total number of macrophyte species, number of rare or endangered species or those with limited populations. Plant cover. Depth	Develop ground-truthed maps. Record number of community types etc. documented during a field visit. Record percentage plant cover, salinity, water level, sediment moisture content and turbidity on a series of permanent transects along an elevation gradient. Take measurements of depth to water table and ground water	Summer survey every 3 years	Entire estuary

Indicator	Monitoring action	Temporal scale (frequency and timing)	Spatial scale
	salinity in supratidal marsh areas.		
Invertebrates (Estuary)			
Zooplankton Benthic invertebrates	Record species and abundance of zooplankton, based on samples collected across the estuary at each of a series of stations along the estuary; Record benthic invertebrate species and abundance, based on subtidal and intertidal grab samples at a series of stations up the estuary, and counts of hole densities. Measures of sediment characteristics at each station	Summer and winter survey every 3 years	Entire estuary (3 - 10 stations)
Fish (Estuary)			
Species diversity Abundance of fish	Seine net and gill net sampling.	Summer and winter survey every 3 years	Entire estuary (3 - 10 stations)
Birds (Estuary)			
Birds	Full count of all water associated birds, covering as much of the estuarine area as possible, from a boat and on foot.	Annual winter (Jul/Aug) and summer (Jan/Feb) surveys	Entire estuary

1 South African Scoring System version 5.

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18 APPENDIX A: OPERATIONAL SCENARIO DESCRIPTIONS

This appendix provides the definitions of all scenarios with the identification labels referenced in the reports and serve as a lookup reference.

Table 18.1 Definition of scenario applied in the comparison and evaluation process

Sc	Scenario Description	Comment
Ai	Ecological protection is priority (minimum discharge to estuaries)	Northern and Southern Cluster: 30% of future ww flow to estuary, remainder through alternative means.
Aii	Ecological protection is priority (minimum discharge to estuaries)	Northern and Southern Cluster: Discharge current capacity, remainder disposal through alternative means.
Aiii	Ecological protection is priority (minimum discharge to estuaries)	All Clusters: Discharge current capacity, remainder disposal through alternative means.
Av	Ecological protection is priority (minimum discharge to estuaries)	As Ai: Option for Central Cluster (discharge to iSipingo as an alternative option to Ai).
Bi	Minimum costs scenario (highest flow through estuaries)	Options for Central Cluster: Low nutrient discharge from (high costs)
Bii	Minimum costs scenario (highest flow through estuaries)	As Bi: Different infrastructure options for Central Cluster (lower costs). uMkhomazi estuary received 50Ml/day WW flow .
Biii	Minimum costs scenario (highest flow through estuaries)	As Bi: Current treatment (high) nutrient discharge (low costs).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Short term increases in discharges. Central Cluster: Short term increases in discharges with low nutrient discharge (high costs)
Ci	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Short term increases in discharges. Central Cluster: As C: Current treatment (high) nutrient discharge (low costs)
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Medium term increases in discharges. Central Cluster: Low nutrient discharge (high costs)
Di	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	Northern and Southern Clusters: Medium term increases in discharges. Central Cluster: As D: Current treatment (high) nutrient discharge WWTW (low costs)
E	Indirect re-use (consider volume and practicalities) Remainder According to Scenario C.	Northern and Southern Clusters: Reuse 50% if future ww flow. Central Cluster: Reuse via Hazelmere Dam.
F	Direct re-use (consider volume and practicalities) Remainder According to Scenario C.	Northern and Southern Clusters: Reuse 50% if future ww flow. Central Cluster: High level of treatment (high operating costs), supply into distribution system.

Note: The grey shaded scenarios were selected for presentation to the Project Steering Committee.

uMngeni River System scenarios

Sc	Scenario Variables							
	Update Water Demands	Update Demands and Return Flows (2022)	Ultimate Development Demands and Return Flows (2040)	EWR	MMTS2[1]	MWP[2]	Darvill Re-use	eThekwini Re-use
UM1	Yes	No	No	No	No	No	No	No
UM2	No	Yes	No	No	Yes	No	No	No
UM41	Yes	No	Yes[3]	No	Yes	No	No	No
UM42	Yes	No	Yes[4]	No	Yes	No	No	No
UM51	Yes	No	Yes[3]	No	Yes	No	Yes	Yes
UM52	Yes	No	Yes[4]	No	Yes	No	Yes	Yes

1 Mooi-Mgeni Transfer Scheme Phase 2 (Spring Grove Dam).
2 Mkomazi Water Project (Smithfield Dam).
3 All future return flows from Phoenix and Mhlanga WWTW to the Mgeni System.
4 All future return flows from Phoenix, Umhlanga and Tongati WWTW to the Mgeni System.

Lovu River Scenarios

Sc	Scenario Variables			
	Update Water Demands	Ultimate Development Demands and Return Flows (2040)	EWR	Reduced Abstraction and Afforested Areas
LO1	Yes	No	No	No
LO2	Yes	Yes	No	No
LO3	Yes	Yes	No	Yes (25% reduction)
LO4	Yes	Yes	No	Yes (50% reduction)

uMkhomazi River System scenarios

Sc	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini Off Channel Dam
MK1	Yes	No	No	No	No
MK2	Yes	Yes	No	Yes	Yes (no support)
MK21	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (no support)
MK22	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (no support)
MK23	Yes	Yes	REC low+[3] (EWR 2)	Yes	Yes (no support)
MK31	Yes	Yes	REC tot[1] (EWR 3)	Yes	Yes (no support)
MK32	Yes	Yes	REC low[2] (EWR 3)	Yes	Yes (no support)
MK33	Yes	Yes	REC low+[3] (EWR 3)	Yes	Yes (no support)
MK4	Yes	Yes	No	Yes	Yes (with support)
MK41	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (with support)
MK42	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (with support)

1 Recommended Ecological Category (Total Flows).
2 Recommended Ecological Category (Low Flows).
3 Recommended Ecological Category (Total Flows for January, February, March and Low Flows remaining months).

Mvoti River System scenarios

Sc	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	Yes	No	No	No	No
MV21	Yes	No	REC tot[2]	No	No
MV22	Yes	No	REC low[3]	No	No
MV3	Yes	Yes	No	Yes	Yes
MV41	Yes	Yes	REC tot[2]	Yes	Yes
MV42	Yes	Yes	REC low[3]	Yes	Yes
MV43	Yes	Yes	REC low+[4]	Yes	Yes

1 Mvoti River Development Project (Isithundu Dam). 2 Recommended Ecological Category (Total Flows)
3 Recommended Ecological Category (Low Flows).
4 Recommended Ecological Category (Total Flows for January, February, March and Low Flows for remaining months).

Scenarios of levels of wastewater treatment

PARAMETER	Level 1 (L1)	Level 2 (L2)	Level 2a (L2a)
Ammonia-N (free) (µg/l)	<3 000	<1 500	<500
Nitrate/Nitrite-N (µg/l)	<8 000	<4 500	<2 500
DIN (µg/l)	**11 000**	**6 000**	**3 000**
DIP (µg/l)	**1 000**	**100**	**20**
COD (mg/l O_2)	**75**	**50**	**30**
Suspended solids (mg/l)	25	15	5
Estimated turbidity (NTU)	**40**	**30**	**20**

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
uMkhomazi Estuary scenarios		
Present	943.39	
Sc 1MKn1 (L1)	945.22	5
Sc 1MKn (L2)	945.22	5
Sc 1MKn (L2a)	945.22	5
Sc 2MKn (L1)	777.27	16
Sc 2MKn (L2)	777.27	16
Sc 2MKn (L2a)	777.27	16
Sc 3MKn (L1)	779.09	21
Sc 3MKn (L2)	779.09	21
Sc 3MKn (L2a)	779.09	21
Sc 4MKn (L1)	789.69	50
Sc 4MKn (L2)	789.69	50
Sc 4MKn (L2a)	789.69	50

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
uMdloti Estuary scenarios		
Present	85.03	7.53
H6_1o	67.02	7.53
ScA1	68.02	0
H6_1p	70.12	7.53
ScA1a (L1)	72.40	12
ScC3 (l1)	77.88	27
ScC3 (L2)	77.88	27
Sc23_2 (L2)	78.97	30
Sc 23_2 (L2a)	78.97	30
ScD4 (L2a)	89.93	60
Sc2 (L1)	113.68	125
Sc2 (L2a)	113.68	125

Scenario (waste water treatment level)	**MAR (x 10^6 m^3/a)**	**WWTW volume (Ml/d)**
Mbokodweni Estuary scenarios		
Present	53.54	33.6
Sc A1	41.26	0
Sc C (A1a) (L1)	61.34	55
Sc C A1a (L2)	61.34	55
Sc C A1a (L2a)	61.34	55
Sc B (L1)	72.30	85
Sc B (L2)	72.30	85
Sc B (L2a)	72.30	85
Little Manzimtoti Estuary scenarios		
Present	6.62	4.76
Sc 1	4.88	0
Sc 2a (L1)	7.80	8
Sc 2b (L2)	7.80	8
Sc 2ca	7.80	8
Sc 3a (L1)	15.83	30
Sc 3b (l2)	15.83	30
Sc 3c (L2a)	15.83	30

Scenario (waste water treatment level)	**MAR (x 10^6 m^3/a)**	**WWTW volume (Ml/d)**
uThongathi Estuary scenarios		
Present	79.2	12.4
Sc 1	74.7	0
Sc 2 (L1)	81.2	18
Sc 2 (L2)	81.2	18
Sc 2 (L2a)	81.2	18
Sc 3 (L1)	84.9	28
Sc 3 (L2)	84.9	28
Sc 3 (L2a)	84.9	28
Sc 4 (L1)	92.2	48
Sc 4 (L2)	92.2	48
Sc 4 (L2a)	92.2	48
Sc 5 (L1)	103.2	78
Sc 5 (L2)	103.2	78
Sc 5 (L2a)	103.2	78
Sc 6 (L1)	132.4	158
Sc 6 (L2)	132.4	158
Sc 6 (L2b)	132.4	158

19 APPENDIX B: ESTUARY SYNONYM LIST FOR KWAZULU NATAL ESTUARIES

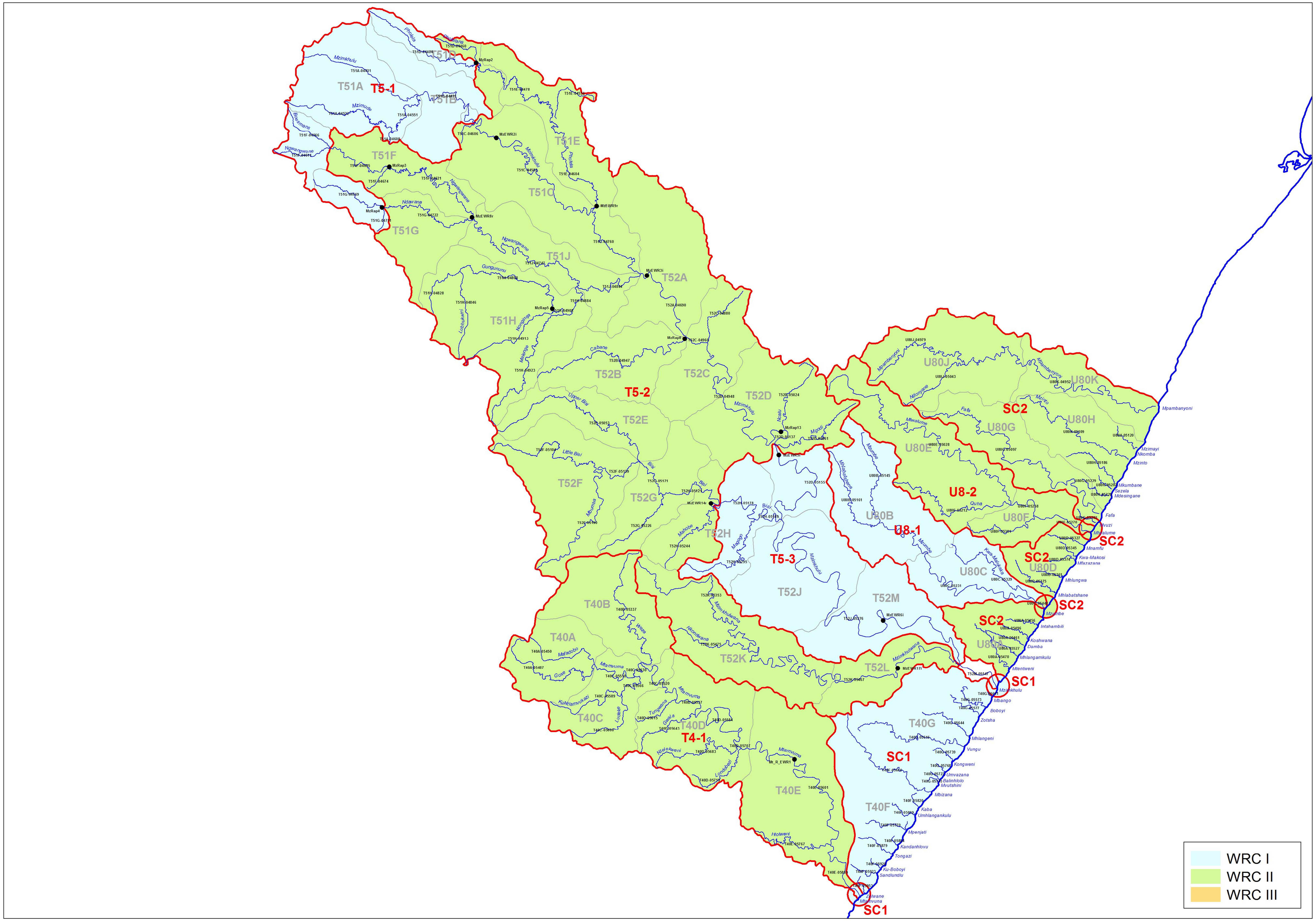
Estuary synonym list for KZN estuaries (Source: B Escott, Ezemvelo KZN Wildlife).

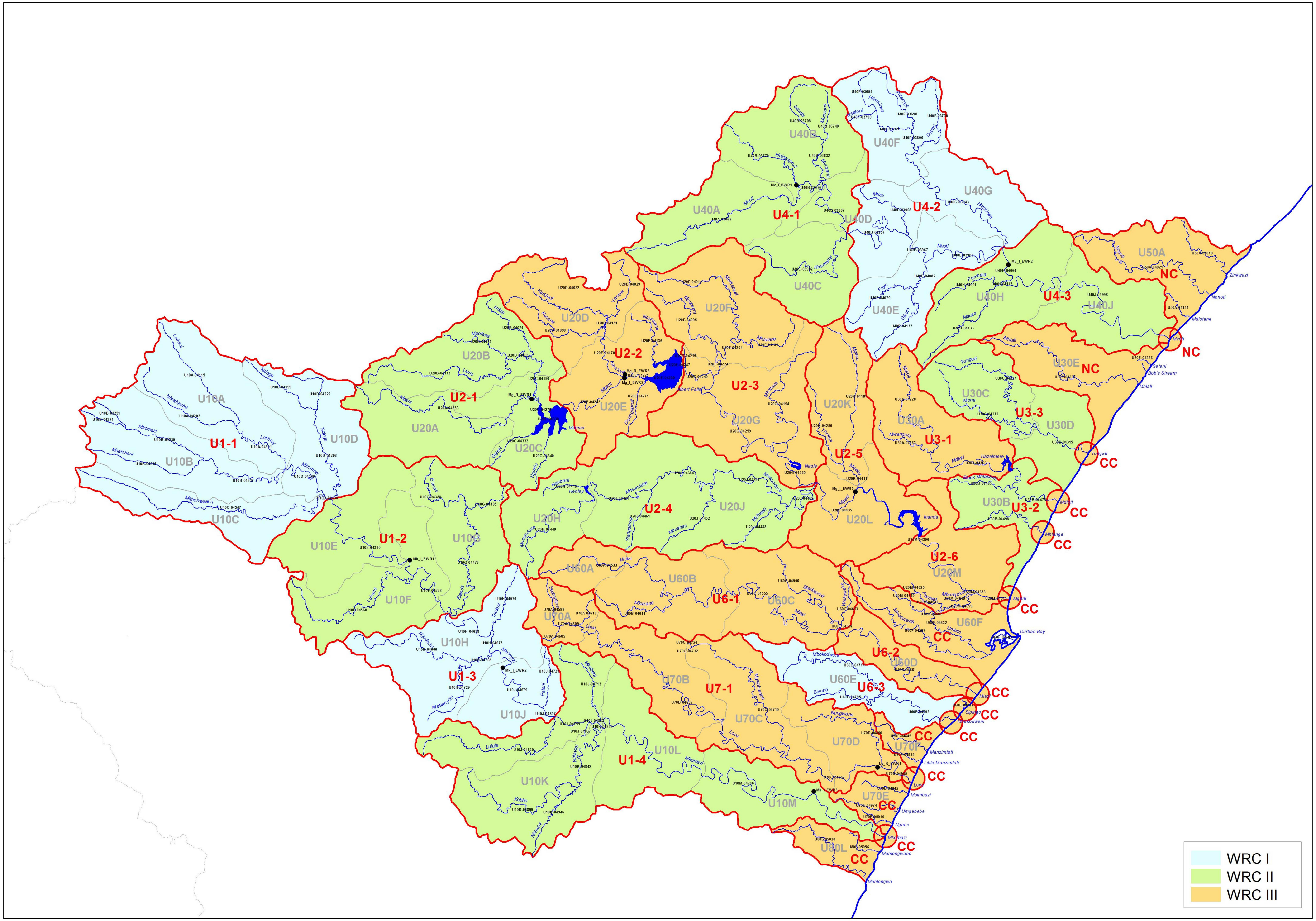
Estuary Name	Synonyms
Bilanhlolo	Ibilanhlolo; Big ibilanhlolo
Bobs Stream	Sharks Bay
Boboyi	Imboyboye
Damba	Domba
Durban Bay	Durban Bayhead
Fafa	iFafa
Intshambili	Ntshambili; Injambili
Isolwane	Zolwane
Kaba	Mkobi; Mkobe; Khaba
Kandandhlovu	Khandandlovu, Kandandlovu, Umkandanhlovu
Kongweni	Inkongweni
Koshwana	Ikotshwana
Kosi	
Ku-Boboyi	
Kwa-Makosi	Makosi
Little Manzimtoti	Little Amanzimtoti
Lovu	Illovu
Mahlongwa	Amahlanga, Amahlongwa
Mahlongwana	Amahlongwana
aManzimtoti	Manzimtoti
Matigulu/Nyoni	Amatikulu, (e) Matikulu, Inyoni
Mbango	Imbonga, Imbango
Mbizane	Mbizana
Mbokodweni	Umbogintwini, umbohodweni
Mdesingane	Mdezingane
Mdlotane	Ndlotane, (u)Mhlutini
uMdloti	Umdloti; Umhloti; Mhloti; Mdhloti
Mfazazana	Mfazazaan; Umfazaan; Umfazazane; Umfazaazan
uMfolozi	Mfolozi, Mfolosi
Mgababa	Umgubaba, Umgababa
uMngeni	Mngeni
Mgobozeleni	Mgobezeleni, Ngoboseleni; Ngobeseleni; Sodwana; Sordwana
Mhlabatashane (Mzimayi2)	Mhlabatshane
Mhlali	eMhlali, uMhlali
Mhlanga	Umhlanga, Ohlanga, Umslanga
Mhlangamkulu	
Mhlangeni	
Mhlatuzane	
Mhlatuze	Mhlathuze, Umhlatuze
Mhlungwa	Umhlungwa
Mkumbane	Inkombane, Umkombana
Mlalazi	Umlalazi
Mnamfu	Unamfu
Mpambanyoni	Mpanbanyoni, Mpambonyoni, Umpambinyoni, Umpambumyani

Estuary Name	Synonyms
Mpenjati	
Msimbazi	uMzimbasi, Umzimbezi
Mtentweni	Mtentwana, Ententweni
Mtwalume	Umtwalumi, Mtwalumi
Mvoti	Umvoti
Mvutshini	Little iBilanhlolo
Mvuzi	Uvuzi
Mzimayi	Umzimai
Mzimkulu	Mzimkhulu, Umzimkulu
Mzingazi	
Mzinto	Umzinto
Ngane	Ingane, iNgane
Nhlabane	Hlobane
Nkomba	
Nonoti	
Qhubu	
Reunion (Canal)	
Richards Bay	
Sandlundlu	Inhlanhlinhlu
Seteni	
Sezela	Isizela
Shazibe	
Sipingo	Isipingo
Siyaya	Siaya, Siyani, Siyaní, Siyai
St Lucia	
uThongathi	Tongaat; Tongaati; Thongathi; Umtongate; Tongati
Tongazi	Thongazi, Intongazi
Tugela	Thukela, Tukela
Umhlangankulu (South)	Mhlangankulu
uMkhomazi	Mkomazi, Umkomaas, Mkomanzi
Umlazi	Mlazi
Umtamvuna	Mtamvuna, Mthamvuna
Umzumbe	Umzumbe, Mzumba, Mzamba, Mzumbe
Unknown	aManzimnyama canal
Uvuzana	
Vungu	Uvongo
Zinkwazi	Zinkwasi, Sinquasi; Sinkwazi
Zotsha	Izotsha

20 APPENDIX C: IUA MAPS AND THE WATER RESOURCE CLASSES

Two maps follow illustrating the IUAs (outlined in red) and shaded according to the Water Resource Class recommended for the IUA.




U1-1
U1-2
U1-3
U1-4
U2-1
U2-2
U2-3
U2-4
U2-5
U2-6
U3-1
U3-2
U3-3
U4-1
U4-2
U4-3
U6-1
U6-2
U6-3
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U10A
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U70A
U70B
U70C
U70D
U70E
U70F
U80L
NC
CC
Mv_I_EWR1
Mv_I_EWR2
Mg_R_EWR1
Mg_R_EWR3
Mg_I_EWR2
Mg_I_EWR5
Mk_I_EWR1
Mk_I_EWR2
Mk_I_EWR3
Lv_R_EWR1
Midmar
Albert Falls
Nagle
Inanda
Henley
Hazelmere
Durban Bay
Mvoti
Zinkwazi
Nonoti
Mdlotane
Seteni
Bob's Stream
Mhlali
Tongati
Mdloti
Mhlanga
Mgeni
Mlazi
Sipingo
Mbokodweni
Manzimtoti
Little Manzimtoti
Lovu
Msimbazi
Umgababa
Nkomazi
Mkomazi
Mahlongwane
Mahlongwa
Mngeni
Msunduze
Mkhomazi
Lufafa
Xobho
Nhlavini
WRC I
WRC II
WRC III

21 APPENDIX D: CATCHMENT VISIONING OUTCOMES

This Table below is the result of the outcomes of a PSC meeting held on 24 January 2013. The Table was populated during the meeting as well as after the meeting when PSC members used questionaires to obtain additional information from their constituents. A Spatial Development Framework Plan (SDF) was provided by eThekweni Municipality as support to this task.

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
Mr Rob Dyer: Planning Engineer - SAPPI SAICCOR					
U1-4 EZ: Lower uMkhomazi U6 -3: Mbokodweni CC: Coastal Cluster		Identification of estuaries that can receive more effluent from near development.	City growth.	▪ Degradation of estuaries. ▪ Permanent open systems.	Need over plan for south at the city – where can increased effluent be discharged?
Mr Claude Edwards: Exco Member: Env Affairs; Umgeni Residents and Ratepayers Association					
U2-1: uMngeni - Upstream from Midmar Dam U2-2: uMngeni - Midmar to Albert Falls Dam	Midmar Dam	Sewerage upstream Mpophomeni and Currys Post Landfill site.	Because of unabated water being polluted and a remaining life span of TWO Years and Six months.	Continual water pollution.	Lack of capacity.
Mr Spurgeon Flemington: Member: Umzimkulu Water Users' Association; Chairman: Underberg Himeville Trout Fishing Club					
T5-1: Upper Umzimkulu Mountain Zone	Eco-Tourism, Water Quality	▪ Better management and control of buffer zones alongside rivers. ▪ Water extraction. ▪ Application of fertilizers, pesticides and weedicides adjacent to watercourses.	Ensure sustainability of water quality and availability upon which Eco-tourism is dependent.	Long term survival and growth of Eco-Tourism industry.	▪ Resources. ▪ Administration. ▪ Capacity.
	Irrigation	Better communication with DWS with regard to water use rights. Collaboration monitoring of water resources between	Ensure sustainability of water resource while simultaneously maximizing	▪ Long term preservation of the water resource. ▪ Growth in agriculture and	▪ Policy. ▪ Administration. ▪ Capacity.

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
		DWA and water users.	its benefits to agriculture and food security.	food production together with employment in Agricultural Sector.	
	Storage	Move streamlined and efficient process with regard to the application to build dams and store water	Ensure water availability during drought and low flow periods.	▪ Greater water availability during dry periods. ▪ Ability to release water downstream into the catchment during dry periods. ▪ Securing food production.	▪ Policy. ▪ Administration. ▪ Capacity.
Mr Grant Fryer: Pollution Control Officer, Msunduzi Local Municipality					
U2-2: uMngeni –Midmar to Albert Falls Dam U2-4: uMnsunduze River (work area)	Health	There is insufficient policing and enforcement of polluters.	Water resources are suffering major impacts as a result of pollution.	▪ Major financial cost as well as health. ▪ The more polluted the more it will cost to produce for consumption. ▪ Water borne diseases will also increase.	Mainly Industrial Pollution as well as Illegal dumping of Domestic Builders waste. Alien vegetation also a problem.
Ms Asha Ramjatan: Scientist: Water and Environment, Umgeni Water					
U2-4: uMnsunduze River	No	Yes	The quality of the uMnsunduze river and many of its tributaries are unsatisfactory, highly polluted and cannot be used for recreational purposes. It poses a threat to human health.	Improved river health and fitness for use (various uses).	Pollution, alien weeds, elevated nutrient levels and potential of eutrophic conditions, not suitable for recreation.
Mr Percy Sithole: Water Resources Planner, Umgeni Water					
Umgeni Water works in all IUAs except T5-1, T5-3, UI-3, U6-3, CC, U4-1 and U4-2	Sedimentation in river dams	Landuse practices and management.	▪ More water resources are required more and more as water requirements increase. ▪ Sedimentation reduces storage capacity of	▪ More water security for the present and future. ▪ Less water quality impacts.	▪ Scarcity. ▪ Demand Supply balance (demand outweighs supply). ▪ Water quality. ▪ Assurance of Supply.

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
			dams.		
	Assurance of Water Supply	The assurance of supply gets worse every year as water demands increase but the infrastructure is not. Normally, schemes that have been identified do not get on the ground timeously and this increases pressure on the current supply. The biggest challenge is implementation and it needs to improve.	Umgeni Water believes that efficient implementation of water resource schemes will not compromise assurance levels of water supply to customers such as municipalities, etc.	The risk of not being able to supply water services is minimised if water resources infrastructure is constructed timeously.	▪ Ever increasing demands of water. ▪ Water losses both on the resource side and municipal side. ▪ Meter accuracy issues.
	Water Use Licencing	▪ The Water use licencing process need to be efficient. Umgeni Water gets frustrated with the process sometimes in cases where application forms have been lost or the same information that has been submitted is requested time and time again. ▪ The process it takes to be granted a licence has be fast tracked especially if its project of a strategic nature as mandated by the government of the country. ▪ The conflict between water use licence Local Department vs. National Department is unnecessary. It seems one department does not talk to the other, e.g. Lower Thukela Water Supply Project.	The water resources projects can happen within the set time frames so that the lives of the communities are improved as soon as possible.	Delivery of water services will improve and this is what Umgeni Water is striving for at all times.	The administration of the whole water use licencing process needs to be efficient.
	Reserve Determination Studies	▪ Previous and current process of reserve determination studies needs to be more efficient. It is either very slow or not happening at all especially for Umgeni Water strategic rivers such as Mgeni, Mdloti, etc. ▪ Umgeni Water believes this is one of the reasons why DWA started this project, and so we are hopeful of the	Umgeni Water needs to know the impact of the reserve in terms of quantity when they undertake water resource development studies.	This improves the allocation of water resources and helps Umgeni Water know how much water is available for human consumption.	Administrative issues, especially delays in undertaking reserve studies

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
		improvement.			
	Water Quality in Umgeni Water areas of operation	▪ Management of land use needs to be given priority. Poor land use management accelerates sedimentation and its impacts on rivers and dams. Department of Agriculture has to step in as this directly falls within their area of responsibility. ▪ Municipalities and industries must manage their sewerage effluent better than what is happening at the moment, if at all there is any sewerage management in some places.	Sedimentation impacts on dam capacities in terms reducing life span and water quality resulting to treatment challenges	Umgeni Water will continue to provide good water quality and the dams will have a longer life span.	▪ Roles and responsibilities for different institutions, especially land use management issues ▪ Proper land use management (manage overgrazing, working for water, etc.) ▪ Community empowerment related to education on water issues
	Funding of Infrastructure	Sustainable long term supply solutions should be funded and delays in securing funding should be minimised.	Timeous implementation of infrastructure assists with social upliftment of the poor including provision of water services.	Economic empowerment and job creation opportunities are some of the benefits brought by infrastructure projects.	▪ Capacity and empowerment bring a sense of ownership to communities. ▪ Funding models that are affordable to the end consumer need to be sought.
Mr Peter Woolf: Senior Manager: Planning KZN Human Settlement					
All IUAs	Bulk Supply - No	Availability of suitable and sufficient funding sources to ensure that bulk services are made available for sustainable human settlement development.	Rural communities are a fact and a part of creating sustainability. Certain areas are being identified for densification. Without bulk services this goal is unattainable.	Urbanisation will continue and the pressure on unsuitable land will create social problems. Service delivery protest will increase as well as the under utilisation of rural community facilities.	In many districts there is no bulk infrastructure to support development
Mr Mike Willment: Member, Underberg Famers Association					
T5-1: Upper Umzimkulu Mountain Zone	The current state of the water resource in	▪ More storage of water facilities should be considered to store water for time of shortage which, with climatic change, is becoming more frequent.	▪ The upper areas of the Umzimkulu and Umkomaas catchment area are high potential	▪ Good quality jobs would be created in the fields of Dairy, Potato and Beef farming as well as in the	▪ Legislation and bureaucratic processes hinder development. In many cases,

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
	terms of Agriculture is NOT acceptable.	▪ The dams to be built do not necessarily have to be large dams but smaller earth wall dams.	areas for agriculture and tourism and borders on the Ukhahlamba World Heritage Site.	tourism industry. These enterprises play a big role in the economy of South Africa, for example 20% of the milk produced in the country comes from the Southern Kwa-Zulu region. Employment would be created in the construction and maintenance of these dams. ▪ Quality water would be stored for irrigation and use by rural communities downstream. ▪ Agriculture on high potential land in the rural areas could be developed leading to food security, poverty alleviation and the improvement of the lives of rural dwellers.	partnerships with the private sector could overcome some of the financial limitations i.e. farmers could pay for the construction of dams. ▪ Proper structures should be put in place to streamline development and conserve our environmental status. ▪ Proper policing and management of legislation should be done.
Mr Borain Gordon: Process and Quality Manager, Umgeni Water					
U2-4: uMnsunduze River	Water Quality	Sewer leaks and industrial discharges to the uMnsunduze River.	These issues are seriously affecting the quality of the water for potable treatment and recreational use.	Reduction is cost of treatment. Greater safety for recreational use.	Umgeni Water database.
Mr Derek Airey: Environmentalist, SAPPI SAICCOR					
U1-4 EZ: Lower Mkomazi	Assurance of supply.				Assurance of supply.
Mr Luthando Maphasa: Director, KwaZulu-Natal Museum					
T5 – 1: Upper Umzimkulu Mountain	No	Availability of water resources during dry periods, more dams.	▪ To improve irrigation, farming and food production status.	▪ Economic empowerment of the poor and increased food production.	▪ Increasing demands dries out water during dry periods.

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
Zone			▪ The area is also mostly dairy production area and relies on adequate water. ▪ To prevent diseases resulting from lack of adequate clean water.	▪ More dams could result in more catchments for dry periods. ▪ Possibility of hydro-electric power production. ▪ Increased job creation opportunities.	▪ Capacity/empowerment needs from rural communities/farms. ▪ Technology (water savings, best practices etc).
Miss Nombulelo Zungu: Deputy Director, Department of Agriculture & Environmental Affairs					
U4-2: Middle Mvoti	Ecology	Controlled sand mining operations. Currently there are approximately 8 sand mining operations in this IUA mostly being illegal. Municipal sewage pump stations in the vicinity of the Mvoti River. Sappi Stanger and Gledhow Sugar Mill discharging on Mvoti River.	Fish die in the estuary due to pollution and sedimentation. Water quality in terms of turbidity is not ecologically acceptable.	The Mvoti River in this IUA has totally transformed when compared to aerial photos of 1930s and is degrading gradually. Vegetation consist of reeds which are as a result of sedimentation due to sand mining and movements, river channel has become narrow and is diverted.	COGTA has requested an intervention from DAEA as the iLembe District Municipality finds it difficult to supply water from Mvoti River due to accumulation of sand in the river.
Mr Roderick Bulman: Member, Coastwatch					
U2-4: uMnsunduze River	Quality	<u>Administration</u> ▪ More stringent application of discharge bylaws, including illegal connections to storm water drains, with more effective prosecutions of offenders. ▪ More policing of dumping in water courses, with effective prosecution of offenders. ▪ More effective sewage management. ▪ Better resourced, better qualified water management staff. ▪ More effective run-off management including from agriculture. ▪ More dedicated (environmental) courts with properly trained prosecutors. ▪ Improved municipal infrastructure and better management of it.	▪ To protect the resource and improve equity. ▪ To mitigate the private benefit of a public resource.	▪ Better equity in access to water. ▪ More responsible use of a scarce resource. ▪ Better conservation practices. ▪ Better and more responsive governance. ▪ Reduction in political interference.	▪ Industrial pollution. ▪ Sewage pollution. ▪ Irresponsible municipal management. ▪ Poor waste management.

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
		▪ Better integrated management and governance, especially with development approvals. ▪ Better coordination between departments of Water, Environmental Affairs and Mineral Resources at municipal, provincial and national level.			
Cllr Jean Lindsay: KZN Conservancies Association					
U2-6: Inanda to Estuary	I am unable to complete your questionnaire because my issues involve a number of water resource matters. We were disappointed that DWA/ACER used a number of ‘out of town’ consultants who were not familiar with local issues, local knowledge, and local reports, assessments and documents e.g. DUCT data, Umgeni Water data, SASS data and a number of Estuarine reports. I will list a number of water issues which greatly concern me as a resident living in eThekwini. ▪ Lack of participation from councillors ▪ A more concerted effort to reduce water losses in the city ▪ More education and awareness – most residents who receive free water have little value of the cost and seldom report the leaks. ▪ The deteriorating ecological status of our rivers and catchments. ▪ Water education in the schools. ▪ Town planning – consider water availability before committing to development. ▪ Town planning – enforcement of flood water attenuation systems especially new developments. ▪ More incentives for rain water harvesting especially new developments. ▪ More effort to reduce water pollution resulting from overflowing sewers. ▪ Waste Water treatment plants – more funds and budget to upgrade and maintain. ▪ More attention to the future impacts and effects of Climate Change. ▪ Sand mining – compliance and rehabilitation. ▪ Recycling of sewerage – pilot projects to be encouraged. ▪ Education and awareness of the value of ecosystem goods and services. ▪ Ecological reserve to maintain biodiversity of the river systems. We as residents are tired of talk and workshops, it is now time for education, implementation and enforcement.				
Prof DP Cyrus: Head: Department of Zoology and Coastal Research Unit, University of Zululand					
The major issue I have with this project is related to the title and what it is aimed to achieve: CLASSIFICATION OF WATER RESOURCES AND **DETERMINATION OF THE COMPREHENSIVE RESERVE** AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA The title is extremely misleading particularly that the product will be the **"....Determination of the Comprehensive Reserve .....".** The methodologies that are to be followed for this project will only be sufficient to produce Rapid Reserve Determinations for a **selected number** of the estuaries in the WMA They will not be able					

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
meet the requirements for an Intermediate Reserve, let alone a Comprehensive Reserve. The Title of the Project must be changed as it is very misleading. The above leads me on to my second point of concern with this project which is that there have already been several Rapid Reserves undertaken on estuaries in the WMA, with so little additional data being collected one has to wonder to what extent this project will be able to go beyond what is already available and that has already been produced in the form of Rapid and other assessments.					
Dr AWP Coleby: Farmer, Nottingham Road Landowners Association					
U2-2: uMngeni –Midmar to Albert Falls Dam	Water Quality	▪ Education of communities to get sense of ownership to prevent contamination due to rubbish and washing in river and streams, i.e. Upper reaches of Karkloof River. ▪ Ignorant development of housing on banks on Midmar Dam. ▪ Education of municipalities and town dwellers on waste of water, they are using my water.	▪ To decrease cost of water treatment. ▪ To protect ecological status of rivers.	▪ With human contamination and misuse eliminated. ▪ The ecological state and biodiversity will take care of itself. ▪ Quality of water for agricultural and human use will improve.	
I am a tree farmer with 70 Ha of well-run plantations producing timber for structural, paper and other uses, hopefully reducing the destruction of natural forests, PLUS 1500 Ha of pristine highland sourveld and indigenous forest that is managed to give maximum clean water downstream. Because I grow trees I am charged a “stream flow reduction” levy whereas I ought to be paid for my conservation efforts, producing good clean water for the ungrateful people in the cities downstream. As a citizen I have a problem with “developments” because there is a lack of adequate EIA oversight especially with their storm water and sewage disposal provision. This is the result of political mismanagement and greed of the developers, there is no insistence that sewage disposal takes cognizance of wet weather flows and distance of discharge of “treated water” into steams or rivers. This treated water should flow into a wetland before reaching the stream or river. We have a problem with a development that proposes to build “affordable houses” on the banks of Midmar Dam as a case in point where the above provisions are set to be ignored, which will result in massive extra costs to treat the off-take from Midmar for potable water. “Development” must be secondary to maintaining the ecology and biodiversity of our water sources. Farmers for most part are trying to reduce or eliminate any effects of agriculture on the water supply for users downstream including the fauna and flora of the riparian area. Politically run municipalities have neglected to maintain water reticulation system in favour of an unbridled increase in new users. This has resulted in a massive waste of treated water due to broken and aged pipes that should have been replaced 10 years ago. In addition there is an inability or unwillingness in the municipal organizations to act timeously to repair these leakages. Add to this, the waste of treated water for washing driveways as well as taps left running in “informal” settlements where the users do not pay for water. Congratulations to the organizers and presenters for an informative and well run workshop meeting and to the efficient caterers.					
Mr Bill Pfaff: eThekwini Metropolitan Municipality					
The purpose of the Visioning exercise was for each stakeholder to articulate their ‘vision’ for the part of the WMA in which they have an interest. The long term vision of the desired spatial form of the eThekwini Municipal area is presented in the Spatial Development Framework (SDF). This is copied below. *The SDF is an integral component of the Integrated Development Plan (IDP); it translates the IDP spatially and shows how the implementation of the IDP occurs in space. It also directs the overall spatial distribution of land uses within the Municipality in order to give effect to the vision, goals and objectives of the Municipality as*					

IUA	Is the current state of the water resource acceptable?	If not, what would you like to change?	Why do you need changes?	What are the possible consequences of the changes?	What are your water resource issues in this IUA?
identified within the Long Term Development Framework (LTDF), Imagine Durban and the Integrated Development Plan (IDP). *The SDF is also aligned with other municipal sector plans and strategies as a way of ensuring that the desired spatial form and outcomes of the Municipality in terms of its biodiversity, economic and social objectives are achieved.* *The SDF must also be read in conjunction with the (four) Spatial Development Plans (SDPs) which have been developed to bridge the gap between the strategic/conceptual SDF and the detailed land-use schemes included in the municipal hierarchy of plans, including the more detailed Local Area Plans (LAPs) and Functional Area Plans.* A GIS version of all these Plans can be provided which will enable an overlay to the project IUAs.					

22 APPENDIX E: REPORT COMMENTS

Page &/ or section	Report statement	Comments	Changes made?	Author comment
B Pfaff: Received 8 February 2016				
		Table 13.9 only refers to those estuaries that require improvements to achieve the REC and why and then the reason for the TEC. This implies that those estuaries which are omitted from table 13.9 (viz: Ngane, uMdloti and uThongathi) do NOT require improvements to achieve the REC ?? This is NOT correct and this section needs further clarification. There is commentary in your e mail with respect to the uThongathi, but no mention of the situation surrounding the Ngane and uMdloti.	Yes	Ngagane is omitted as the PES is the same as the REC (a C) and it therefore does not require improvement. Regarding the uMdloti and uThongathi. The confusion came in due to the two tables (in the Water Resource class Report and the Main Report) were different. The one in the WaRC report included all estuaries that require improvements to achieve the REC. The one in the Main report (Table 13.9) included only the estuaries requiring improvement to meet the TEC. That is why uMdloti and UThongathi were left out. I acknowledge the confusion and have made both sets of tables the same so that they include all estuaries that require improvements to achieve the REC and then the reasoning for the resulting TEC. I have also indicated this change in the comments register in the reports. Ngane is therefore not included, but uMdloti and uThongahi are.
Chapter 2; Table 2.1 – step 2.		The eThekwini submission as part of the catchment visioning step was the submission of the approved eThekwini 'spatial development framework plan'. Although this was used as a basis for part of the eThekwini study by R4A, it does not seem to have been considered under the DWS study. As examples: Lovu estuary – 3.2.11. The comment "...there are no planned developments". This ignores the SDF Refer item 9.11 below for similar comments in respect of the uThongathi and uMdloti catchments. As detailed under item 3.3 it seems doubtful whether the economic assessment considered the SDF development.	Yes	The visioning outcoms of the meeting has been included as an Appendix. Reference has been made to the SDF.
		Consideration of the SDF in deciding on IUAs and Hotspots is unclear.	No	The SDF was considered in the Water Resource Use Importance analysis, which formed part of the hotspot assessment.
Exec sum	"the estuaries where hotspots dominate are uMgeni and Umgagbaba due to its existing dam developments"	The existing dam on the Umgagbaba is not in use and no new dams	No	The impacts of the dam is irrespective of its use i.e. barrier effect, sedimentation regime.

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Exec sum		Estuaries where hotspots dominate are listed as: uMkhomazi, uMngeni, Umgababa, Mhlanga uMdloti, uThongathi, Sipingo, Durban Bay which are considered because of " current / future wastewater discharges issues". However, two estuaries - Little Amanzimtoti and Mbokodweni - which are also affected by "current / future wastewater discharges issues" are omitted.	No	Hotspots are the result of a combination of criteria. Little Manzimtoti and Mbokodweni are not hotspots due to the low score resulting from the poor ecological current state. I.e. not all estuaries with future developments will neccesarily "hotspots".
	Table 5.10: Summary of EcoClassification results.	A new acronym has been introduced without this being included in the list of definitions.	Yes	
Page 2-11		U6 should refer to Mlazi , not uMdloti	Yes	
3.2.12		IUA rationale. Shongweni dam is existing, not proposed as noted.	Yes	
3.2.14		Mbokodweni and Isipingo estuaries quoted as "average importance from a biodiversity perspective "need to add" low conservation importance " for completeness.	No	Low conservation importance is a specific scoring description. In this case reference is made to average importance from a biodiversity perspective, which does not relate to any formal evaluation.
3.2.16		IUA Midmar dam to Albert Falls. The Water Resources section which refers to 'reuse feasibility studies' is not relevant to this IUA as any re-use proposal is downstream of this IUA.	Yes	Corrected text.
Table 2.21		Umgeni estuary PES is E, not D/E as listed (refer to results of Rapid Reserve under EWS study).	No	You are correct that the previous studies indicated a D PES. However, the resolution of the Categories was improved during this study to accommodate the so-called half Categories. This means that the % associated with the PES has not changed but now falls within the half category range.
		How was the 'cost' of releasing an EWR from Inanda Dam determined and how was this figure factored in as an impact on the current socio-economics?		There should be no cost involved in releasing the EWR, as it is a legigal implication which is apparently not being implemented.
3.2.21		If the IUA is defined by Hazelmere Dam being at the lower end of the IUA then water quality issue as per the table will NOT include industrial discharges etc. as any industry is downstream of the dam	Yes	Corrected text.
3.2.22 and 3.2.23		The King Shaka airport, Dube Trade and associated developments all need to be recorded under "economy" for both this IUA and the similar IUA on the uThongathi river. This, and similar non disclosures for other IUAs, is a clear example of the SDF visioning document	No	The IUA description was not completed in finer detail and serves as a broad description of the IUA.

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		NOT being adopted by the study. (refer 9.2 above).		
3.2.22		Ecology - Artificial mouth breaching is NOT practised in either Ohlanga or uMdloti systems (but may happen due to tampering by individuals).	Yes	Revised text.
3.2.23		There is no mention of a water treatment plant which abstracts water from the uThongathi. There are also several water use licenses for irrigation. The Ilembe Frazer WWTWks also discharges to the estuary. The estuary is a D PES, NOT E as noted. There is no formal artificial opening. An illegal causeway strongly influences the state of the estuary and needs to be added.	Yes	The descriptions of the IUAs are based on the Status Quo report – 2013. The ECs provided were prior to revision. The results for use in the Water Resource Class used a D PES. All these aspects were integrated in the Operational scenario Report.
3.2.28		IUA CC: Coastal Cluster. This records 6 estuaries in the central coastal cluster (Msimbazi, Mgagbaba and Ngane, aManzintoti, Durban Bay and Little a Mananzimtoti whereas item 10.7 “Estuaries Central Cluster IUA” lists 5 estuaries. There are a total of 16 estuaries within eThekwini and these two items, and other items throughout this Report and other various technical reports, need to be corrected.	Yes	Text amended.
		The IUA rationale for what is stated as a “logical grouping” appears to make little sense as the impacts on the estuaries cannot be claimed as being “very similar” (Durban Bay vs Ngane!!).	Yes	These cluster IUAs were regrouped according to municipal boundaries. The overriding criteria were therefore that the estuaries can be managed as an entity. It is acknowledged that the ecological Status of these estuaries are very different within these IUAs.
6.1.2		This item attributes the decline in ecological health of the estuary to the high nutrient load from the WWTWs. This is unlikely as the volume is less than 1 Ml /day discharging at the mouth.	Yes	
		uMkhomazi estuary. An updated and revised reserve and scenario assessment for the uMkhomazi estuary was conducted under the eThekwini study. The results of this study should replace those in item 9.2.	No	The EWR (Reserve) was not updated during the eThekwini study. Additional scenarios were evaluated as part of this study and these are reported in section 9.4 of this report.
9.4.2		An updated and revised series of scenarios were conducted for a number of the estuaries affected by existing or future flows of wastewater. The scenarios referred to in the text of the Main Report need to be explained and the full results of these additional studies needs to be included in the Main	No	This is a stand alone report that explains the scenarios and their associated consequences. The main report only report only provides a summary and cannot repeat all results. Waste Water scenarios are summarised in Section 7.5.7.

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		Report.		
		Mbokodweni: Sc 3 was for 85 Ml/day, not 30 Ml/day.		
Table 10.4		This appears to introduce scenarios labelled A; C; D … etc without any accompanying description.	Yes	
Chapter 11 Introduction		Reference is made to a Report Volume 4, Economic Consequences October 2014. However the Report Volume 4 which was issued for comment by Stakeholders by October 2015 was “estuary resource quality objectives’.	Yes	Both reports are correct. Economic consequences refer to Volume 4 of Operational Scenario and Management Class report volumes. There are seven report volumes pertaining to operational scenarios. Estuary Resource Quality Objectives is report volume 4 of a total of 4 report volumes pertaining to RQOs determined during the study.