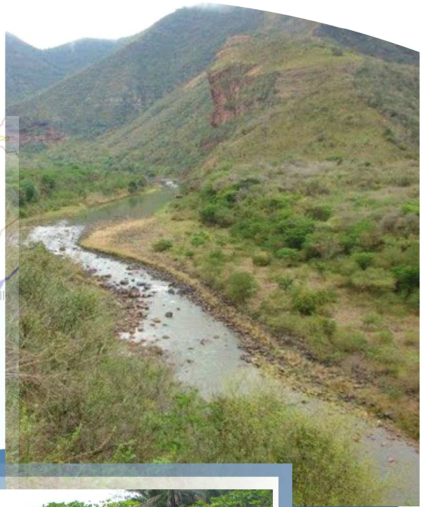
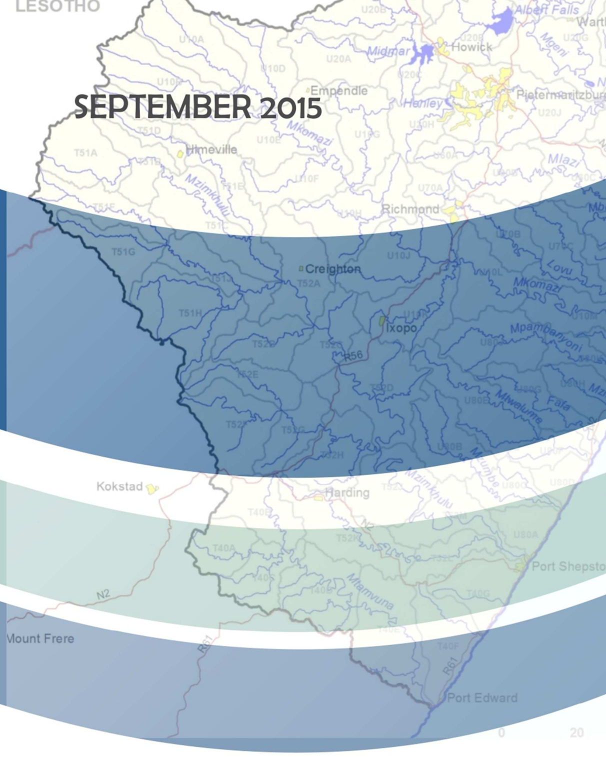
REPORT NUMBER: RDM/WMA11/00/CON/CLA/0215

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

PROJECT NUMBER: WP 10679



VOLUME 7B:
RECOMMENDED WATER RESOURCE CLASSES FOR THE T4, T5, U2, U3, U5, U6, U7 AND U8 SECONDARY CATCHMENTS



SEPTEMBER 2015

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

RfA17_2015

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

Report Number: RDM/WMA11/00/CON/CLA/0215

JANUARY 2015

REFERENCE

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa, September 2015. 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. DWS Report: RDM/WMA11/00/CON/CLA/0215.

DOCUMENT INDEX

Index Number	DWA 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	DWA 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	DWA 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

VOLUME 7B: RECOMMENDED WATER RESOURCE CLASSES FOR THE T4, T5, U2, U3, U5, U6, U7 AND U8 SECONDARY CATCHMENTS

Approved for RFA by:

…………………………………… ……………………………………
Delana Louw Date
Project Manager

DEPARTMENT OF WATER AND SANITATION (DWS)
Approved for DWS by:

…………………………………… ……………………………………
Chief Director: Water Ecosystems Date

AUTHORS

The report was authored by:

Author	Company
Huggins, Greg	Nomad Consulting
Louw, Delana	Rivers for Africa
Mullins, William	Mosaka Economists
Van Niekerk, Lara	CSIR
Van Rooyen, Pieter	WRP

Report editor and compiler: Delana Louw and Shael Koekemoer
Internal review: Delana Louw

ACKNOWLEDGEMENTS

Contributions in analysis were supplied by:
Deacon, Andrew (Private Consultant)
Koekemoer, Shael (Koekemoer Aquatic Services)
Kotze, Pieter (Clean Stream Biological Services)
Mackenzie, James (Mackenzie Ecological and Development Services)
Rountree, Mark (Fluvius Environmental Consultants)
Scherman, Patsy (Scherman Colloty and Associates)

Development of a Multi Criteria Decision Analysis tool to determine the Water Resource Class (2013) (not part of this study):
Overall:
Pieter van Rooyen (WRP)
Ecological sub - model:
Deacon, Andrew (Private Consultant)
Kotze, Pieter (Clean Stream Biological Services)
Louw, Delana (Rivers for Africa)
Mackenzie, James (Mackenzie Ecological and Development Services)
Economic Impact sub - model:
William Mullins (Conningarth Economists)
Ecosystem Services:
Huggins, Greg (Nomad Consulting)

eThekwini Metropolitan Municipality: Results of a parallel study (eThekwini Metropolitan Municipality, 2015).

REPORT SCHEDULE

Version	Date
First draft	September 2015
Second draft	December 2015
Final draft	February 2016

EXECUTIVE SUMMARY

INTRODUCTION

This report is associated with step 4 and 5 of the Water Resource Classification System. In summary, this report forms ***part*** of Step 4 within the integrated approach adopted for this study, i.e. the identification and evaluation of scenarios within the Integrated Water Resource Management Process. The purpose of this report is to recommended operational scenarios and draft Water Resource Classes for stakeholder evaluation. The focus is on the study area excluding U1 (uMkhomazi) and U4 (Mvoti) which have been addressed in a previous report.

INTEGRATED CONSEQUENCES EVALUATION APPROACH

Considering that the core purpose of the Classification process is to select the Water Resource Class (DWAF, 2007) for a water resource, the scenario evaluation process provides the information needed to assist in arriving at a recommendation that will be consideration by the Minister of the Department of Water and Sanitation or delegated authority to make the final decision.

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water to sustain socio-economic activities. Once the preferred scenario has been selected the Water Resource Class is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenario evaluation process therefore estimates the consequences of a set of plausible scenarios will have on these elements by quantifying selected metrics to compare the scenarios on relative bases with one another. The scenarios were ranked, first, for the individual variables and secondly an overall integrated ranking was derived based on multi-criteria analysis methods.

The results of the initial set of scenarios were interpreted to identify alternative release rules to improve the integrated scores with the objective to find and recommend an optimised scenario.

SCENARIO DESCRIPTION

During the PSC meeting of 18 June 2014 a range of scenarios were presented for various systems. Consequences on the uMngeni and Lovu Rivers have not been reported on. The uMngeni River scenarios include variables that consisted of ultimate 2040 developments, the river EWRs, the uMkhomazi Water project, Darvill Re-use and eThekwini Direct Re-use. The Lovu scenarios consisted of the ultimate development demands and return flows, the river EWR and reduced abstraction from the dam and decreased forestry.

A key factor that was identified to influence the ecological health of several estuaries in the study area was ‘treated waste water discharges’ servicing the various urban areas located along the coast. At the PSC meeting held on 24 March 2015 the extent of the current and potential future waste water discharges were presented along with the possible alternative waste water options to manage current and future waste water due to urban expansions. The initial set of scenarios was formulated along selected themes as indicated in the table below.

Primary themes defining waste water 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)

Twenty five (25) of the sixty four (64) estuaries are affected by the waste water discharge scenarios. The following alternative waste water management measures were considered, resulting in a range of volumes discharged into the estuaries and therefore a range of scenario subsets to the above list of scenarios. For each scenario in the above table, a subset of scenarios considering the following management measures were created:

- 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 waste water through sea outfall works - discharges to estuaries are reduced or eliminated.
- Re-use of treated waste water, both direct and indirect.

All the scenarios were formulated to handle the ultimate future waste water volumes for each of the urban areas. The relevant study areas are contained in three Integrated Units of Analysis (IUAs) called the Southern Cluster (SC) IUA, the Central Cluster (CC) IUA and the Northern Cluster (NC) IUA. All 64 estuaries are grouped according to the three municipal boundaries of Ugu, eThekwini and iLembe into these three IUAs. The cost of the alternative management measures were determined and applied in the macro-economic assessment to estimate the socio-economic implication of each scenario.

ECONOMIC CONSEQUENCES

uMngeni and Lovu economic consequences for rivers: The various operational scenarios in the uMngeni all present positive answers and should all make a positive contribution to the economic growth and employment creation in the four catchments. The Lovu scenarios were negative as forestry and irrigation were decreased from present.

Economic consequences of the waste water management scenarios for estuaries in the Southern, Central and Northern Cluster IUAs: The different identified scenarios investigated provide different impacts allocated to the different economic sectors. The overall evaluation is that some of the scenarios will, from an economic point of view, be very beneficial to the estuaries while others will be less beneficial. The final integration with the environmental and ecosystem services sectors must still take place, but it should be possible to select a scenario which will be good to the environment without causing too much of a negative economic impact.

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:

Evaluation of the Southern, Central and Northern Clusters as one area: The scenario which yields the highest Net Present Value (NPV) of Gross Domestic Product (GDP) is Scenario Biii (minimum cost scenario with highest flow through estuaries and applying standard (prevailing) nutrient removal waste water treatment processes). The scenario which yields the lowest NPV of GDP is Scenario F (see table above). Most of these differences in the NPVs are a result of changes to the construction and operational costs of the waste water options.

Southern 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 NPV of GDP 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 NPV of GDP. The biggest impact is as 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 NPV of GDP is Scenario D and Scenario Di (an alternative to Scenario D - reduction in treatment costs by applying standard nutrient removal waste water treatment processes), this is again because of the low capital and operational costs.

ECOLOGICAL CONSEQUENCES

The ecological consequences of the Scenarios are evaluated at the key biophysical nodes (EWR sites) by determining the impact on the Ecological Category (EC). The process to determine the ecological consequences consists of analysing the flow and quality regime of scenarios and determining how the biophysical components (drivers/abiotic: geomorphology physico-chemical variables, hydrology, mouth condition etc.; responses/biotic: fish, riparian vegetation, macro-invertebrates, microalgae, macrophytes) will respond to these changes. A range of models are then applied and the predicted EC for each component determined. An EcoStatus for rivers and estuarine health Score (overall EC or EcoStatus) can also then be determined.

RIVERS

Scenarios were evaluated on the uMkhomazi, Mvoti, uMngeni and Lovu Rivers. The uMkhomazi and Mvoti Rivers were reported on before. The consequences on the uMngeni and Lovu Rivers are summarised below.

All the scenarios meet the Recommended Ecological Category (REC) while two scenarios improve the REC in the Lovu River. Although improvement is not required, it would decrease the risk that the REC will not be maintained and may be an advantage for the estuary.

In the uMngeni River, the objectives are set to maintain the Present Ecological State (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 affect the last two issues. These components (flow and quality) are improved by all the scenarios apart from scenario MG2 (which did not include updated water demands). This scenario (MG2) was marginal in terms of improved flow and water quality and therefore insufficient to improve the fish component. All the other scenarios are acceptable / desirable from an ecological viewpoint.

ESTUARIES

A range of scenarios consisting of various waste water management and dam development options (uMkhomazi and Mvoti) were evaluated as part of this study. The dam scenarios for the uMkhomazi and Mvoti were reported on at a previous meeting and the focus here is on the waste water management scenarios (which also include the dam options where necessary). 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 IUA

Ten estuaries are of conservation importance: Mtamvuna, Mpenjati, Zotsha, Umzimkulu, Domba, Koshwana, Intshambili, Mhlabatashane, Mfazazana and the Kwa-Makozi. The scenarios resulted in the following changes:

- Sezela: Most of the scenarios maintain the current condition, but the removal of the waste water will improve the system’s condition. Under the worst case scenarios (e.g Scenario B) the estuary declines in condition.
- Koshwana: Most scenarios maintain the current condition. While Scenario A1 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 Scenario A1 (reduction in waste water) the systems shows a significant improvement in condition, while under the worst case scenarios (e.g. Scenario B) it shows a further decline.
- Boboyi, Mhlangeni, and Vungu: Most of the scenarios maintain their current health conditions, with a decline under the worst case waste water scenario (e.g. Scenario B).
- Kongweni: Most of the scenarios show a further significant decline in health (PES = D/E). A reduction in the waste water does not achieve the REC of a D, without further interventions.
- Mvutshini: 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 waste water scenarios. About half of the scenarios indicate a (significant) decline in condition, while others maintain or improve the present state.

Central Cluster IUA

Nine systems are of conservation importance: aMahlongwa, Mahlongwane, uMkhomazi, Umgababa, Msimbazi, Lovu, Durban Bay, uMngeni, and Mhlanga. 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, uMngeni. The small systems was also relative insensitive to level of waste water 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 waste water 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 waste water removed, as the catchment water quality is very poor. Less waste water 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 potential 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 waste water is removed.
- Little aManzintoti: Most of the scenarios show a severe decline in health. The system improves significantly in condition if waste water is reduced/removed.
- uMkhomazi: All “flow” scenarios maintain the current state as the system requires other interventions to attain the REC. Most of the waste water 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

Four systems are of conservation importance (Mhlali, Mvoti, Mdlotane, Zinkwasi).

- Nonoti: Most waste water scenarios maintain the current condition. Scenario A1 showed an improvement in condition and the worst case scenario (e.g. Scenario B) shows a decline in health.
- Mvoti: Under most flow scenarios the system maintains its current health state. The system requires other intervention to attain the REC. Additional waste water will reduce the current condition, but likely to maintain the class.
- Mhlali: 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 waste water is removed.

ECOSYSTEM SERVICES CONSEQUENCES

Natural habitats and ecosystems provide a range of environmental goods and services that contribute, and are even essential, to human well-being. River systems and their associated use values are of particular importance. For operational purposes this study follows the approach defined in the 2005 Millennium Ecosystem Assessment and classifies ecosystem services along functional lines using categories of provisioning, regulating, cultural, and supporting services.

There are no negative consequences on Ecosystem Services on the Lovu and uMngeni Rivers with respect to the identified scenarios. The consequences on the three estuary IUAs are summarised below.

Southern Cluster IUA

In terms of the scenarios evaluated for the relevant estuaries in the South Coast IUA the following summarises the major findings.

- All scenarios for the Mbango Estuary are generally neutral.
- Boboyi and Mhlangeni estuaries: The scenarios involving loss of fish stocks (increased waste water 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 waste water discharge are positive. Scenarios with greatly increased waste water 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.
- Mvutshini Estuary: The scenarios that increase waste waterdischarge 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 waste waterdischarge 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 waste water 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 waste water 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 waste water discharge. Scenarios with elevated waste water discharges are negative for the reverse reasons.

Central Cluster IUA

In terms of the scenarios evaluated for the relevant estuaries in the Central IUA the following summarises the major findings.

- uThongathi and Mbokodweni Estuary scenarios that remove the waste water 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 waste water 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 waste water development is less significant but still negative.
- Little aManzimtoti 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 waste water to ultimate capacity are negative for reverse impact reasons.
- uMkhomazi Estuary: Scenarios with waste water 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

In terms of the scenarios evaluated for the relevant estuaries in the North Coast IUA the following summarises the major findings.

- Nonoti Estuary: Only scenarios with minimum discharge to estuaries show an improvement due to increased availability of fish. Discharge scenarios show a decline in fish. All other scenarios maintain status quo.
- Mhlali Estuary: A group of scenarios that either maintain current state or have increased waste water 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.

DRAFT WATER RESOURCE CLASSES

A range of alternative Water Resource Criteria settings were evaluated by the study team leading to the recommended criteria parameters presented below.

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 resulting Water Resource Classes (WRCs) for the recommended scenario/s (red text below) are provided in the following tables:

IUAs and their associated WRCs

IUA	PES	REC	WRC (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
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
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			

IUA	PES	REC	WRC (TEC)
U8-1	I	I	I
U8-2	II	I	II

The table shows the Present Ecological State (PES) and Recommended Ecological Category (REC) Scenario for the IUAs (excluding the estuary IUAs) where Scenarios other than the PES and REC were either not evaluated or had no impact on the ecological status. Of the 19 IUAs, there were 21% Class I; 37% in Class II and 42% in Class III. There are two IUAs in the uMngeni and the uMlazi where the WRC requires non-flow related improvements to achieve the Class. Note that there are many nodes in the catchment configuration that require improvements, but this did not impact on the WRC. The recommendations for the WRC are therefore set as a combination of the PES and REC. There are no implications for any users or the ecology.

The implications of the WRC and catchment configuration for the estuary IUAs are summarised below:

Southern Cluster 1 IUA

- The TEC = REC at 18 of the 20 estuaries.
- The TEC is an improvement of the PES at three estuaries (i.e. Mtamvua, Mpenjati and Zotsha estuaries).
- Non-flow related measures must be applied to achieve the TEC at three estuaries.
- Zolwane, Tongazi: Scenarios that allow some increase in waste (e.g. Sc C and D) will meet the TEC.
- Mvutshini: Limited additional waste (as per Sc C) will meet the TEC.
- Vungu: Any planned increased waste water must be diverted.
- Kongweni and Mbango: The socio-economic cost will be significant to improve the estuaries (more than half the current waste must be removed) and the estuaries are of low ecological importance. The ecological cost of improvement can also be significant as it may imply that other more important estuaries will not achieve the REC or will degrade from its current state. Further waste can be accommodated in the Kongweni and Mbango estuaries, but estuaries must still comply with all required health standards. This means that criteria other than ecological become the driving criteria to be considered on the volume and quality of waste that can be accommodated.
- WRC is a Class I (based on the estuarine area that is in a B or higher).

Southern Cluster 2 IUA

- The TEC = REC at 16 estuaries of the 21 estuaries.
- The TEC is an improvement of the PES at two estuaries i.e. the REC is partially met (i.e. Koshwana and Mhlatatshane).
- The TEC = PES at three estuaries (Domba, Intshambili and Mfazazane).
- Non-flow related measures must be applied to achieve the TEC at five estuaries.
- Sezela: Limited additional water (as per Sc C) will meet the TEC.
- WRC is a Class II (based on the estuarine area that is in a C or higher).

Central Cluster IUA

- The TEC = REC at six of the 16 estuaries.
- The TEC is an improvement of the PES at four estuaries i.e. the REC is partially met (i.e. Lovu, Umgababa, uMkhomazi and Sipingo).

- This means that the TEC is an improvement of the PES for 10 estuaries (i.e. aMahlongwa, Mahlangwana, uMkhomazi, Umgababa, Lovu, Manzimtoti, Sipingo, Durban Bay Shallow water and intertidal zone, Mgeni and Mhlanga).
- The TEC is the same as the PES but does not meet the REC at four estuaries (i.e. Umgababa, Msimbazi, uMdloti and uThongathi).
- The TEC falls within the EF EC at four estuaries (all three estuaries have a PES of an EF).
- Non-flow related measures must be applied to achieve the TEC at the Umhlanga, uMngeni, Manzimtoti, Mahlongwana and Mhlungwa estuaries.
- The EWR must be implemented at uMngeni and the pumping scheme must be operated to achieve the existing EWR for Umhlanga.
- uMkhomazi: No further waste must enter the estuary. The proposed Smithfield Dam with appropriate operating rules will comply with the TEC.
- Little aManzimtoti and Mbokodweni: The cost to improve these estuaries to a D is significant and the estuaries are of lower importance than others. Further waste can be accommodated, but estuaries must still comply with all required health standards. This means that criteria other than ecology become the driving criteria.
- uMdloti: Increased waste water can be discharged in the estuary towards the point where it starts degrading. In the short term, the TEC is likely to drop while Hazelmere Dam is being raised and fully utilised and the long term TEC achieved (e.g. Sc Gi).
- uThongathi: Re-use all waste water (via Hazelmere Dam). In the long term, the TEC will therefore be met. In the short term, further discharge must be allowed in the estuary while alternative options for waste are being developed. This means that it the short term, the estuary will stay in the EF category, but will then improve in the long term to the TEC (e.g. Sc Gi).

In Summary:

- The WRC associated with the REC is also the recommended WRC of a III.
- The WRC under current conditions do not comply with a WRC III due to the large estuarine areas in a Category below a D.
- The WRC of a III can be achieved through the recommendations summarised in previous sections and it is especially important that a large estuary such as the uMngeni achieves the TEC. If not, the WRC will not be met.

Northern Cluster IUA

- The TEC = REC at four of the seven estuaries (i.e. Bobstream, Seteni, Mdlotane and Nonoti).
- The TEC is an improvement of the PES at three of the seven estuaries (one to a B TEC), i.e. the REC is partially met (Mhlali, Mvoti and Zinkwazi).
- The TEC falls below the PES at one estuary.
- Non-flow related measures must be applied to achieve the TEC at the Mvoti, Zinkwazi and Mdlotane estuaries.
- The WRC and TEC allow for increased waste water discharges in the short term to a specific point (e.g. Sc C and D) in the Nonoti and Mvoti. Then alternative measures for additional waste will be required.
- A combination of interventions on the Mvoti estuary must be investigated that will ensure the TEC is achieved when waste water is increased prior to future dam development.

In Summary:

The WRC associated with the REC would be a Class II. This could only be met by:

- Removing new infrastructure at Mhlali.
- Applying all interventions at the Mvoti and removing SAPPI effluent or applying very costly techniques to remove the high organic content.

The above two estuaries are the largest and carry a high weight. As such, to comply with a Class II requirement, they would have to improve from a C/D and/or D to at least a C EC. This would be the least desirable option from a socio-economic viewpoint.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CC	Central Cluster IUA
CD: WE	Chief Directorate: Water Ecosystems
CMA	Catchment Management Agency
DM	District Municipality
DWA	Department of Water Affairs (Change after 2008)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water Affairs and Sanitation (Change after May 2014)
EC	Ecological Category
EHI	Estuarine Health Index
EIS	Ecological Importance and Sensitivity
ER	Economic Region
EWR	Ecological Water Requirement
GDP	Gross Domestic Product
IUA	Integrated Unit of Analysis
KZN	KwaZulu-Natal
MCA	Multi Criteria Analysis
MM	Metropolitan Municipality
MMTS2	Mooi-uMngeni Transfer Scheme Phase 2
MWP	uMkhomazi Water Project
NC	Northern Cluster IUA
NPV	Net Percent Value
PD	Present Day
PES	Present Ecological State
REC	Recommended Ecological State
RQO	Resource Quality Objective
Sc	Scenario
SC	Southern Cluster IUA
SQ	Sub-quaternary (may also be termed a quinary)
TEC	Target Ecological Category
uMWP1	uMkhomazi Water Project, Phase 1
WRC	Water Resource Class
WMA	Water Management Area
WRCS	Water Resources Classification System
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management area (WMA), which is one of three WMAs that form part of the Pongola to Umzimkulu Proto Catchment Management Agency (CMA), are able to sustain their level of uses and be maintained at their desired states. The determination of the Water Resource Classes (WRC) 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, 2011). 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, 2011).

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, 2011).

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, uMdloti, 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, 2011). 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, 2004).

1.3 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the National Water Classification System, the Reserve and RQOs are supplied in

Table 1.1.

Table 1.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s) (completed).
2	Initiation of stakeholder process and catchment visioning (on-going).
3	Quantify the Ecological Water Requirements 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.

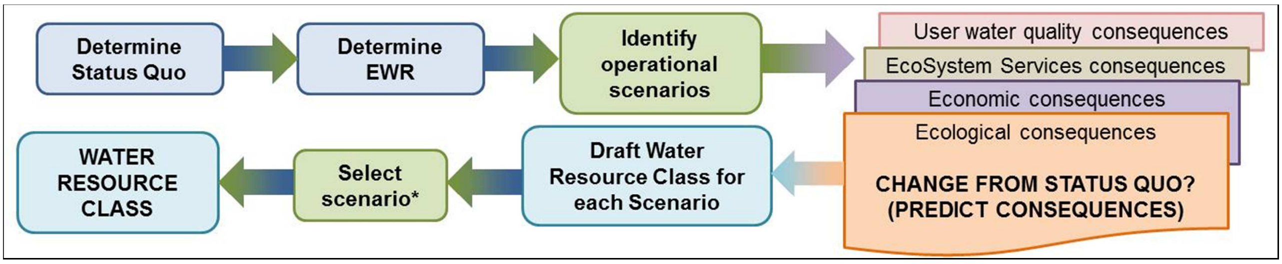
This task forms ***part*** of Step 4, i.e. the identification and evaluation of scenarios within the Integrated Water Resource Management Process. This step is closely linked to the next step where the scenarios are tested with stakeholders and the draft WRCs are determined. Using the results of the status quo assessment (DWA, 2013) (Step 1), the subsequent steps were initiated and the results of Step 4 for the study area excluding the uMkhomazi and the Mvoti systems are documented in this report. The WRCs of the uMkhomazi and the Mvoti systems are documented in DWS (2014a).

1.4 TASK D4: IDENTIFICATION AND EVALUATION OF OPERATIONAL SCENARIOS TO IDENTIFY CONSEQUENCES

This task is associated with step 4 and 5 of the Water Resource Classification System (WRCS). In practice, these two steps function as one and are integrated as Task 4 (or step 4 within the integrated approach) (DWA, 2012). The objective of this task was to describe and document the following:

- Identification of operating scenarios in accordance with the Reconciliation Strategy Study (DWAF, 2008).
- River ecological consequences of the scenarios (Sc) at the key biophysical nodes (Ecological Water Requirements (EWR) sites) and the estuary by evaluating and determining the impact on the Ecological Category (EC).
- Economic consequences of operational scenarios by determining the impact of any water allocation changes.
- Assessment of the impacts of the various scenarios on Ecosystem Services of operational scenarios to identify the direction of change (either positive or negative) and estimate the magnitude of the change in benefits and costs that may be experienced within the river system.
- Integrate the consequences to provide preliminary WRC for stakeholder evaluation.

The process described above is illustrated in Figure 1.1 and Figure 1.2. Figure 1.1 illustrates the broad conceptual process from the determination of the Status Quo (Integrated Step 1) through to the determination of WRCs. Within these steps there are further sub-steps that pertain to integrated step 4 which are described in Figure 1.2.



* Note that the selected scenario can include the scenario that maintains the status quo (Present Ecological State (PES) scenario), or improves the state (Recommended Ecological Category (REC) scenario) or a combination there-of.

Figure 1.1 The process in Step 4 and 5: Identification of scenarios to the gazetted WRC

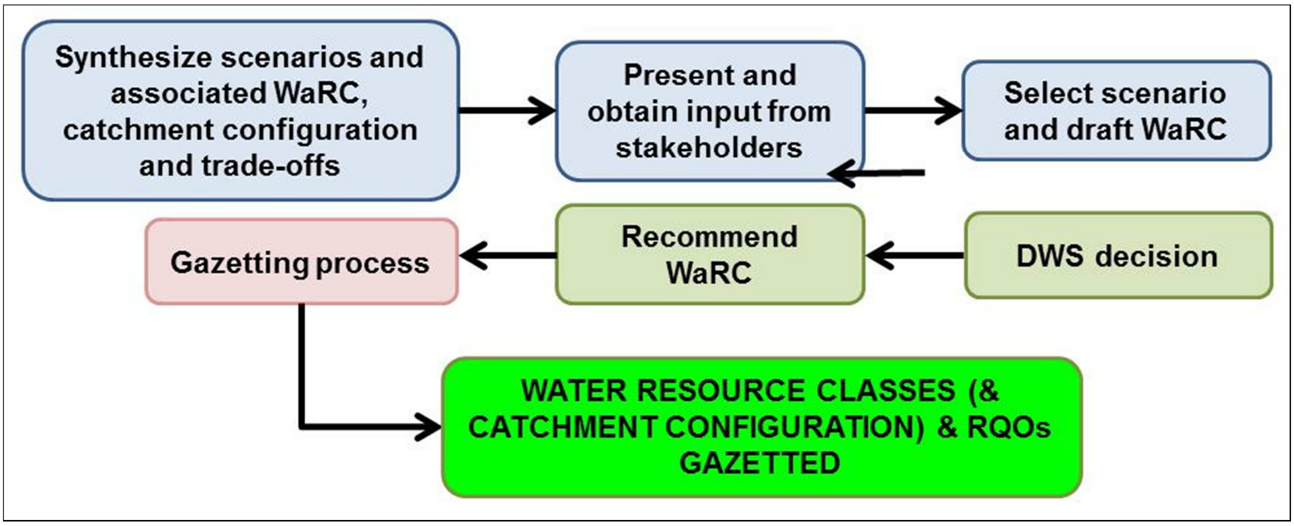


Figure 1.2 Step 5: Illustrates the steps from the testing of scenarios with stakeholders to a final gazetted WRC and catchment configuration

1.5 NAMING OF RIVERS AND ESTUARIES

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

1.6 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to recommended operational scenarios and preliminary WRCs for stakeholder evaluation for the relevant secondary catchments. The preliminary WRCs of the uMkhomazi (U1) and the Mvoti (U4) River systems have been addressed in DWS (2014a).

The report outline is provided below.

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

Chapter 2: Integrated Consequences Evaluation Approach
This chapter provides an overview of the scenario evaluation process. Ecology, Ecosystem Services and the Economic benefits are compared when determining the degree of achieving the appropriate balance between ecological objectives the socio-economic benefits and this chapter provides an expanded description of how the metric for each of the three components were derived.

Chapter 3: Scenario Description

The scenarios considered for evaluation are discussed.

Chapter 4: Economic Consequences

The impact results of different scenarios on the economic sectors are presented in this Chapter.

Chapter 5: Ecological Consequences (Rivers)

The results of the ecological consequences of the various scenarios are presented in this Chapter.

Chapter 6: Ecological Consequences (Estuaries)

The results of the ecological consequences of the various scenarios are presented in this Chapter.

Chapter 7: Ecosystem Services Consequences

The results of impact of the different scenarios on Ecosystem Services are presented in this Chapter.

Chapter 8: Integrated Multi-Criteria Results

The results of the rating, weighting and scoring for the three variables, Economy, Ecology and Ecosystem Services presented in Chapters 4 – 7 were integrated to obtain the overall ranking of the scenarios and described in this chapter.

Chapter 9: Water Resource Classes and Catchment Configuration

The recommended WRCs among the scenarios are presented. Conclusions and recommendations are provided.

Chapter 10: References

Chapter 11: Appendix A: Operational Scenario Description

This appendix provides the definitions of all scenarios with the identification labels referenced in the main sections of this report and serves as a lookup reference.

Chapter 12: Appendix B: Estuary Synonym List for KwaZulu-Natal Estuaries

The Ezimvelo KZN Wildlife list of names or synonyms for KZN estuaries is included.

Chapter 13: Appendix C: IUA Maps

The recommended WRC for the IUAs are mapped.

Chapter 14: Appendix D: Report Comments

Comments from reviewers are listed.

2 INTEGRATED CONSEQUENCES EVALUATION APPROACH

2.1 OVERVIEW OF THE SCENARIOS EVALUATION PROCESS

Considering that the core purpose of the Classification process is to determine the WRC (DWAF, 2007) for a water resource, the scenario evaluation process provides the information needed to assist in arriving at a recommendation that will be considered by the Minister of the DWS or delegated authority to make the final decision.

The overarching aim of the scenario evaluation process is to find the appropriate balance between the level of environmental protection and the use of the water to sustain socio-economic activities. Once the preferred scenario has been selected the WRC is defined by the level of environmental protection embedded in that scenario.

There are three main elements (variables) to consider in this balance, namely the Ecology, Ecosystem Services and the Economic benefits obtained from the use of a portion of the water resource. The scenarios evaluation process therefore estimates the consequences that a plausible set of scenarios will have on these variables. The evaluation process uses the quantification of selected metrics to compare the scenarios on relative basis with one another.

During the evaluation process stakeholders are engaged at various stages, initially by providing their respective visions for the catchments (Integrated Units of Analysis - IUA), then defining and selecting the scenarios for evaluation and finally to assess the consequences with the aim to make a recommendation of which WRC should be implemented.

The scenario evaluation process entails a sequence of activities followed during the study and are illustrated schematically in Figure 2.1.

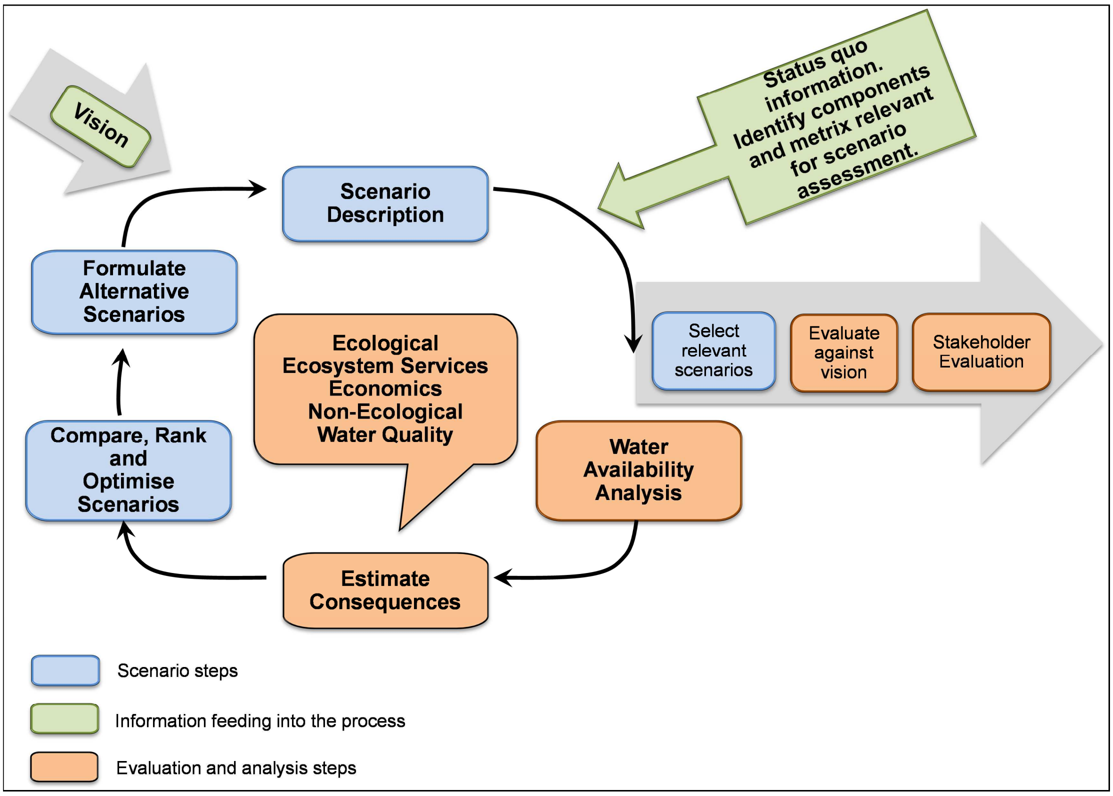


Figure 2.1 Schematic representation of the scenario evaluation process

Each activity presented in Figure 2.1 is briefly described in the following sections.

2.1.1 Vision

The visioning activity was carried out through interactive engagements with stakeholders where their respective views as to what the desired future state of the water resources should be were obtained. These visions were documented in the form of narrative descriptions and captured for the twelve delineated IUAs and summarised in Appendix D.

2.1.2 Scenario description

The definition and evaluation of scenarios were undertaken in context of the prevailing and proposed water resource management activities in the study area. A scenario, 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. While a workshop was held with stakeholders to identify scenarios, the development options were already well established as part of several previous studies (such as DWAF, 2008). This preliminary list was presented to stakeholders for their consideration after which a final list was compiled for evaluation (see Chapter 3 for a description of the scenarios that were evaluated). Although the focus, when scenario are defined, is primarily on identifying alternative operational aspect relating to the water resources, the results of the assessment of present day conditions (usually simulated with a water resource model) and the associated Present Ecological State (PES) for the biophysical nodes and EWR sites is in essence also a scenario that can be compared with the other alternatives. Similarly, a scenario where the Recommended Ecological Category (REC) is implemented as the driver for the water requirements in a river, is also another scenario.

2.1.3 Assign attributes to EWR nodes (includes estuaries)

Applying the Status Quo information (DWA, 2013) all the relevant properties (attributes) were defined for the biophysical nodes with respect to the Ecology, Ecosystem Services as well as the economic characteristics (in context of the IUA). A key aspect of this activity was to incorporate these nodes into the water resource simulation model to enable the generation of monthly time series of flow data for the scenarios where appropriate. At selected nodes (key biophysical nodes or EWR sites) the flows required to achieve a particular ecological state were also defined, along with rules to make releases from upstream weirs and dams.

2.1.4 Water availability analysis

This activity applied the water resource simulation model to determine the volume of water that is available for abstraction from the water resource for economic use, given that the flow regime in the river is maintained to achieve a certain ecological state. Appropriate discharges are also simulated as part of the volumetric analyses. The ecological state is defined by the particular EC specified for the scenario under consideration, which could be the REC, PES or any other appropriate EC.

2.1.5 Estimate consequences

The simulated flow regimes at the nodes and the water available for abstraction form the basis for evaluating and estimating the consequences of each scenario. The text box in the centre of Figure 2.1 indicates the aspects that were evaluated. Table 2.1 lists these aspects and provides a brief description of the evaluation method and purpose as well as references to where further detail information are provided.

Table 2.1 Variables considered in the scenario comparison and evaluation process

Variable	Evaluation purpose and method
Ecological	Determine the EC and indicate the degree in which the scenario achieves the REC.
Ecosystem Services	Determine the extent that each scenario changes the Ecosystem Services relative to the PES conditions.
Economy	Determine the economic benefit of utilising the available water (abstractions) in terms of Gross Domestic Product (GDP) and Employment (Jobs).
Non-ecological Water Quality	Consider the consequences of having to achieve elevated water quality standards for users other than the ecology (fitness for use or Userspecs). This may involve determining the economic implications of such elevated standards.

2.1.6 Compare, rank and optimise

The consequences from the above mentioned activity are expressed numerically for the scenarios and compared separately for each variable and then the results are combined for all variables to derive overall scores which give effect to the ranking of scenarios. The methodology employed for this is based on Multi Criteria Analysis (MCA) approach where weighting factors are applied, firstly to give effect that certain nodes are more important than others and secondly that the variables listed in Table 2.1 may differ in their relative importance (see Section 2.2) for further details on the MCA methodology.

All the scenarios are described in Chapter 3.

2.1.7 Formulate alternative scenarios

This activity involves the formulation of alternative scenarios, usually consisting of adjustment to the initial list (rather than completely different scenarios) for further consideration. The other steps are then repeated as indicated by the circular arrows depicting the information flow from one activity to the next.

2.1.8 Select scenario subset for stakeholder evaluation

The technical study team assessed several scenarios of which the results defined the boundaries of the variable settings and point to the aspects that are important to consider in the study area. A relevant subset of the full list of scenarios was selected for discussion with stakeholders.

2.2 MULTI CRITERIA ANALYSIS FOR SCENARIO EVALUATION AND COMPARISON

2.2.1 Evaluation variables

As explained in Section 2.1 there are three main aspects that are compared when determining the degree of achieving the appropriate balance between the ecological objectives on the one hand and the socio-economic benefits on the other.

The ecological state (or health) rating is expressed relative to how the scenario achieves the REC. This is quantified as a numerical ratio ranging usually between 1 and 0, where a score of 1 indicates the scenario achieves the REC and zero when the scenario is typically in an F EC.

The rating of the Ecosystem Services for a scenario is expressed numerically and relative to the baseline Ecosystem Services available under current conditions (2013). A score of 1 indicates the scenario will provide the same services as under present conditions where a score of 1.2 implies there is 20% more utility in terms of Ecosystem Services. A score of 0.8 indicates a reduction of 20% in the services provided by the scenario.

In terms of the socio-economic component, two aspects are evaluated, namely the GDP and employment (the number of jobs) that will be supported by the volume of water that is abstracted from or discharges into the system for the scenario. The GDP is expressed in monetary terms (Rand) and employment in the number of jobs supported.

The following sections provide an expanded description of how the metric for each of the three components presented above were derived.

2.2.2 Ecological metric

a) Rivers

Deriving a single metric (one number), that reflects the ecological health relative to the REC for the river, requires several steps, sub-steps and the application of various tools. Broadly, the rationale to achieve this single rating is based on the following.

- Scenarios at each EWR site are ranked on the basis of the degree to which the scenarios meet the REC.
- Comparing the impact of the scenarios at the different EWR sites to determine a ranking from a system context, depends both on the degree to which the scenario meets the REC, as well as the relative ecological importance of the sites.

To further explain this, if a scenario is ranked highest at a site of low importance, but lower at a site of high importance, this scenario will not carry the same weight as the scenario that scored the highest at the sites of high importance.

The steps and sub-steps to derive a single number are illustrated in Figure 2.2 and Figure 2.3 and described in the bulleted list below:

- **Step 1: Rank scenarios at each EWR site (Figure 2.2 and Figure 2.3)**
    - Apply the EcoClassification (Kleynhans and Louw, 2007) process at each EWR site where the scenario influences the flow or water quality to determine the EC for each component[1].
    - Provide the associated percentage that represents the category.
    - Calculate the degree to which the scenario meets the ecological objectives which is represented by the REC. I.e., if the REC for a component is 62% and the scenario results in this component being at 62%, then the resulting score would be a 1 (or a 100% successful in meeting the REC). If a scenario's rating for the component is 48%, then the score would be 0.77 (or 77% successful in meeting the REC).
    - Average the score at each component to obtain a score for the scenario at the site.
    - Each site's score is then normalised to obtain a rating that is 1 if the REC is achieved, above one if the REC is exceeded (i.e. 1.1) or between 1 and zero if the score (EC) is below the REC.
    - Rank the scenarios in terms of a numerical scale with values zero and one (typically, where one (1) indicates the scenario achieves the REC and a zero (0) represents the situation where the scenario results in a "F").

1 Component: Habitat drivers (geomorphology and water quality (hydrology is a given)); Biological responses (fish, macroinvertebrates, riparian vegetation).

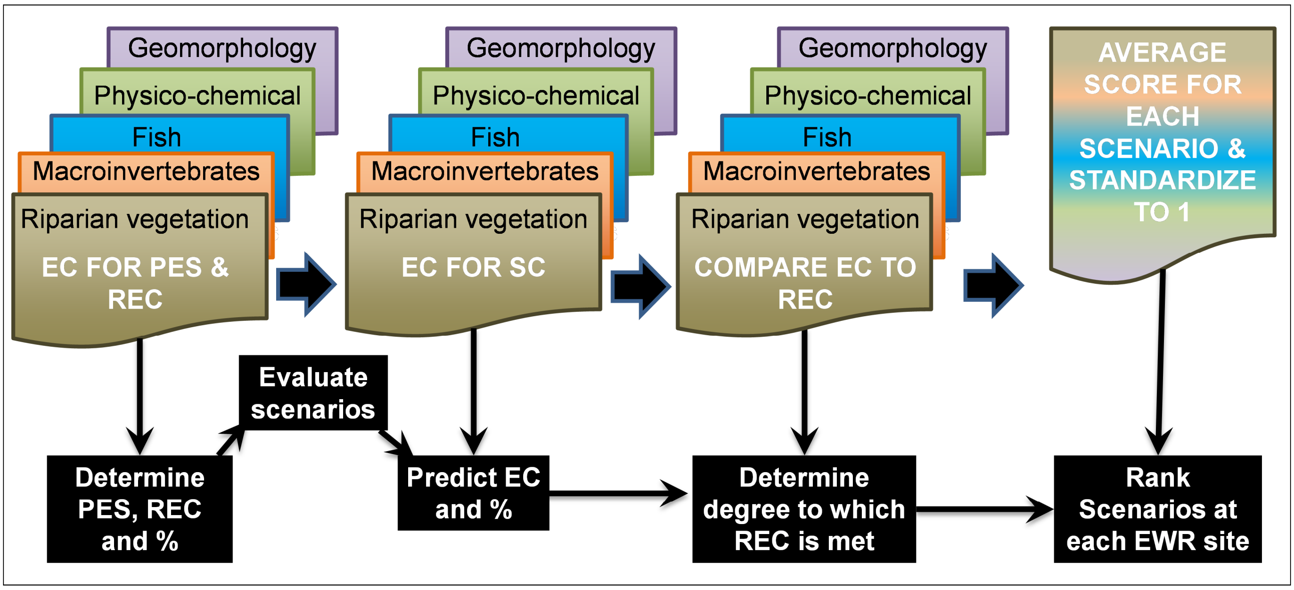


Figure 2.2 Process to rank scenarios at each EWR site

- **Step 2: Determine the relative importance of EWR sites to each other (Figure 2.3)**
  The following aspects are considered when determining the relative importance of the EWR sites to each other:
  - PES: The higher the PES the more important the EWR site. The PES percentage is used in this calculation.
  - Ecological Importance and Sensitivity (EIS): The higher the EIS rating, the more important the EWR site. The EIS score is used in this calculation.
  - Conservation importance: The locality of the site within a declared conservation area is highlighted. A site within a Trans-frontier park or a Wilderness Area will be more important than a National Park which in turn will be more important than a provincial nature reserve.

The above metrics are averaged and the score is then normalised out of one.

- **Step 3: Rank the scenarios in a system context (Figure 2.3)**
  All the scores from the EWR sites are then combined into a single score by accounting for the above site importance ranking. This is achieved by assigning different weights (factors) to each site to reflect the importance relative to the others.

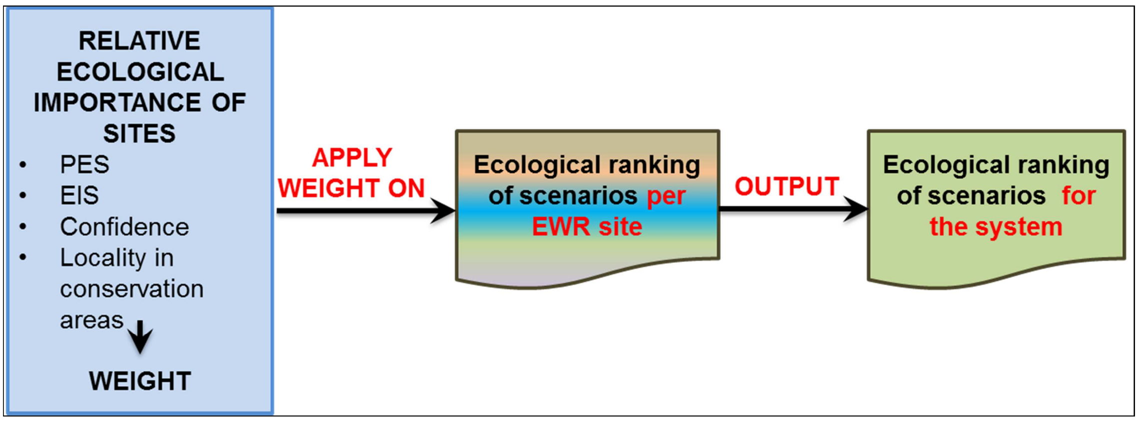


Figure 2.3 Process to achieve the ecological ranking of all scenarios on the river systems

The output of the application of these processes result in an ecological ranking of each scenario for the relevant secondary catchments excluding the uMkhomazi, and Mvoti River systems. The individual ranking and consequences at each EWR site have therefore been integrated into one ranking and consequences applicable to the specific river system.

b) Estuaries

- Deriving a single metric (one number), that reflects the ecological health relative to the REC for the estuaries, requires a number of steps. Broadly, the rationale to achieve a single rating is that each scenario at each estuary is ranked on the basis of the degree to which the scenarios meet the REC. The following approach was applied:
  - Apply the Estuary Health Index (EHI) to each scenario that influences the flow or water quality to determine the EC for each component.
  - Provide the associated percentage that represents the category.
  - Calculate the degree to which the scenario meets the ecological objectives which is represented by the REC.
  - The score of each scenario is then normalised to obtain a rating that is 1 if the REC is achieved, above one if the REC is exceeded (i.e. 1.1) or between 1 and zero if the score (EC) is below the REC.
  - Rank the scenarios in terms of a numerical scale with values zero and one (typically, where one (1) indicates the scenario achieves the REC and a zero (0) represents the situation where the scenario results in a “F”).

A relative weighting was used on the catchment scale. Estuaries scores were normalised to their relative size, ecological importance, functional importance and present condition. Health was incorporated to ensure that good condition systems were rated higher than poor condition systems, but size also plays a role. For example, a large, poor condition system such as Durban Bay still provide important functional habitats and processes, while a small, poor condition estuary, that experience regular fish kills, contribute significantly less to the overall condition and resilience of the estuarine network that dots this coast.

Functional importance was based on the maximum value (High = 5, Low = 1) of: nursery function for estuarine and coastal fish; export of detritus, sediment and nutrients to the nearshore; and connectivity with the marine environment (marine linkages). This last aspect was incorporated to reflect the fact that estuaries are connected coastwise and are affected if their neighbouring systems are in a poor state. To account for this phenomena, key physical features (Mean Annual Runoff (MAR), percentage open to the sea, distance to the next system) were normalised to ensure that isolated systems weigh more heavily that connected systems.

In addition, estuaries were also rated with reference to their recreation importance. A rating out of 5 was applied, with estuaries adjacent to Blue flag beaches and resorts were rated 5. Low use areas were rated 1.

c) Integration of rivers and estuaries

To produce a final ecological ranking, the rivers and estuaries must be combined and inherently, the associated estuary is treated as an additional EWR site. This means that as the river EWR sites are weighted, the estuary must now also be weighted and all EWR site weights adjusted pro rata. Factors considered in the rating are ecological and conservation importance, the PES, the functionality of the estuary, the sensitivity of the estuary to scenario changes and the length or size (area) of the river and estuary respectively.

The weights applied to derive the WRC where rivers and estuaries form part of the same IUA was set to be 20% for the rivers and 80% for the estuaries. Since the length (in kilometres) of a river reach defines the weight of the river reach and the area of the estuary the weight of the estuary, an equivalent river "area weight" was calculated in order for the sum thereof resulting in the 20% river: 80% estuary ratio.

2.2.3 Ecosystem Services metric

Natural habitats and ecosystems provide a range of environmental goods and services that contribute to human well-being. River systems and their associated use values are of particular importance in many instances. For operational purposes this study followed the approach defined in the 2005 Millennium Ecosystem Assessment (MEA, 2005) and classifies ecosystem services along functional lines using categories of provisioning, regulating, cultural, and supporting services.

With this in mind an analysis of EWRs for the rivers 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. Each site was evaluated under the impact against a base value of 1, representing the status quo. Anticipated change was evaluated against the base value with a negative impact represented as a score lower than 1 and an overall positive score represented as greater than 1. The process to determine an integrated ranking of the different scenarios required determining the relative importance of the categories of ecosystem services. Here the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role.

The scenario impact on various ecosystem services 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 Sub Quaternary catchments (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.

For the Estuaries a very similar process was followed. Each estuary was evaluated under the impact against a base value of 1, representing the status quo. As with the rivers, anticipated change was evaluated against the base value, with a negative impact represented as a score lower than 1 and an overall positive score represented as greater than 1. The process to determine an integrated ranking of the different scenarios required determining the relative importance of the categories of ecosystem services. Here again the perceived vulnerability of households dependent on the provisioning aspect of Ecosystem Services played a major role. The offshore impact was also examined and where there was linkage between the estuary and offshore impact, particularity linked to utilisation of the beaches for recreational purposes, greater consideration was given to the recreational aspects - expressed in the cultural score – in terms of weighting the categories to normalise the score back to 1. Where blue flag beaches were potentially impacted extra significance was given to the overall importance of the estuary as well as the cultural aspects of the service weighting.

2.2.4 Relationship between economic, environmental and social impact

The economic analysis consists of the status quo of the current economic activities as well as the impact of Waste Water Options in the Mvoti to Umzimkulu WMA. The approach followed in the evaluation process of the different scenarios is in line with Mullins *et al*. (2014).

It was decided to use, in both the baseline as well as the different scenarios (where applicable), two metrics, namely a macro-economic indicator, GDP and a socio-economic indicator, employment. Although the use of the GDP created is generally accepted as an economic growth indicator, it sometimes does not present the full picture. In the case of irrigation agriculture, irrigated sugarcane provides a very large GDP contribution. If the area is highly rural and impoverished, however, then job creation is perhaps more important than GDP creation.

Each catchment is divided into regions of economic activities, which takes into consideration climatic and topographic issues, and therefore is evaluated as Economic Regions (ER). The economic value of water use for each economic sector is determined. The economic evaluation of the impact of the different scenarios, as evaluated, is based on the broad assumption that the utilisation of any additional, current or future water allocation is utilised at maximum efficiency.

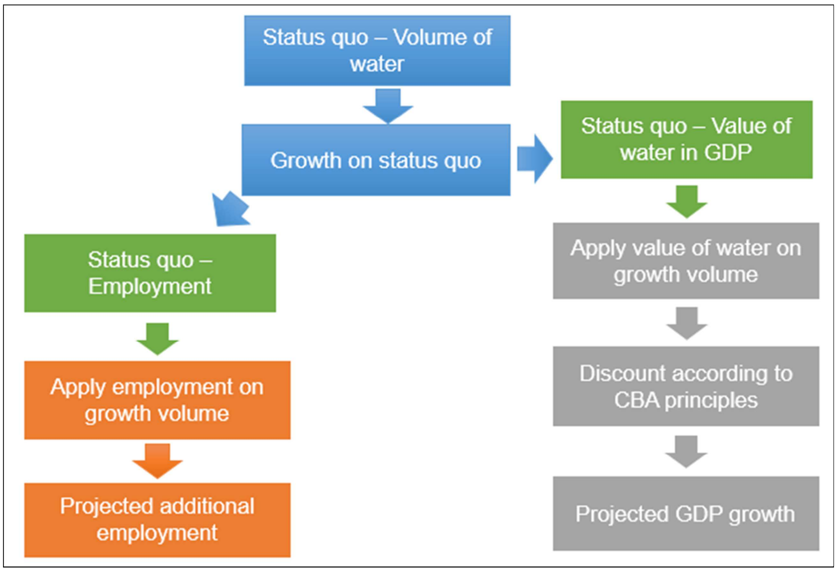
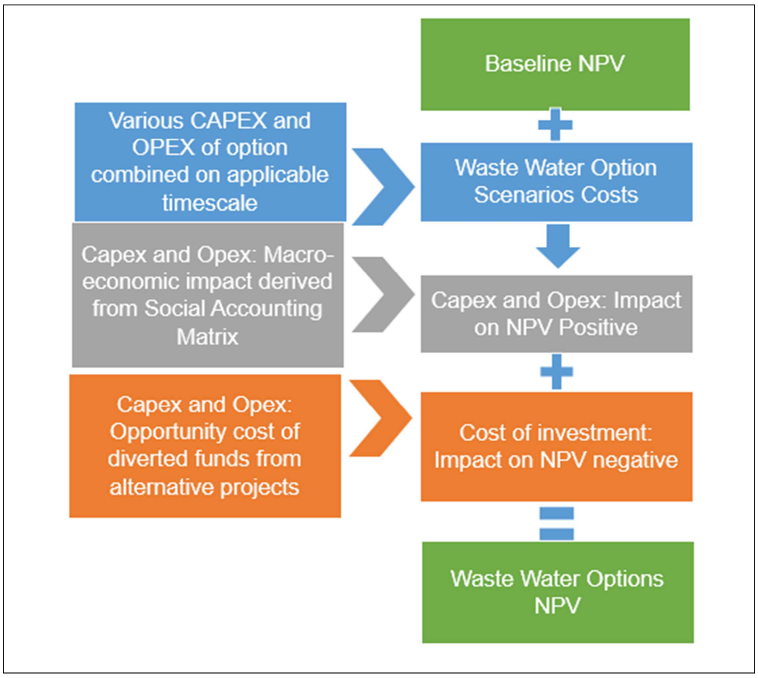


Figure 2.4 Baseline methodology based on Cost Benefit Analysis (CBA) principles

This then provides a tool to create an appropriate economic baseline (Figure 2.4), against which to measure the possible impact of changes in Waste Water Options by means of scenarios. Thereby the macro-economic impact of any possible Waste Water Option on the economy in the Mvoti to Umzimkulu WMA can then be determined (Figure 2.5).



NPV – Net Percent Value

Figure 2.5 Waste Water Options integration in CBA

Since the status quo of the current economic activities was already calculated/estimated in previous parts of the study it was only required that the cost as well as the benefit of each of the Waste Water Option scenarios be calculated.

The Costs of the Waste Water Option scenarios was identified with the scale of the cost in relation to the quality of water in the respective estuaries being improved.

The benefit, or impact, of the Waste Water Option Scenarios is calculated by making use of the Social Accounting Matrices to measure the magnitude of the impact that the capital and operational costs will have on the economy.

The direct re-use and indirect re-use of waste water have an additional benefit in terms of the value of the water which is also forms part of the CBA.

There is therefore three categories of benefits in this evaluation:

- GDP generated by water use.
- GDP generated by capital expenditure,
- GDP generated by operational cost.

These same benefits are also applicable on employment.

If the re-use options were implemented additional water would be made available for use or application before the supply from Smithfield Dam has reached its maximum capacity.

To model this principle the assumption was made that Smithfield Dam will provide a smaller volume (Figure 2.6). This seemingly smaller dam will have a lower capital cost which equates to a higher benefit.

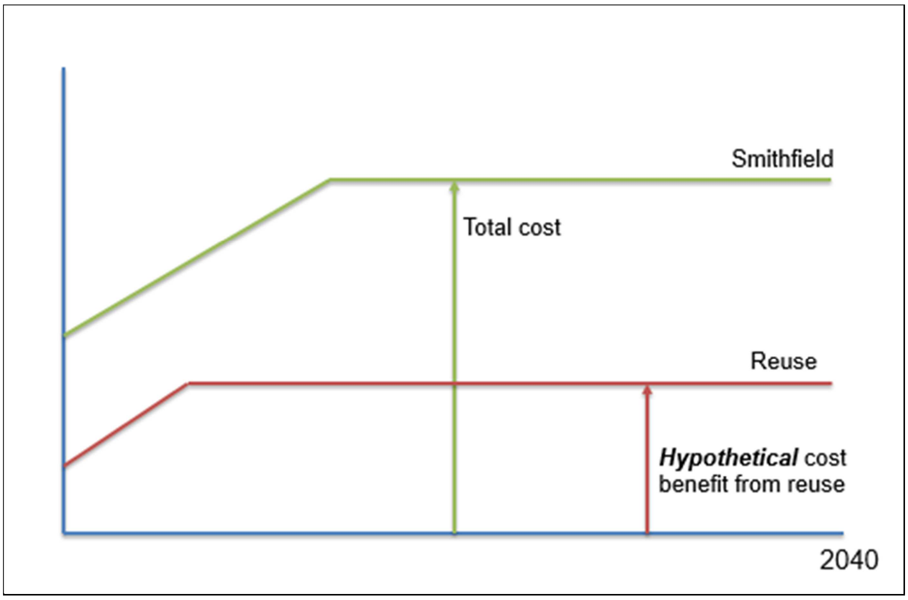


Figure 2.6 Hypothetical cost benefit from reuse

This is purely a hypothetical way to model the opportunity cost, so the usual feasibility approach is not applicable in this model.

The different options, excluding the additional water options, were then analysed by adding the capital and operational costs to the current costs in the operational scenarios selected. The costs used are the cost estimates for the different proposed dams as well as the operational and management costs as sourced from the different reports made available.

Table 2.2 Waste Water Option scenarios

Scenario	Description	CAPEX (R Million)	OPEX (R Million)
Scenario Ai	Ecological Protection Priority	7 069.80	551.83
Scenario Aii	Fall Back option for Scenario Ai	7 476.83	453.00
Scenario Aiii	As in Ai but waste water plants to capacity	6 921.73	582.35
Scenario Bi	Highest discharge into estuaries	6 873.80	810.69
Scenario Bii	Scenario Bi with alternative	7 336.54	753.38
Scenario C	5 year plan	6 727.96	626.10
Scenario D	10 year plan	6 409.62	688.29
Scenario E	Indirect reuse	8 372.07	710.73
Scenario F	Direct reuse	14 063.28	1 319.28
Scenario Biii	Highest discharge into estuaries	5 400.41	191.46
Scenario Aiv	Ecological Protection Priority	7 338.59	602.68
Scenario Av	Alternative of Scenario A	7 178.33	454.60
Scenario Ci	5 year plan	6 134.07	322.83
Scenario Di	10 year plan	5 667.25	338.52

The GDP is expressed in terms of R million/m^3 and the water in m^3. By multiplying the two, an answer in Rand million is provided. The GDP is available per catchment, as it was calculated as part of the economic status quo.

The employment is expressed in terms of Number/million m^3 and the water in million m^3. By multiplying the two, an answer in employment numbers is provided. The employment is available per catchment as it was calculated as part of the economic status quo.

The construction of a CBA in the public sector is approached from the point of view of the total community and not only the shareholders as in the case of a private sector company. It is also necessary that it be highlighted that a CBA does not provide answers about affordability, tariffs and funding by the responsible authority.

After the metrics are derived a ranking is applied which is based on the highest net benefit to society in terms of GDP and employment stimulation. This is a simple linear relationship where the highest Net Present Value of each scenario or option transcends the other scenarios or options.

2.2.5 Overall ranking metric

The first aspect to consider in deriving the overall ranking for each scenario is the method employed to normalise each variables' results. This is necessary to remove the effect of the different dimensions (Rand for the economy, number of jobs for employment and the different rating scales for the ecology and Ecosystem Services) and make the scores of each variable comparable. The second aspect is to make provision to vary the importance each variable has in the overall ranking. Both these are described further below.

2.2.6 Relative importance among variables

The relative importance (among the variables) is defined by assigning relative weights to each of the four variables. Examples of how different weights would result in a preselected bias are presented in Table 2.3 for illustration purposes. The actual weight scheme applied in the study is discussed in Chapter 7.

Table 2.3 Explanation of the application of variable weights

Pre-selected Importance Bias	Weights assigned (sum of weights for the four variables must equal one)			
	Ecological Protection	Ecosystem Services	Economic Indicator (GDP)	Employment Indicator (Jobs)
Neutral[1]	0.5	0.1666	0.1666	0.1666
Preference for ecology	0.7	0.1	0.1	0.1
Preference for socio-economy	0.3	0.2333	0.2333	0.2333
Preference for socio-economy with emphasis on employment	0.3	0.2	0.2	0.3
Preference for socio-economy with emphasis on economy	0.3	0.2	0.3	0.2

1 This weight scheme is neutral because all the socio-economic variables together carry the same weight as the ecology variable. Note that Ecological Protection refers to rivers, wetlands and estuaries.

2.2.7 Normalising methods

The normalisation scheme applied in the calculations is to adjust the values for each scenario by scaling (adjust) the values to be between 0 and 1, where the scenario with the best score is 1 and lowest score is 0. This is carried out for each variable respectively.

The overall rank for a scenario is therefore determined by the sum of the products of each variable's metric multiplied with importance weight of the variable.

2.3 WATER RESOURCE CLASS DETERMINATION

In accordance with the WRCS Guidelines (DWAF, 2007), the WRC for an IUA is defined by the distribution of the selected ECs for the biophysical nodes in an IUA. In general, if the nodes are in "A" or "B" ECs the IUA is in a Class I, a Class II will be assigned if most nodes are in a C EC and if the nodes mostly fall in a D EC the IUA is in a Class III.

The guidelines recommend the scheme presented in Table 2.4 as the criteria to determine the WRC. The "units" applied in the table is the percentage of river length (associated with a biophysical node) falling in each of the indicated ECs.

The following is an example interpretation to illustrate the application of the guideline scheme.

An IUA is in WRC I if the following applies:

- 40% or of the units must be greater than or equal to an A/B EC.
- 60% of the units should be greater or equal to and B EC.
- 80% of the units should be greater or equal to and C EC.
- 99% of the units should be greater or equal to and D EC.
- Less than 1% of the units can be in an E EC.

Table 2.4 Preliminary guidelines for the calculation of the IUA Class for a scenario (DWAF, 2007)

		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥C	≥ D	< D
Class 1		40	60	80	99	-
Class 2			40	70	95	-
Class 3	**Either**			30	80	-
	Or				100	-

The results presented in Chapter 9 lists the IUA WRCs for the indicated scenarios. The specific rules (adjusted from the guideline rules presented in Table 2.4) are also presented and discussed in Chapter 9.

It must be noted that no scenarios other than the PES and REC scenarios and combination there-of were identified or evaluated for the following river sections of these secondary catchments:

- T4 (Mtamvuna).
- U3 (uMdloti and uThongathi).
- U5 (Nonoti).
- U6 (uMlazi).
- U8 (Mtwalume and Mzumbe).

All estuaries have been included in three IUAs and assessed accordingly. The river sections of the above secondary catchments will be classified according to the approach outlined in this chapter.

3 SCENARIO DESCRIPTION

3.1 INTRODUCTION

During the course of the study scenarios were identified, presented to the Project Steering Committee for comments and subsequently evaluated, compared and ranked as a means to determine the appropriate balance between water use and ecological protections for deriving the WRCs. When identifying and formulating scenarios for analysis the following aspects are considered:

- Identify the pertinent water resource operational and developments in the system.
- Define a range of scenarios the will, on the one hand, provide high levels of ecological protection and on the other hand, maximise the utility from the water resource - usually resulting the lower levels of protection.
- Typically the water uses that are considered for scenarios include the taking of water (abstraction), storing of water (dams) as well as the utilisation a water resource for discharging waste.

Scenarios for the Mvoti River and uMkhomazi River were described in the study report DWS (2014b). The scenarios covered in this document and described in the subsequent sections are:

- uMngeni River System.
- Lovu River System.
- Waste water management scenarios (influencing the estuaries).

3.2 uMNGENI RIVER SYSTEM SCENARIOS

Table 3.1 show the scenario summary matrix indicating the drivers of the scenario (different columns) for the list of scenarios provided by the rows.

Table 3.1 uMngeni: Summary of operational 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-uMngeni Transfer Scheme Phase 2 (Spring Grove Dam).
2 uMkhomazi Water Project (Smithfield Dam).
3 All future return flows from Phoenix and Mhlanga Waste Water Treatment Work (WWTW) to the uMngeni System.
4 All future return flows from Phoenix, Mhlanga and uThongathi WWTW to the uMngeni System.

Each scenario is described in the following sections.

3.2.1 Scenario UM1: Present Day with MMTS2

Scenario representing the Present Day (PD) conditions with respect to abstractions and return flows, existing storage and conveyance infrastructure and applying the prevailing operating rules in the system.

3.2.2 Scenario UM2: 2022 Development level, MMTS2

Scenario UM2 incorporates the MMTS2 (Spring Grove Dam and transfer infrastructure) to augment the water supply of the KZN Metropolitan area. Water requirement and return flows as it is projected for the year 2022 development scenario, one year prior to the expected implementation of the UWP. The MMTS2 interbasin transfer discharges into the Mpofana River, which is a tributary of the Lions River that flows into Midmar Dam catchment and will mainly impact on these two rivers.

The uMngeni System is operated for this scenario such that the 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 WWTW) is taking place while maintaining the three months available storage in Midmar Dam as a buffer storage for supplying the Upper uMngeni Demand Centres. The reason for this buffer storage level in Midmar Dam is to protect the water users that can only be supported from the Upper uMngeni River system (that is while other users can receive water from both the Upper and Lower uMngeni Systems).

3.2.3 Scenario UM41 and UM42: Ultimate development, MMTS2 and MWP

This scenario represents the long term future conditions representative expected for the year 2040. This is representative of the “Ultimate Development Level” also reflecting the developmental vision set by the eThekwini Spatial Development Framework. The UWP is assumed to deliver water to the uMngeni River System in accordance with the DWS Water Reconciliation Strategy Study for the KZN Coastal Metropolitan Areas.

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 as described in the footnotes of **Table 3.1** (note that additional waste water discharge scenarios affecting the estuary are described in subsequent sections).

3.2.4 Scenario UM51 and UM52: Ultimate development, PES/REC EWR, MMTS2, MWP, Darvill re-use and eThekwini direct re-use

As for Scenarios UM41 and UM42, including the Darvill Re-use and the eThekwini Direct Re-use options. 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 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.

3.3 LOVU RIVER SYSTEM

Table 3.2 presents the scenario summary matrix, indicating the drivers of the scenario (different columns) for the list of scenarios provided by the rows.

Table 3.2 Summary of the Lovu 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)

3.3.1 Scenario LO1: Present Day

This Scenario represents the PD conditions with respect to abstractions and return flows, existing storage and conveyance infrastructure and applying the prevailing operating rules in the system.

3.3.2 Scenario LO2: Ultimate Development

This scenario represents conditions with 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 higher up in the catchment (U70B, Richmond and township) and information on increased water use and return flows for the domestic sector will be sourced from the DWS All Towns Strategies and other sources such as municipal documents if available.

The purpose of the scenarios is to monitor the flows at the EWR sites and into the estuary for the ultimate development scenario.

3.3.3 Scenario LO3: Ultimate development, reduced abstraction and afforestation areas (25%)

This scenario is based on Scenario LO2 with a reduction of 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% included. The aim with this scenario is to increase the base flow into the estuary.

3.3.4 Scenario LO4: Ultimate development, reduced abstraction and afforestation areas (50%)

This scenario is based on Scenario LO3 with a reduction of abstraction from Lovu Dam in the upper part of the catchment as well as a reduction in the afforested areas by 50% in order to increase base flows included. The aim with this scenario is to increase the base flow into the estuary.

3.4 WASTE WATER MANAGEMENT SCENARIOS

A key factor that was identified to influence the ecological health of several estuaries in the study area was ‘treated waste water discharges’ servicing the various urban areas located along the coast. The extent of the current and potential future waste water discharges are summarised in Table 3.3.

Table 3.3 Current and future potential waste water 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[2])	440	89.4%	1 188	91.6%
Total	**492.5**		**1 296.8**	

1 District Municipality 2 Metropolitan Municipality

Twenty five (25) of the sixty four (64) estuaries are affected by the waste water discharges and the scenarios were formulated along selected themes as presented in Table 3.4.

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 waste water through sea outfall works - discharges to estuaries are reduced or eliminated.
- Re-use of treated waste water, both direct and indirect.

Table 3.4 Primary themes defining waste water 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 waste water volumes for each of the urban areas. The estuaries in the study areas were grouped into three IUAs namely the Southern Cluster (SC), 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 sub-divide the SC further into two IUAs, north and south of the Umzimkulu River (see SC1 and SC 2, Table 3.5). 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 MM).

Total estuary area (size) is an important predictor of the biotic features of an estuary, hence the reason for its incorporation in the national estuary importance rating (DWAF, 2008). To provide for addition resolution and to account for estuary resilience to flow modification and water quality changes, as well as key ecosystem services such as nursery function, estuaries were also weighted by their open water area.

Table 3.5 Estuaries and associated IUAs

No	Estuary Name	IUA	Estuary Area (ha)
1	Mtamvuna	SC1	64
2	Zolwane	SC1	2
3	Sandlundlu	SC1	11
4	Ku-Boboyi	SC1	5
5	Thongazi	SC1	7
6	Kandandhlovu	SC1	5
7	Mpenjati	SC1	33
8	Umhlangankulu	SC1	16
9	Kaba	SC1	15
10	Mbizana	SC1	28
11	Mvuthshini	SC1	4
12	Bilanhlolo	SC1	17
13	Umvazana	SC1	6
14	Kongweni	SC1	7
15	Vungu	SC1	7
16	Mhlangeni	SC1	16
17	Zotsha	SC1	29
18	Boboyi	SC1	14
19	Mbango	SC1	13
20	Umzimkulu	SC1	118
21	Mtentweni	SC2	18
22	Mhlangamkulu	SC2	13
23	Domba	SC2	20
24	Koshwana	SC2	18
25	Intshambili	SC2	10
26	Mzumbe	SC2	36
27	Mhlabatashane	SC2	19
28	Mhlungwa	SC2	17
29	Mfazazana	SC2	16
30	Kwa-Makozi	SC2	15
31	Mnamfu	SC2	14
32	Mtwalume	SC2	39
33	Mvuzi	SC2	18
34	Fafa	SC2	51
35	Mdesingane	SC2	7
36	Sezela	SC2	28
37	Mkumbane	SC2	12
38	Mzinto	SC2	30
39	Nkomba	SC2	13
40	Mzimayi	SC2	0

No	Estuary Name	IUA	Estuary Area (ha)
41	Mpambanyoni	SC2	13
42	aMahlongwa	CC	14
43	Mahlongwana	CC	21
44	uMkhomazi	CC	75
45	Ngane	CC	8
46	Umgubaba	CC	47
47	Msimbazi	CC	28
48	Lovu	CC	40
49	Little Manzimtoti	CC	10
50	aManzimtoti	CC	21
51	Mbokotwini	CC	18
52	Isipingo	CC	27
53	Durban Bay	CC	1148
54	uMngeni	CC	83
55	Mhlanga	CC	83
56	uMdloti	CC	58
57	uThongathi	CC	37
58	Mhlali	NC	42
59	Bobs Stream	NC	0
60	Seteni	NC	7
61	Mvoti	NC	22
62	Mdlotane	NC	25
63	Nonoti	NC	27
64	Zinkwazi	NC	71

1 The estuaries shown in red text is affected by waste water discharges.

The comprehensive list of waste water management scenarios analysed in the study is presented in Table 3.6.

Table 3.6 Full list of scenarios evaluated in the study

Sc	Scenario Description	Comment
Ai	Ecological protection is priority (minimum discharge to estuaries).	NC and SC: 30% of future waste water flow to estuary, remainder through alternative means.
Aii	Ecological protection is priority (minimum discharge to estuaries).	NC and SC: 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 Sc Ai: Option for CC (discharge to iSipingo as an alternative option to Ai).
Bi	Minimum costs scenario (highest flow through estuaries).	Options for CC: Low nutrient discharge from (high costs).
Bii	Minimum costs scenario (highest flow through estuaries).	As Sc Bi: Different infrastructure options for Central Cluster (lower costs). uMkhomazi estuary received 50Ml/day waste water flow .
Biii	Minimum costs scenario (highest flow through estuaries).	As Sc Bi: Current treatment (high) nutrient discharge (low costs).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Short term increases in discharges. CC: Short term increases in discharges with low nutrient discharge (high costs).
Ci	Current and short term (5 year) flow	NC and SC: Short term increases in discharges.

Sc	Scenario Description	Comment
	discharged into river systems, remainder through alternative means.	CC: As Sc C: Current treatment (high) nutrient discharge (low costs).
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Medium term increases in discharges. CC: Low nutrient discharge (high costs).
Di	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Medium term increases in discharges. CC: As Sc D: Current treatment (high) nutrient discharge WWTW (low costs)
E	Indirect re-use (consider volume and practicalities). Remainder According to Scenario C.	NC and SC: Reuse 50% if future waste water flow. CC: Reuse via Hazelmere Dam.
F	Direct re-use (consider volume and practicalities). Remainder According to Scenario C.	NC and SC: Reuse 50% if future waste water flow. CC: 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.

4 ECONOMIC CONSEQUENCES

The results of the different scenarios of each catchment, as it impacts on the different economic sectors, are presented in this Chapter. The impact on GDP as well as on labour is provided for integration into the final results.

4.1 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 (Table 4.1)

Table 4.1 Cluster Results

	CC IUA Results		SC IUA Results		NC IUA Results	
	NPV GDP	NPV Labour	NPV GDP	NPV Labour	NPV GDP	NPV Labour
	Rand million	Number	Rand million	Number	Rand million	Number
Sc Ai	906 032	4 950 859	75 509	243 360	21 646	82 402
Sc Aii	906 287	4 950 959	75 759	244 251	21 798	82 959
Sc Aiii	905 760	4 950 849	75 759	244 251	21 798	82 959
Sc Bi	904 381	4 949 795	75 717	244 113	21 710	82 666
Sc Bii	904 503	4 949 644	75 717	244 113	21 710	82 666
Sc C	906 978	4 952 524	75 680	243 963	21 790	82 931
Sc D	907 113	4 952 885	75 711	244 079	21 839	83 108
Sc E	906 276	4 952 044	75 402	242 576	21 620	82 313
Sc F	901 553	4 945 522	75 402	242 576	21 620	82 313
Sc Biii	909 819	4 960 261	75 717	244 113	21 710	82 666
Sc Aiv	905 419	4 950 367	75 759	244 251	21 798	82 959
Sc Av	905 784	4 951 226	75 509	243 360	21 646	82 402
Sc Ci	908 856	4 954 222	75 680	243 963	21 790	82 931
Sc Di	909 192	4 954 770	75 711	244 079	21 839	83 108

Discounted Values

As already explained the total capital cost of the proposed project 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 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.

Ranking

Ranking is applied which is based on the highest net benefit to society in terms of GDP and employment stimulation. This is a simple linear relationship where the highest Net Present Value of each scenario or option transcends the other scenarios or options.

4.2 uMNGENI RIVER SYSTEM

Table 4.2 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.

4.3 LOVU RIVER SYSTEM

Table 4.3 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

4.4 CENTRAL CLUSTER IUA RESULTS

The results are provided in traffic diagrams in Figures 4.1 – 4.6 with explanations of the results adjacent to the traffic diagrams.

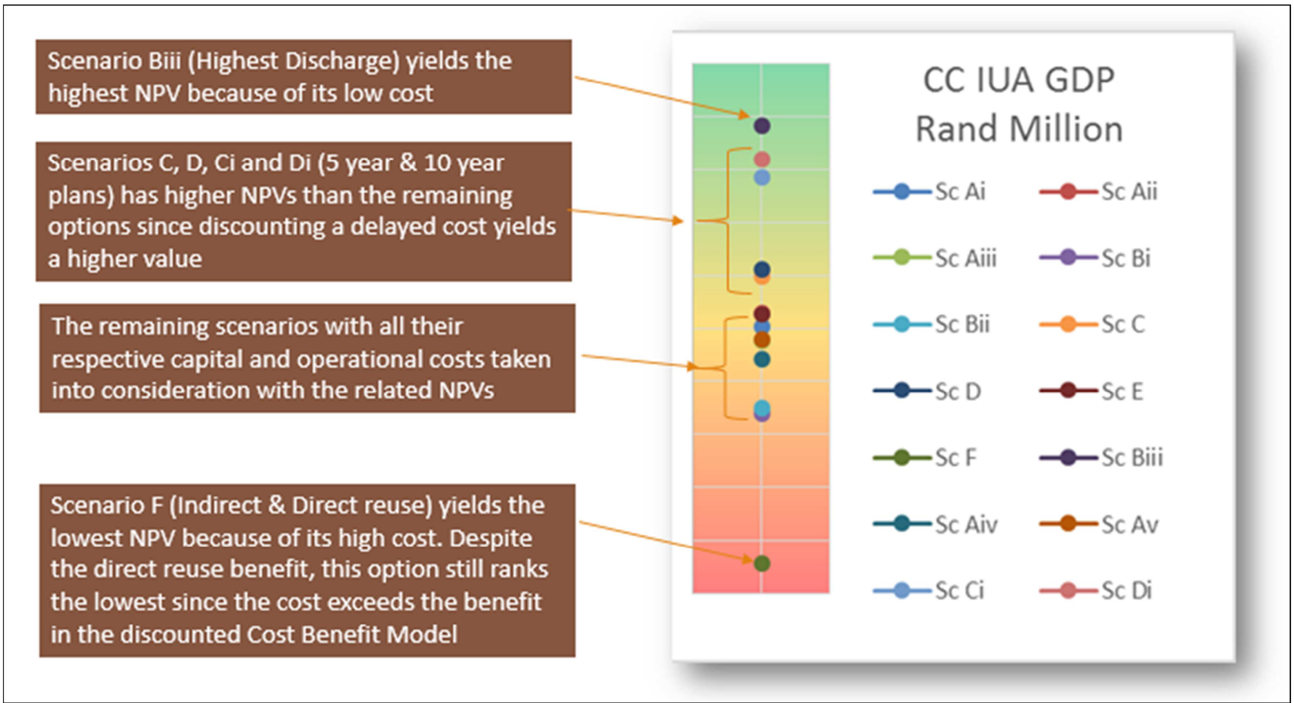


Figure 4.1 Central Cluster GDP Ranking

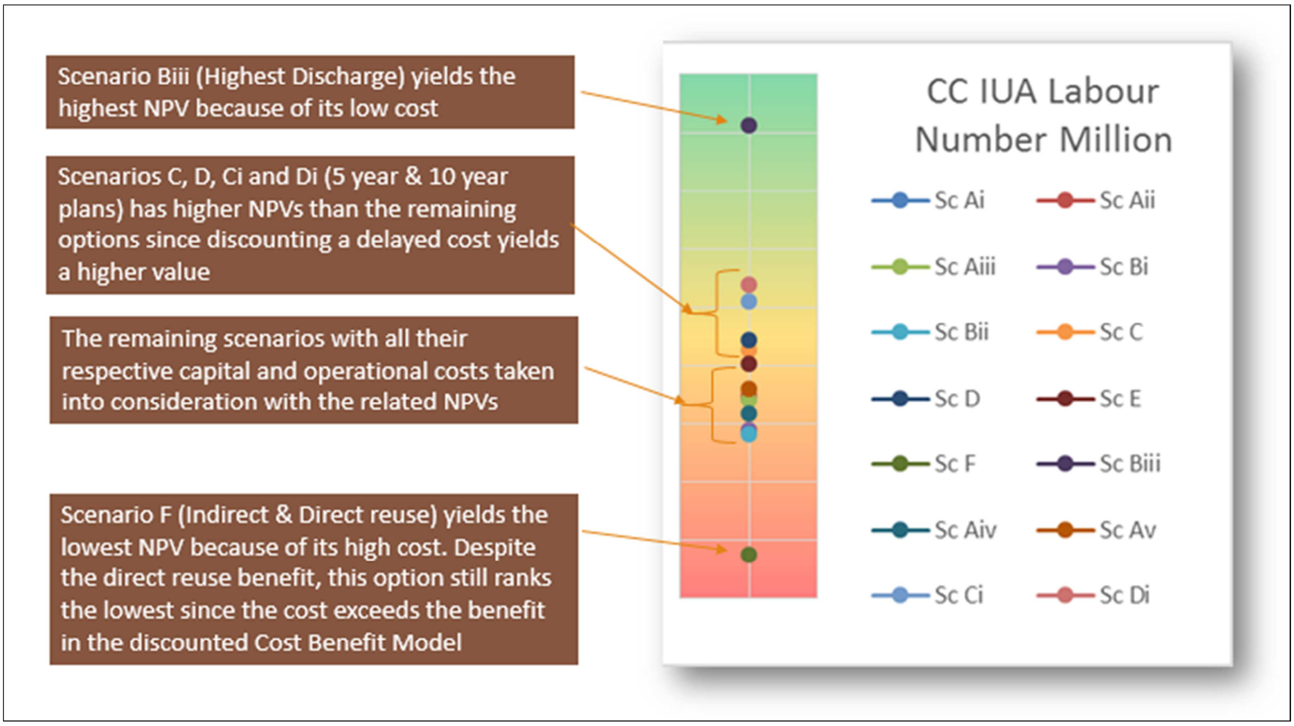


Figure 4.2 Central Cluster Employment Ranking

4.5 SOUTHERN CLUSTER IUA RESULTS

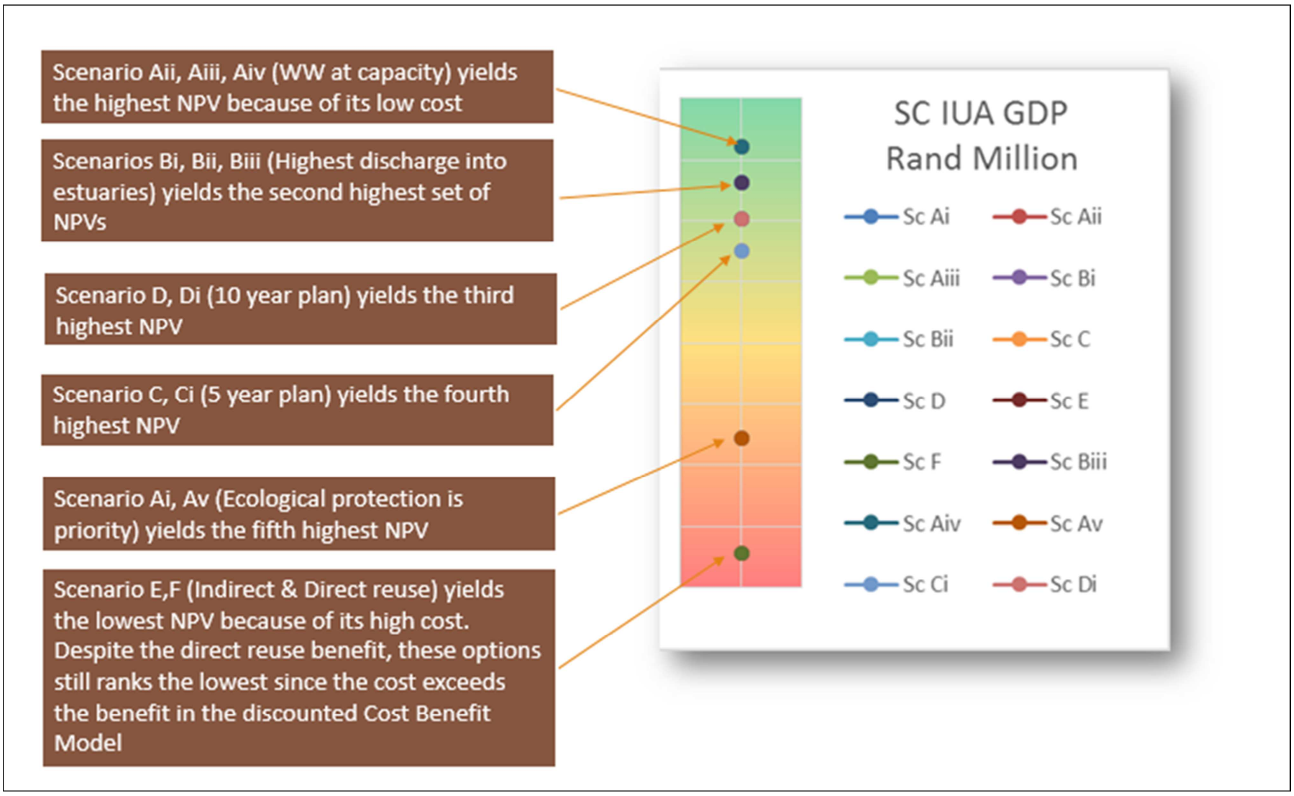


Figure 4.3 Southern Cluster GDP Ranking

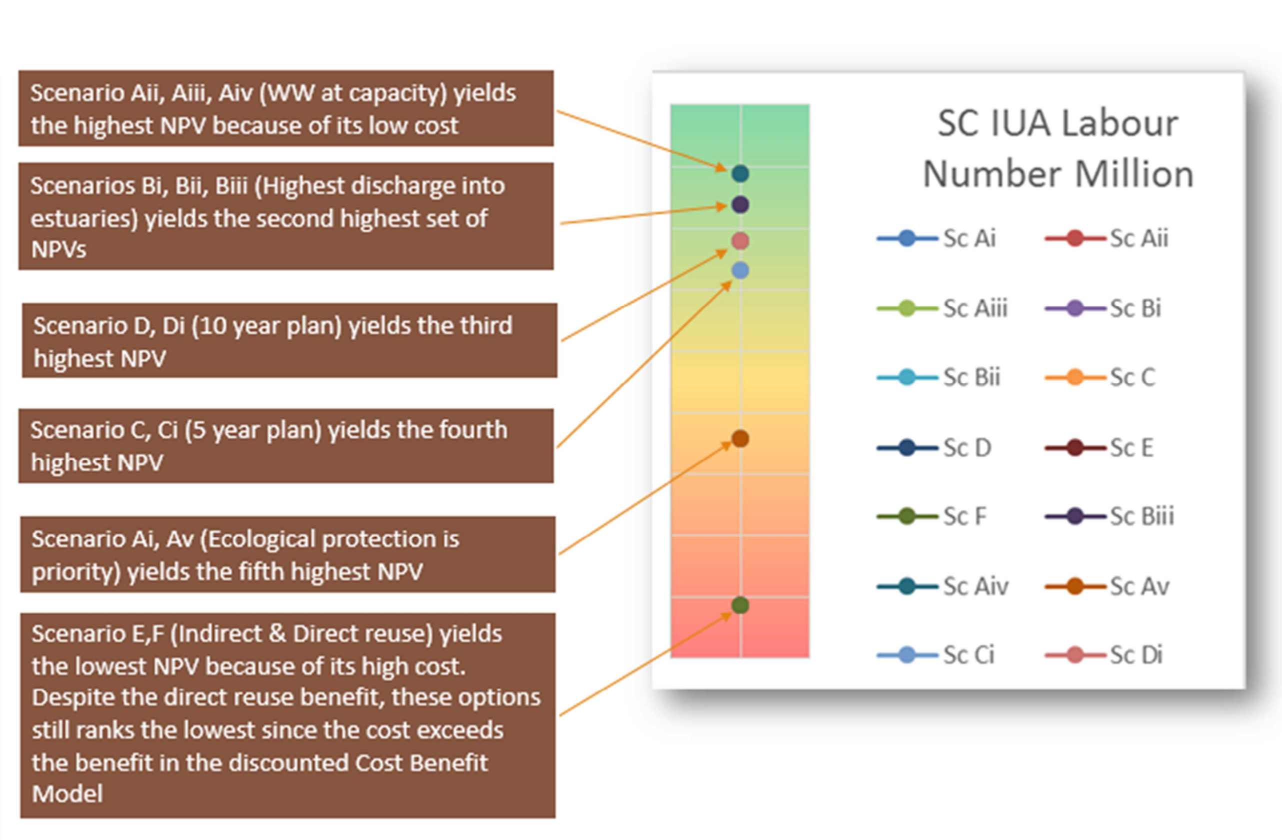


Figure 4.4 Southern Cluster Employment Ranking

4.6 NORTHERN CLUSTER IUA RESULTS

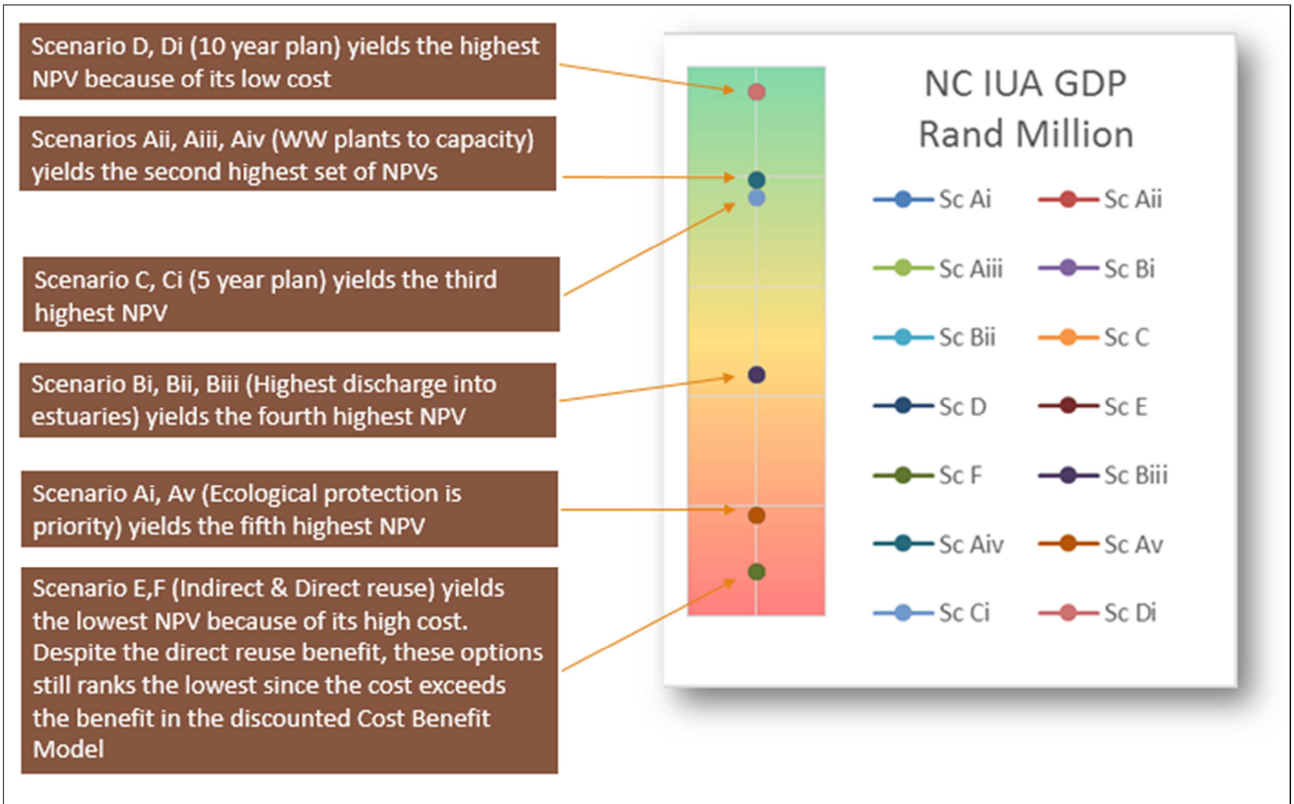


Figure 4.5 Northern Cluster GDP Ranking

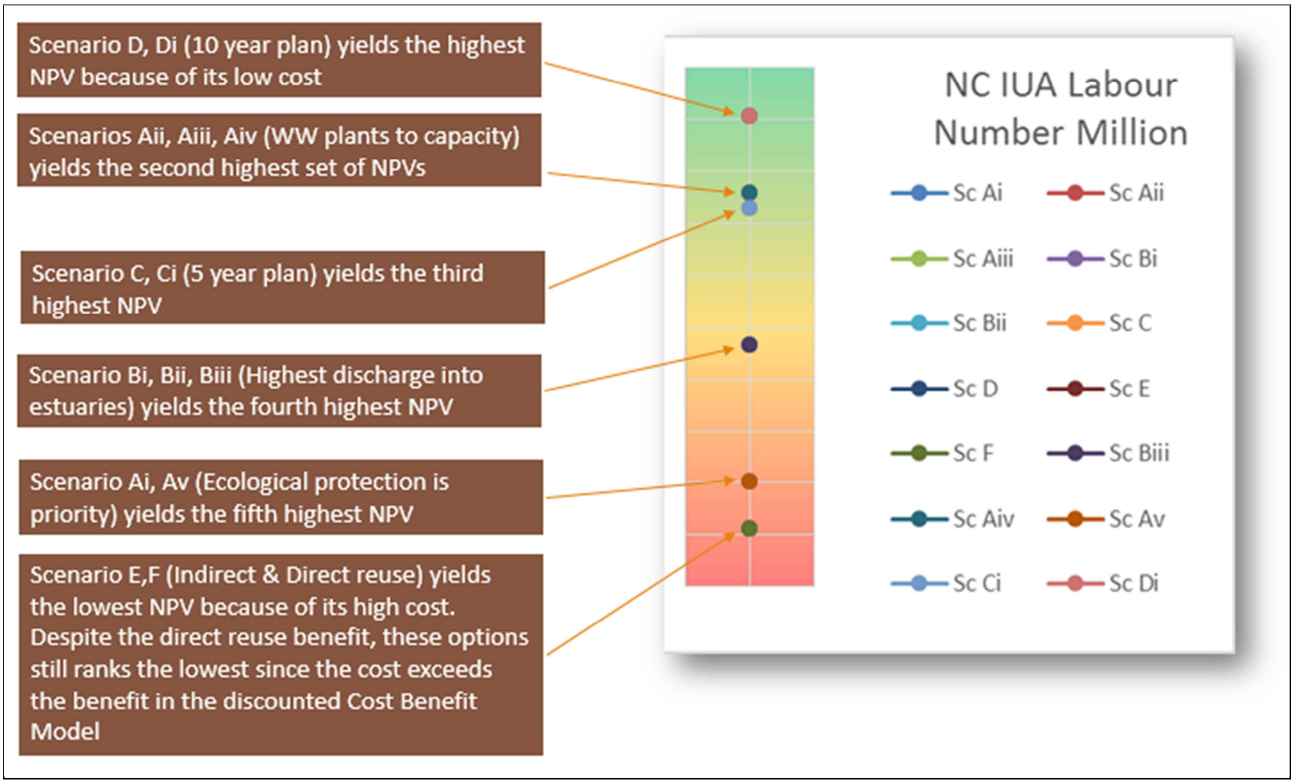


Figure 4.6 Northern Cluster Employment Ranking

4.7 CONCLUSION

The various operational scenarios all present positive answers and should all make a positive contribution to the economic growth and employment creation in the four catchments. The final preferred option will depend on the interaction between the economic values, the goods and services and the environmental impacts.

5 ECOLOGICAL CONSEQUENCES (RIVERS)

Apart from the uMkhomazi and Mvoti Rivers, the only other rivers where scenarios have been evaluated are the uMngeni and Lovu Rivers (DWS, 2014c).

The scenarios are described in DWS (2014b). The ecological consequences are summarised in Table 5.1. The first column provides the ECs for each component at the EWR site. The second column provides the ranking of the scenarios. The third column includes a short explanation of the consequences and ranking.

Table 5.1 Lovu and uMngeni River Systems: Summary of ecological consequences at the EWR sites

Ecological consequences as ECs	Ecological consequences	Ranked scenarios	Ranking rationale

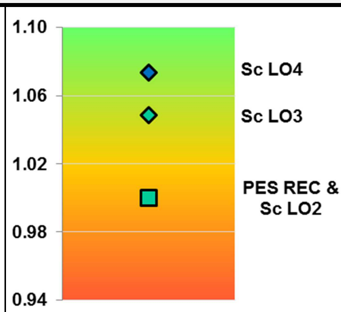
Lo_R_EWR (LOVU RIVER)

Ecological consequences as ECs

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

Ecological consequences: 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.

Ranked scenarios:



Ranking rationale: 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.

MG_I_EWR2 (UMNGENI RIVER)

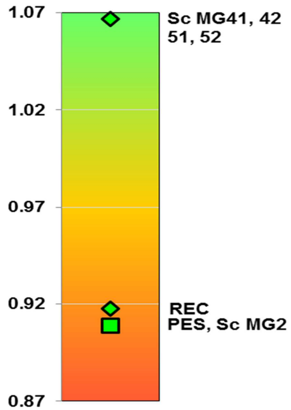
Ecological consequences as ECs

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

Ecological consequences: 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.

Ranked scenarios:

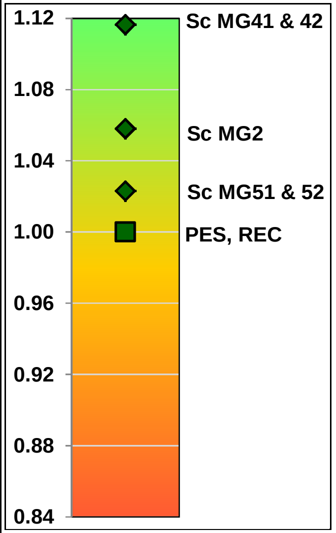


Ranking rationale: The objectives are set to maintain the PES but to improve the fish. The problems with fish are partly due to the presence of alien fish, migratory barriers, flow changes and water quality problems. Scenarios only effect the last two issues. These (flow & quality) are improved by all 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.

The individual site rankings are illustrated in Figure 5.1.

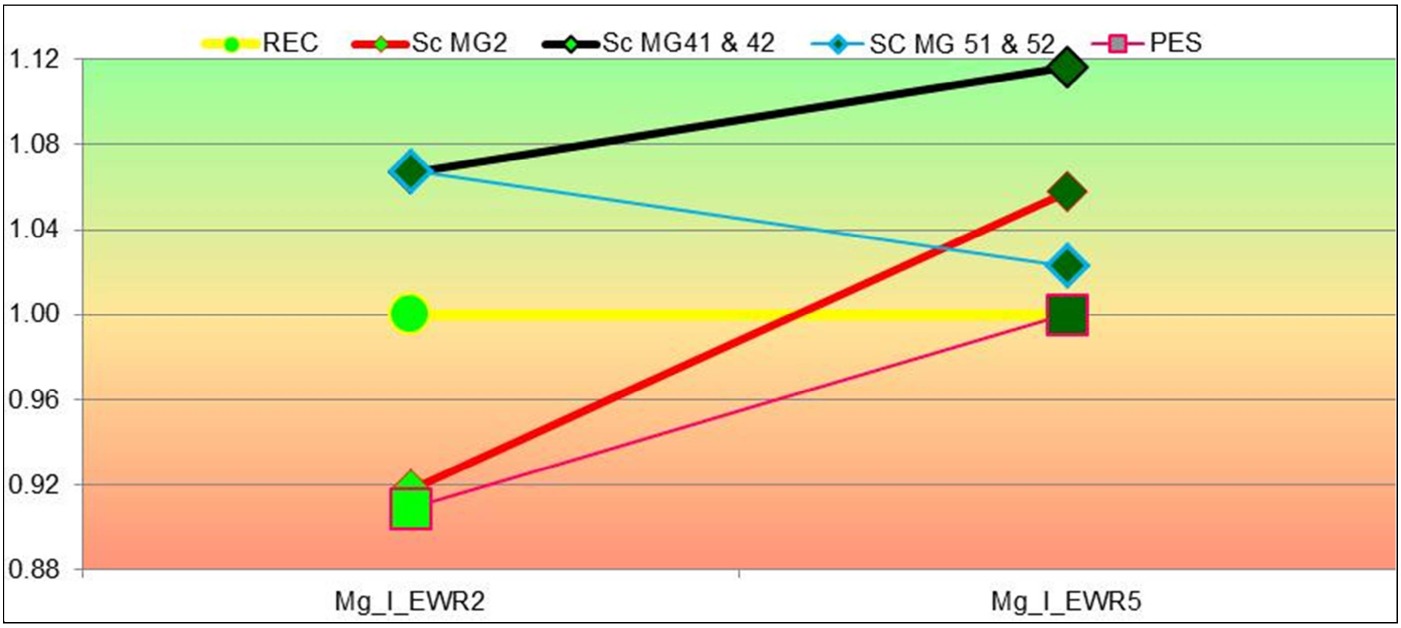


Figure 5.1 uMngeni River system: Ranking of scenarios

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 5.2) indicates that the weight between the sites is similar. Mg_I_EWR2 carries the highest weight due to its PES and being situated in a private nature Reserve.

The weights are provided in the Table 5.3. The weight is based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 5.2 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
Mg_I_EWR2	C	Moderate	2	3.5	0.52
Mg_I_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 5.4 after the weights have been taken into account.

Table 5.3 uMngeni River system: Ranking value for each scenario resulting in an integrated score and ranking

EWR site	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 5.2) 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 WRC determination is summarised in **Error! Reference source not found.**.

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.

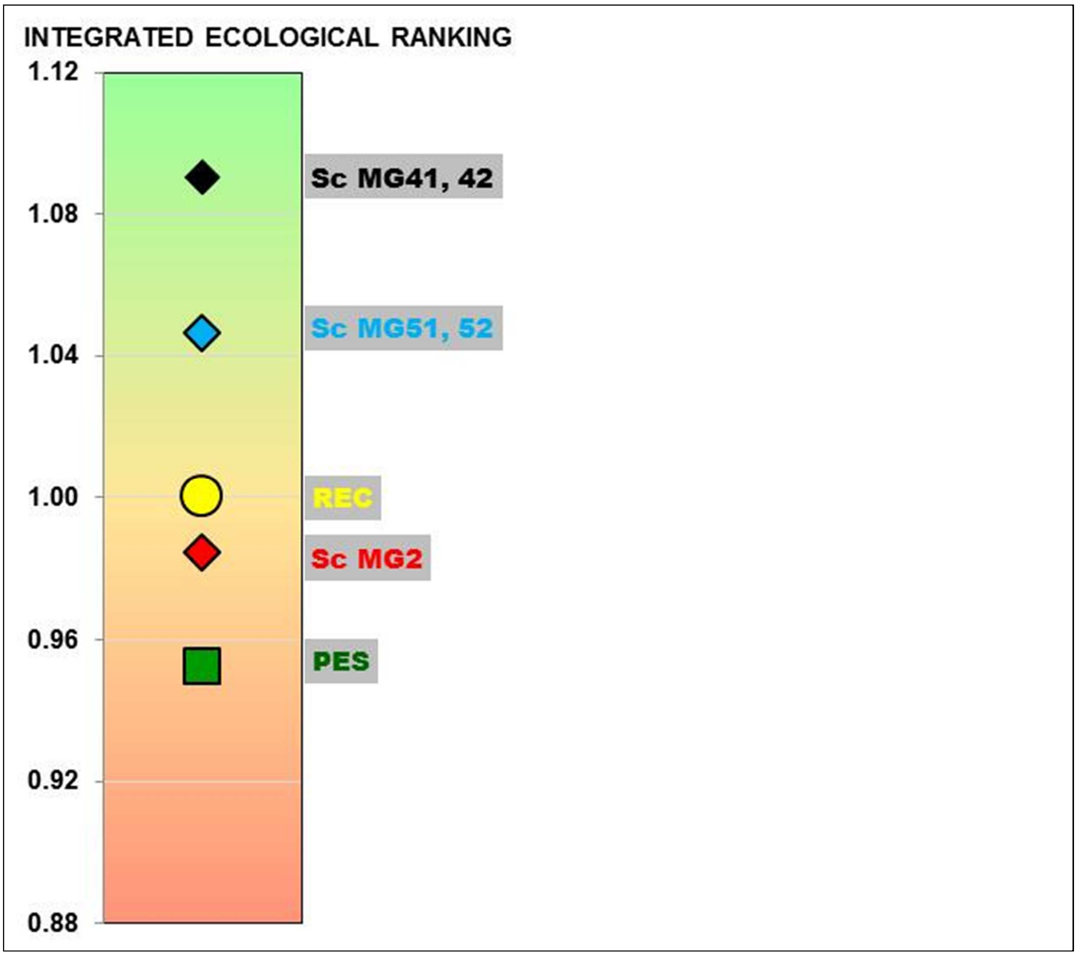


Figure 5.2 Ranking of scenarios for the uMngeni River system

6 ECOLOGICAL CONSEQUENCES: (ESTUARIES)

6.1 SUMMARY OF INDIVIDUAL ESTUARY ASSESSMENT RESULTS

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 6.1.

6.1.1 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.

6.1.2 Central Cluster IUA

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:

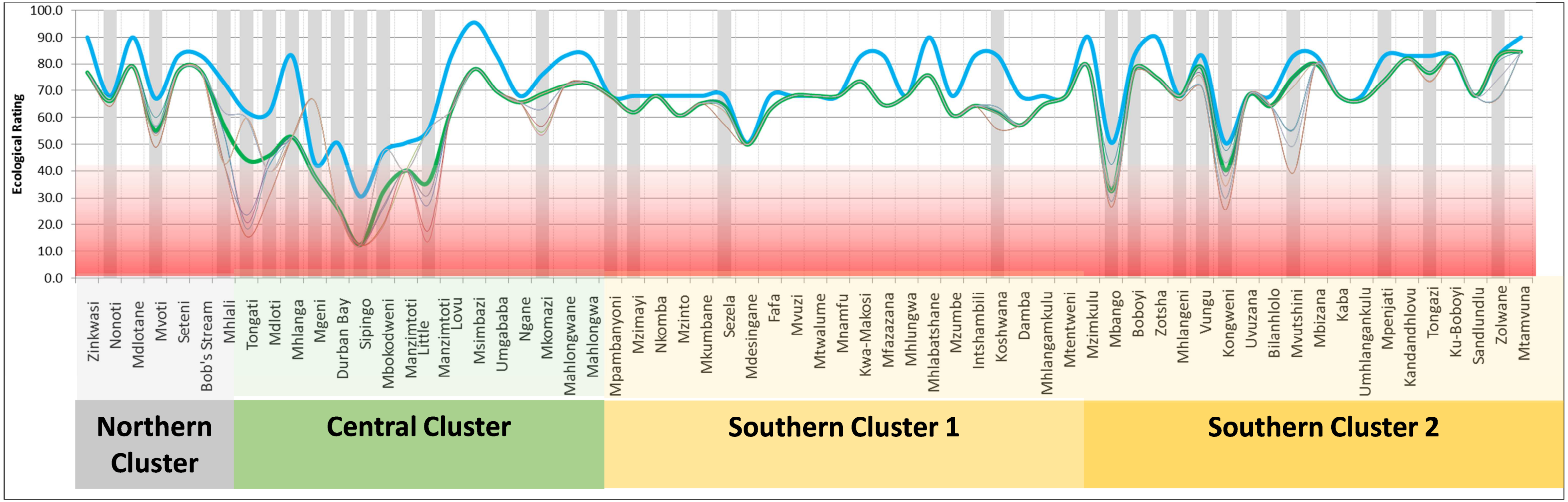
- **uThonghathi:** The estuary is at present in fair state (PES = D). The estuary showed some sensitivity to the level of treatment, with Level 1 treatment generally being much worse than Level 2 and Level 2a treatment. Under Sc A1 (no WWTW discharges) the estuary increases in condition to a Category 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.

Implications and details of waste water management interventions relating to these findings can be found in eThekwini Metropolitan Municipality, 2015.

6.1.3 Northern Cluster IUA

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.



Grey bars represent systems with existing WWTW.

Figure 6.1 Summary of the PES, REC and scenario consequences for the estuaries of the Mvoti to Umzimkulu WMA

6.2 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 through the process described in Chapter 2. The results are provided below and illustrated on traffic diagrams in Figure 6.2.

6.2.1 Southern Cluster IUA

The following was concluded from the catchment-scale operational scenario assessment for the Southern Cluster (Figure 6.2):

- Overall, the scenario configuration Ai maintains the PES, while scenarios C, D, E, F, Di, Ei and Ci reduce the Southern Cluster estuaries condition.
- 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.

6.2.2 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 condition.
- 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.

6.2.3 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.

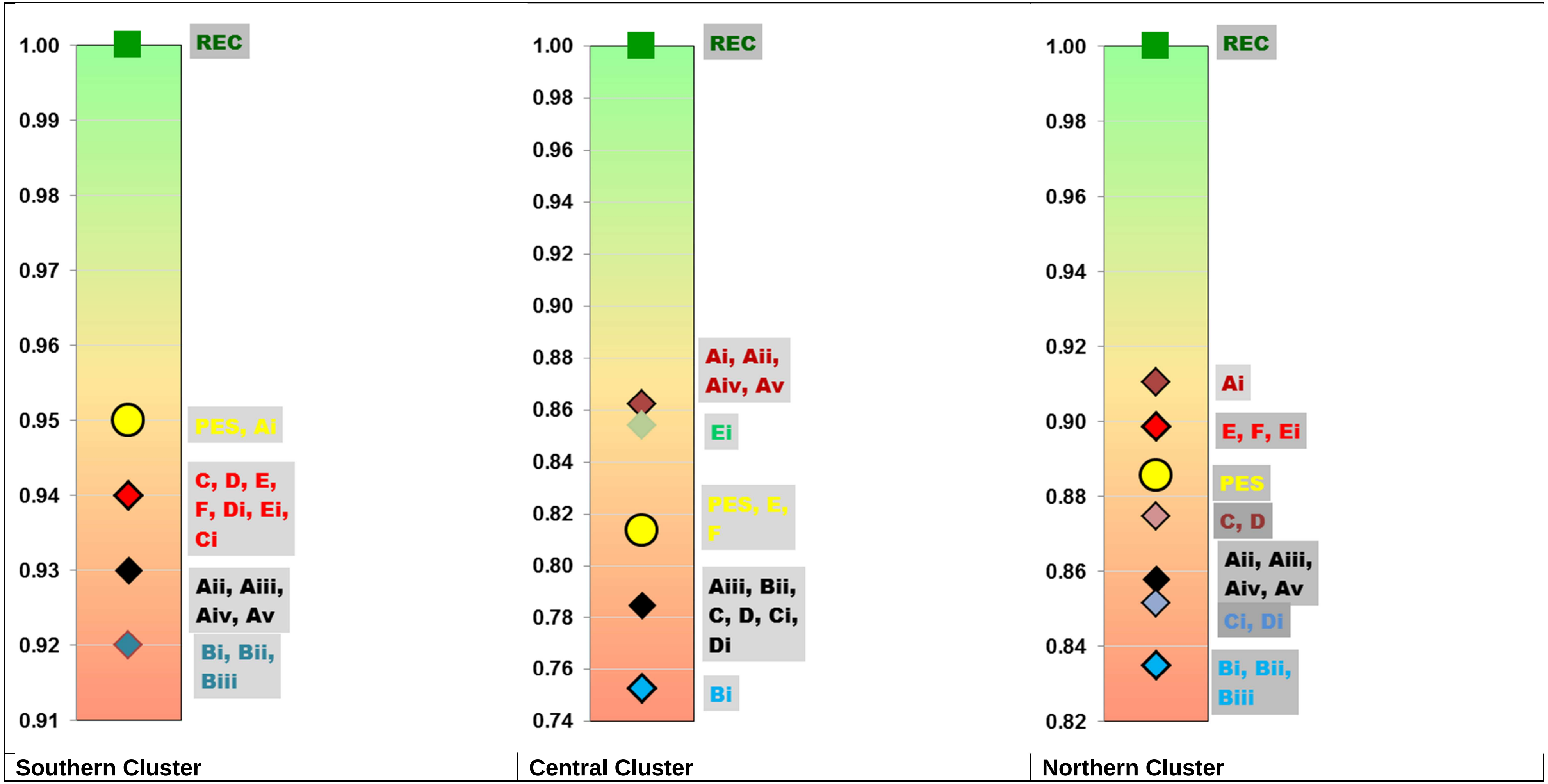


Figure 6.2 Summary of the operational scenario consequences in relation to the REC for the estuaries of the Mvoti to Umzimkulu WMA

7 ECOSYSTEM SERVICES CONSEQUENCES

This section examines the results of the analysis of the potential consequences of scenarios on Ecosystems Services following the method as described in Section 2.2.3. The results of the scenario analysis on the Lovu River and the uMngeni River is set out first. This is followed by the overall analysis of the remaining estuaries that were potentially subject to development scenarios and as described in Section 6 above.

7.1 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 7.1). 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 7.1 Lovu River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystems Services at the LO_R_EWR1

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**

7.2 uMNGENI RIVER SYSTEM

7.2.1 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 allocated 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 7.2). Scenario MG2 would likely result in a static level of Ecosystems Services, 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 7.2 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystems Services 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**

7.2.2 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 allocated 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 7.3). Scenario MG41 would likely result in a static level of Ecosystems Services, 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 Sc MG41 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 7.3 uMngeni River System: Ranking value for each scenario resulting in an integrated score and ranking for Ecosystems Services 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**

7.3 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 waste water 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 waste water 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 status. However, declines in state will occur under the worst case waste water 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.
- **Mvutshini:** 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.
- **Thongazi:** 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 the Table 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 7.4 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
Thongazi	10	Limited importance
Mhlangeni	10	Recreational
Vungu	**12**	Recreational
Mpambanyoni	**12**	Recreational
Kongweni	**15**	Aesthetic, recreational use
Score	**100**	

Figure 7.1 below summaries the relative ranking of all scenarios in the SC of estuaries. Scenarios in the B group 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

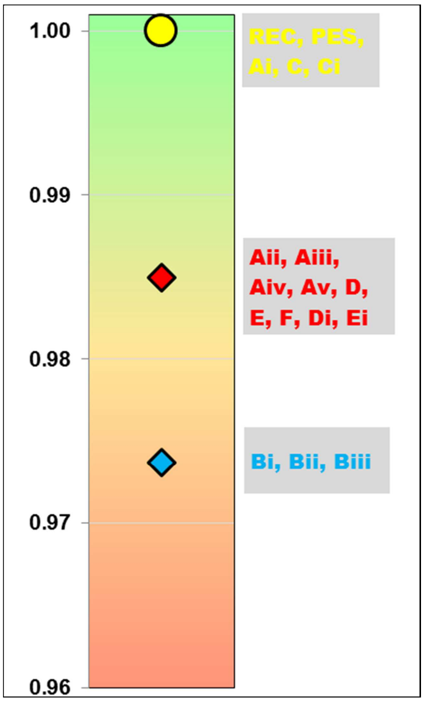


Figure 7.1 Ranking of impact of scenarios in the Southern Cluster

7.4 ESTUARIES: CENTRAL CLUSTER IUA

- **uThongathi:** The estuary showed some sensitivity to the level of treatment. Under Sc A1 (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's open water area 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. As with the uThongathi, a substantial increase in WWTW discharges will negatively impact on ecosystem services.
- **Mbokodweni:** The system is at present in a poor condition. The system improves significantly if WWTW effluent is reduced and/or removed from the system. Under the 55 Ml/d Scenario at all three levels of effluent treatment, the system will maintain PES. Under the 85 Ml/d the estuary show a severe decline in condition to a Category E/F.
- **Little Manzimtoti:** The system is at present in a poor condition. The system improves significantly if WWTE effluent is reduced and/or removed. Under the 8 Ml/d Scenario, at all three levels of effluent treatment, the system will maintain the PES. Under the 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. 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 estuary. Even the 5 Ml/d scenario, 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. Under the other scenarios contact recreation, harvesting of invertebrates and estuarine vegetation will fish potentially suffer 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 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 7.5 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 7.2 below summaries the relative ranking of all scenarios in the CC of estuaries. Most A group scenarios maintain and improve the current Ecosystems Services state. Taking into account that the uMkhomazi is the most important, the range of Sc A and Sc 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.

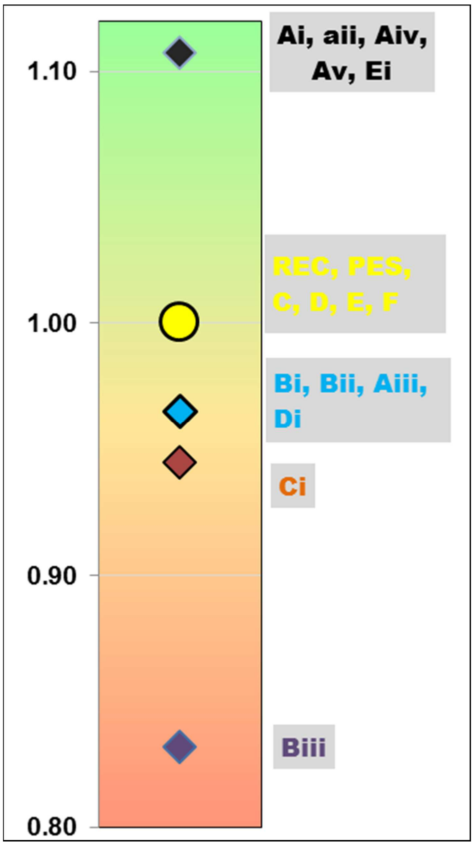


Figure 7.2 Ranking of impact of scenarios in the CC

7.5 ESTUARIES: NORTHERN CLUSTER IUA

- **Mhlali:** A group of scenarios that either maintain current state or have increased waste water shows an improvement due to overall improvement in ecological functioning. Scenarios that impact negatively on water quality and mouth closure show negative Ecosystems Services for invertebrate and fish presence.
- **Mvoti:** All the waste water 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 waste water 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 Table 7.6. 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 7.6 Relative Importance of Estuaries

Estuary	Weight	Motivation
Mhlali	28	**Aesthetic and Recreational use**
Mvoti	27	Average score
Nonoti	45	Aesthetic
Score	**100**	

Figure 7.3 below summaries the relative ranking of all scenarios in the NC of estuaries. Again the B group scenarios are the most negative in terms of impact.

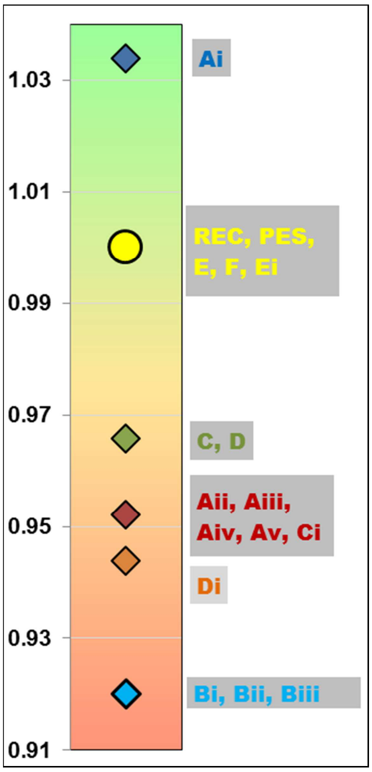


Figure 7.3 Ranking of impact of scenarios in the NC

8 INTEGRATED MULTI-CRITERIA ANALYSIS RESULTS

The results of the rating, weighting and scoring for the four variables, Economy, Employment, Ecology and Ecosystem Services presented in the previous chapters were integrated to obtain the overall ranking of the scenarios as described in this chapter. Provision was made in this process to incorporate all the biophysical nodes in each of the IUAs.

Integrated MCA models were compiled respectively for the SC1, SC2, CC and NC IUAs as defined Table 3.5. Note that the original SC IUA was split into two IUAs due to its large number of estuaries (41) and because there is a distinct difference in ecological state and therefore WRCs between the southern and northern estuaries in the original IUA.

8.1 SOUTHERN CLUSTER IUA: INTEGRATED SCENARIO RANKING RESULTS

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment are presented graphically in Figure 8.1. The scenarios presented are identified in accordance with their labels presented in Table 3.6. Note that only the scenarios that are relevant for the discussion and decision making process are listed. The scenarios not shown provided intermediate perspectives for evaluation purposes and were superseded by other scenarios during the analysis process. The four individual graphs shown in Figure 8.1 have the following interpretation:

- **Ecological Status relative to REC:** This is the measure of how each scenario's ecological status is ranked relative to the REC. As indicated **Sc Bi (highest waste water flow into estuaries)** has the lowest ecological score while **Sc Ai (minimum discharge into estuaries)** the highest and the other scenarios in between.
- **Ecosystem Services:** The score indicates to what extent each scenario changes the Ecosystem Services relative to the present conditions. The ranking order is similar to the Ecological Status.
- **Economic Indicator (GDP):** This metric represents GDP in Rands with **Sc Aii and Bi** ranking the highest and the **Sc E and Sc Ai** the lowest.
- **Employment:** The number of people employed is indicated by the metric with **Sc Aii and Bi** ranking the highest and the **Sc E and Sc Ai** the lowest.

The lines depicted in Figure 8.1 connect the variable points for a scenario and when opposing consequences are observed (among the variables) the lines cross. This indicates opposing outcomes of the variables and an overall (variable rating x variable weight = integrated score) will define (mathematically) the optimum solution – "the desired balance between protection and use".

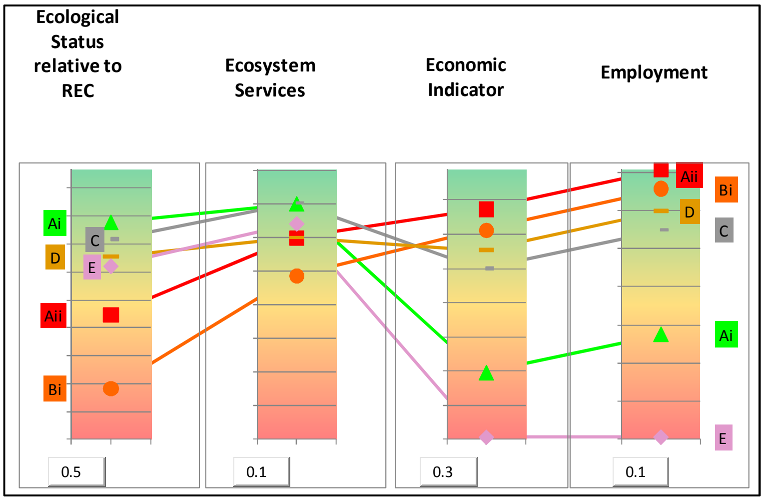


Figure 8.1 Southern Cluster IUA: Graphical results of individual variables

The final step in the MCA was to determine the integrated and overall rank of the scenarios and this is depicted in Figure 8.2 for the normalised ranking methods

The relative weight applied to each variable for calculating the overall ranking is indicated numerically at the bottom of each bar graph. Each weight has a value between zero and one and a set of selected weights for all four variables must add up to one. The rationale for the weights selected is to assess what the balance is between the ecological health and the socio-economic benefits, therefore a weight of 0.5 (or 50%) is assigned to the ecology and the remaining 50% is divided among the other three variables; Ecosystem Services (10%), Economy (30%) and Employment (10%).

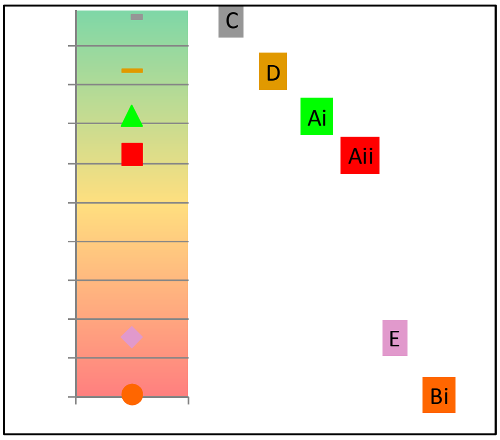


Figure 8.2 Southern Cluster IUA: Graphical results of overall ranking from the MCA

In order to determine how sensitive the ranking results are for alternative weight settings, Table 8.3 provides scenario ranking results for a range of variable weights. **Scenario C** is ranked first for most of the alternatives and only differs where weight for the ecology is less than 0.3 and GDP to 0.7. The analysis result is therefore not sensitive for different variable weights.

Table 8.1 Southern Cluster IUA: Sensitivity analysis of scenario ranking for alternative variable weights

Weights					Normalisation Ranking Method) (1 = Best, 6 = Worst)					
Alternative	Ecology	Ecosystem Services	GDP	Jobs	Ai	Aii	Bi	C	D	E
1	0.50	0.10	0.30	0.10	3	4	6	**1**	2	5
2	0.50	0.15	0.15	0.20	2	4	6	**1**	3	5
3	0.50	0.10	0.20	0.20	3	4	6	**1**	2	5
4	0.50	0.05	0.20	0.25	3	4	5	**1**	2	6
5	0.50	0.05	0.15	0.30	3	4	5	**1**	2	6
6	0.50	0.05	0.30	0.15	4	3	5	**1**	2	6
7	0.50	0.05	0.20	0.25	3	4	5	**1**	2	6
8	0.50	0.10	0.40	0.00	3	4	6	**1**	2	5
9	0.50	0.00	0.40	0.10	4	3	5	**1**	2	6
10	0.50	0.00	0.50	0.00	4	3	5	**1**	2	6
11	0.40	0.10	0.40	0.10	4	3	5	**1**	2	6
12	0.30	0.20	0.40	0.10	4	3	5	**1**	2	6
13	0.30	0.10	0.50	0.10	4	3	5	**1**	2	6
14	0.30	0.00	0.70	0.00	5	**1**	4	3	2	6

The ranking results indicate that Sc C and then Sc D provide the best solution. These scenarios incorporated moderate increases in waste water discharges (allow for short term and medium term increases) and thereafter alternative measures of discharge need to be implemented.

8.2 NORTHERN CLUSTER IUA: INTEGRATED SCENARIO RANKING RESULTS –

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment are presented graphically in Figure 8.3. The scenarios presented are identified in accordance with their labels presented in Table 3.6. Note that only the scenarios that are relevant for the discussion and decision making process are listed. The scenarios not shown provided intermediate perspectives for evaluation purposes and were superseded by other scenarios during the analysis process.

The four individual graphs shown in Figure 8.3 have the following interpretation:

- **Ecological Status relative to REC:** This is the measure of how each scenario's ecological status is ranked relative to the REC. As indicated **Sc Bi (highest waste water flow into estuaries)** has the lowest ecological score while **Sc Ai (minimum discharge into estuaries)** the highest and the other scenarios in between.
- **Ecosystem Services:** The score indicates to what extent each scenario changes the Ecosystem Services relative to the PES conditions. The ranking follows largely the same ranking order as that for the Ecological Status.
- **Economic Indicator (GDP):** This metric represents GDP in Rands with **Sc D, Aii and C** ranking the highest and the **Sc E and Ai** the lowest.
- **Employment:** The number of people employed is indicated by the metric with **Sc D, Aii and C** ranking the highest and the **Sc E and Ai** the lowest.

The lines depicted in Figure 8.3 connect the variable points for a scenario and when opposing consequences are observed (among the variables) the lines cross. This indicates opposing outcomes of the variables and an overall (variable rating x variable weight = integrated score) will define (mathematically) the optimum solution – "the desired balance between protection and use".

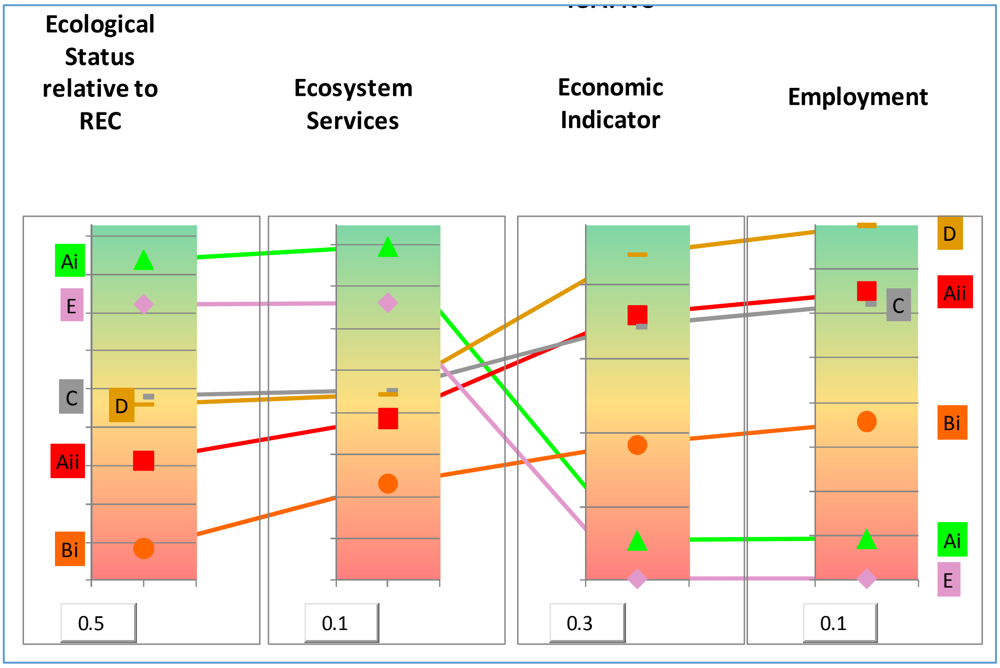


Figure 8.3 Northern Cluster IUA: Graphical results of individual variables

The integrated rank of the scenarios is depicted in Figure 4.8 for the normalised ranking methods.

The relative weight applied to each variable for calculating the overall ranking is indicated numerically at the bottom of each bar graph. Each weight has a value between zero and one and a set of selected weights for all four variables must add up to one. The rationale for the weights selected is to assess what the balance is between the ecological health and the socio-economic benefits, therefore a weight of 0.5 (or 50%) is assigned to the ecology and the remaining 50% is divided among the other three variables; Ecosystem Services (10%), Economy (30%) and Employment (10%).

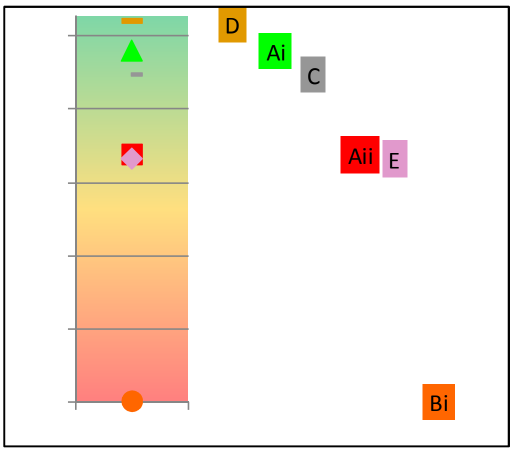


Figure 8.4 Northern Cluster IUA: Graphical results of overall ranking from the MCA

In order to determine how sensitive the ranking results are for alternative weight settings, Table 8.6 provides scenario ranking results for a range of variable weights. **Scenario D** is ranked first for most alternatives. The analysis result is therefore not sensitive for different variable weights.

Table 8.2 Northern Cluster IUA: Sensitivity analysis of scenario ranking for alternative variable weights

Weights					Normalisation Ranking Method) (1 = Best, 6 = Worst)					
Alternative	**Ecology**	**EcoSystem Services**	**GDP**	**Jobs**	Ai	Aii	Bi	C	D	E
1	0.50	0.10	0.30	0.10	2	4	6	3	**1**	5
2	0.50	0.15	0.15	0.20	**1**	5	6	3	2	4
3	0.50	0.10	0.20	0.20	2	4	6	3	**1**	5
4	0.50	0.05	0.20	0.25	3	4	6	2	**1**	5
5	0.50	0.05	0.15	0.30	3	4	6	2	**1**	5
6	0.50	0.05	0.30	0.15	3	4	6	2	**1**	5
7	0.50	0.05	0.20	0.25	3	4	6	2	**1**	5
8	0.50	0.10	0.40	0.00	2	4	6	3	**1**	5
9	0.50	0.00	0.40	0.10	4	3	6	2	**1**	5
10	0.50	0.00	0.50	0.00	4	3	6	2	**1**	5
11	0.40	0.10	0.40	0.10	3	4	6	2	**1**	5
12	0.30	0.20	0.40	0.10	3	4	6	2	**1**	5
13	0.30	0.10	0.50	0.10	4	3	6	2	**1**	5
14	0.30	0.00	0.70	0.00	4	3	5	2	**1**	6

The ranking results indicate that **Sc D** provide the best solution. This scenario incorporated moderate increases in waste water discharges (allow for short term and medium term increases) and thereafter alternative measures of discharge need to be implemented.

8.3 CENTRAL CLUSTER IUA: INTEGRATED SCENARIO RANKING RESULTS

The scenario scores for the four variables, Ecology, Ecosystem Services, Economy and Employment are presented graphically in Figure 8.5. The scenarios presented are identified in accordance with their labels presented in Table 3.6. Note that only the scenarios that are relevant for the discussion and decision making process are listed. The scenarios not shown provided intermediate perspectives for evaluation purposes and were superseded by other scenarios during the analysis process.

The four individual graphs shown in Figure 8.5 have the following interpretation:

- **Ecological Status relative to REC:** This is the measure of how each scenario's ecological status is ranked relative to the REC. As indicated **Sc Biii (highest waste water flow into estuaries and treatment to current nutrient removal standards)** has the lowest ecological score while **Sc Ai (minimum discharge into estuaries)** the highest and the other scenarios in between.
- **Ecosystem Services:** The score indicates to what extent each scenario changes the Ecosystem Services relative to the PES conditions. The ranking follows largely the same ranking order as that for the Ecological Status.

- **Economic Indicator (GDP):** This metric represents GDP in Rands with **Sc Bii, Di** and **Ci** ranking the highest and **Sc F** the lowest.
- **Employment:** The number of people employed is indicated by the metric with **Sc Bii, Di** and **Ci** ranking the highest and **Sc F** the lowest.

The lines depicted in Figure 8.5 connect the variable points for a scenario and when opposing consequences are observed (among the variables) the lines cross. This indicates opposing outcomes of the variables and an overall (variable rating x variable weight = integrated score) will define (mathematically) the optimum solution – “the desired balance between protection and use”.

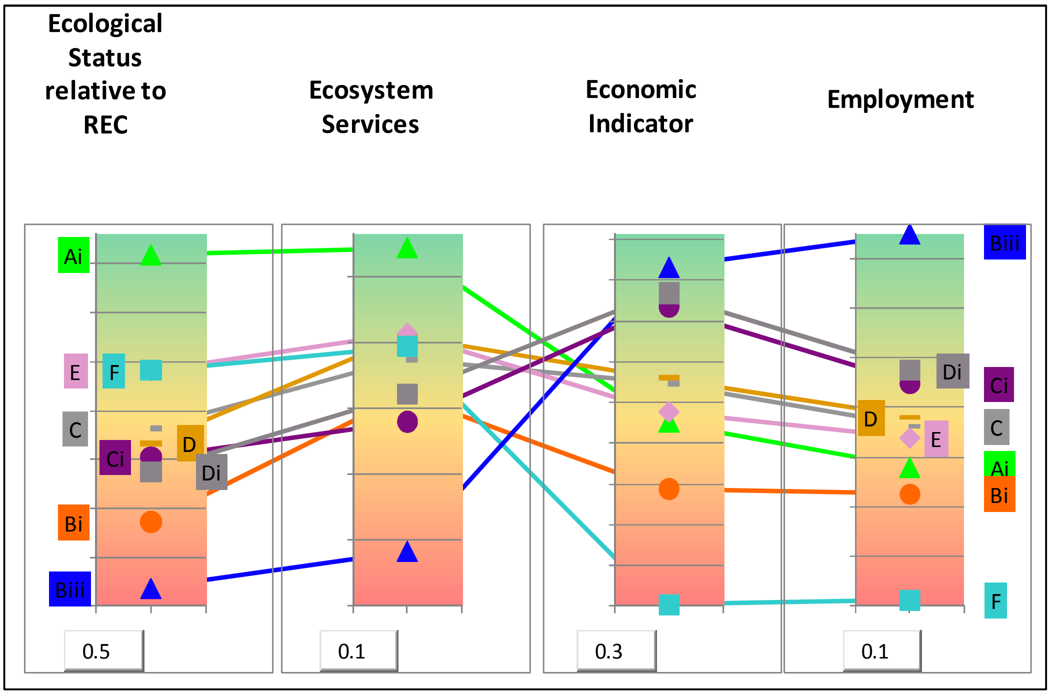


Figure 8.5 Central Cluster IUA: Graphical results of individual variables

The final step in the MCA was to determine the integrated and overall rank of the scenarios and this is depicted in Figure 8.6 for the normalised ranking methods

The relative weight applied to each variable for calculating the overall ranking is indicated numerically at the bottom of each bar graph. Each weight has a value between zero and one and a set of selected weights for all four variables must add up to one. The rationale for the weights selected is to assess what the balance is between the ecological health and the socio-economic benefits, therefore a weight of 0.5 (or 50%) is assigned to the ecology and the remaining 50% is divided among the other three variables; Ecosystem Services (10%), Economy (30%) and Employment (10%).

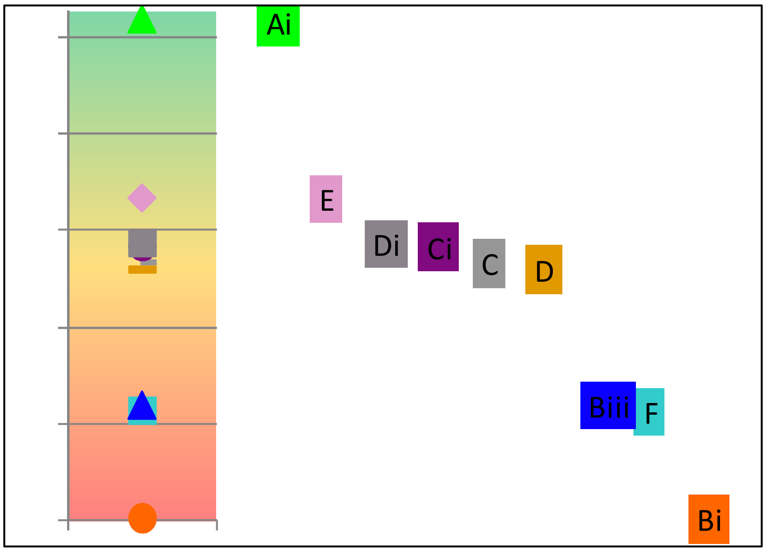


Figure 8.6 Central Cluster IUA: Graphical results of overall ranking from the MCA

The resulting integrated scores show that **Sc Ai** is raked the best, this is driven by the large improvement in the ecological score of **Sc Ai** compared to the other scenarios as illustrated in Figure 8.6 coupled with the weight of 0.5 applied to the ecological variable.

The second best ranked scenarios are all forming a cluster (**Sc E, Di, Ci, C** and **D**) with only small differences in the integrated tanking results.

Scenario Ai, however requires that most waste (including the current discharges) be disposed of through alternative measures (such as marine outfall works) which will be a major activity requiring large capital outlays over the short term. In addition, **Sc F** (indirect reuse) has substantial lower GDP and Employment ratings while the ecological rating is similar to **Sc E** (indirect reuse) (note that **Sc F** implies 365 Ml/day of waste water is treated to such levels appropriate for direct reuse see (eThekwini Metropolitan Municipality, 2015)).

A further MCA was compiled excluding **Sc Ai** and **F**, as discussed below.

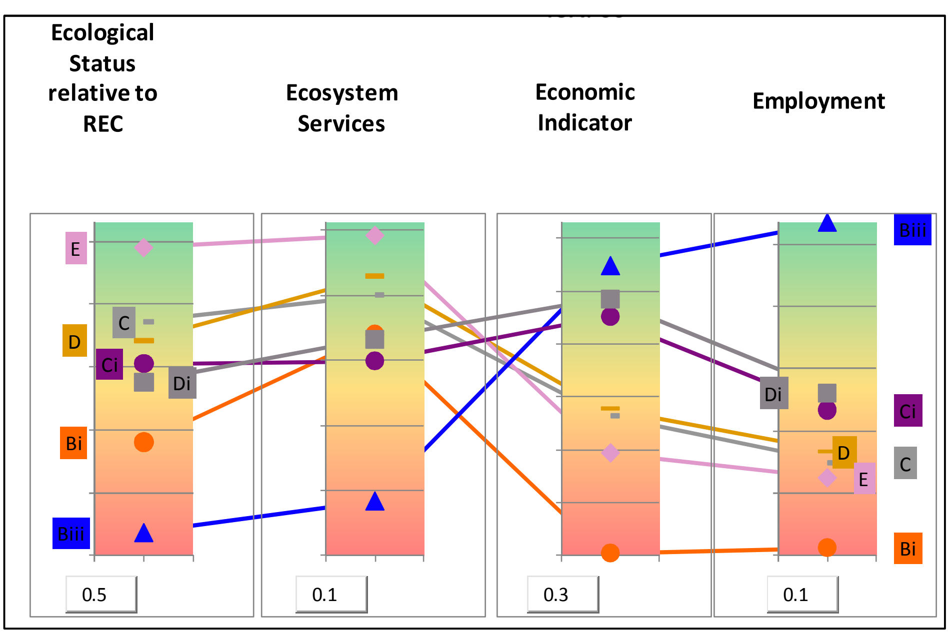


Figure 8.7 Central Cluster scenario subset: Graphical results of individual variables

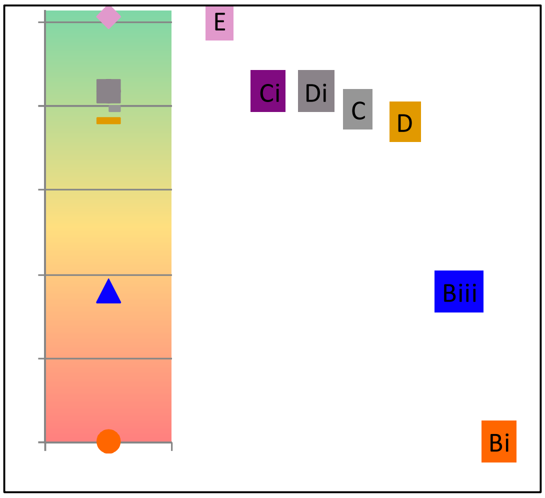


Figure 8.8 Central Cluster scenario subset: Graphical results of overall ranking from the MCA

Scenario E (indirect reuse) ranks the best followed by **Sc Ci, Di, C** and **D** forming a cluster with small differences in ranking results among them. **Scenario E** (indirect reuse) represents a major intervention only affecting the southern two estuaries in the CC (uThongathi and uMdloti). The other scenarios in the second ranking cluster allow for increases (growth) in waste water discharges after which alternative discharge measures need to be implemented to dispose of additional waste water. Note that **Sc E** represents indirect reuse of treated waste water via Hazelmere Dam of 130 Ml/day.

A further MCA was prepared where the scenarios for only the northern two estuaries (uThongathi and uMdloti) in the CC were compared as presented in Figures 8.9 and 8.10.

Scenario E and **Ai** ranks the best, followed by the cluster of **Sc Ci, F, C, Di** and **D**. The indirect reuse option (**Sc E**) was configured such that all the water from the uThongathi waste water works be piped and pumped to Hazelmere Dam, while all the uMdloti waste water disposed of through a marine outfall. It was however recognised, based on the ecological evaluations of various scenarios, that the ecological health rating for the uMdloti Estuary could be improved by increasing the flow (discharging waste water) - in the order of 50Ml/day.

An alternative scenario was therefore formulated (**Sc Gi**) where **Sc E** was adjusted to allow a portion of the waste water from the uMdloti to be discharged into the river and estuary and the remainder through a marine outfall (albeit with a reduced volume). The ranking results of the scenarios, including **Sc Gi**, are presented in Figures 8.11 and 8.12. Note that the Economic and Employment variables for **Sc Gi** were the same as for **Sc E**. It is assumed the results for these two variables would be an improvement to **Sc E** and therefore even further improve the overall ranking of **Sc Gi**. In summary **Sc Gi** is representative of the waste water management option where in the order of 50 Ml/day of waste water is discharged into uMdloti, the remainder to a sea outfall, and all waste water from the uThongathi catchment piped and pumped to Hazelmere Dam, which requires both a sea outfall and a return pumping scheme to Hazelmere Dam.

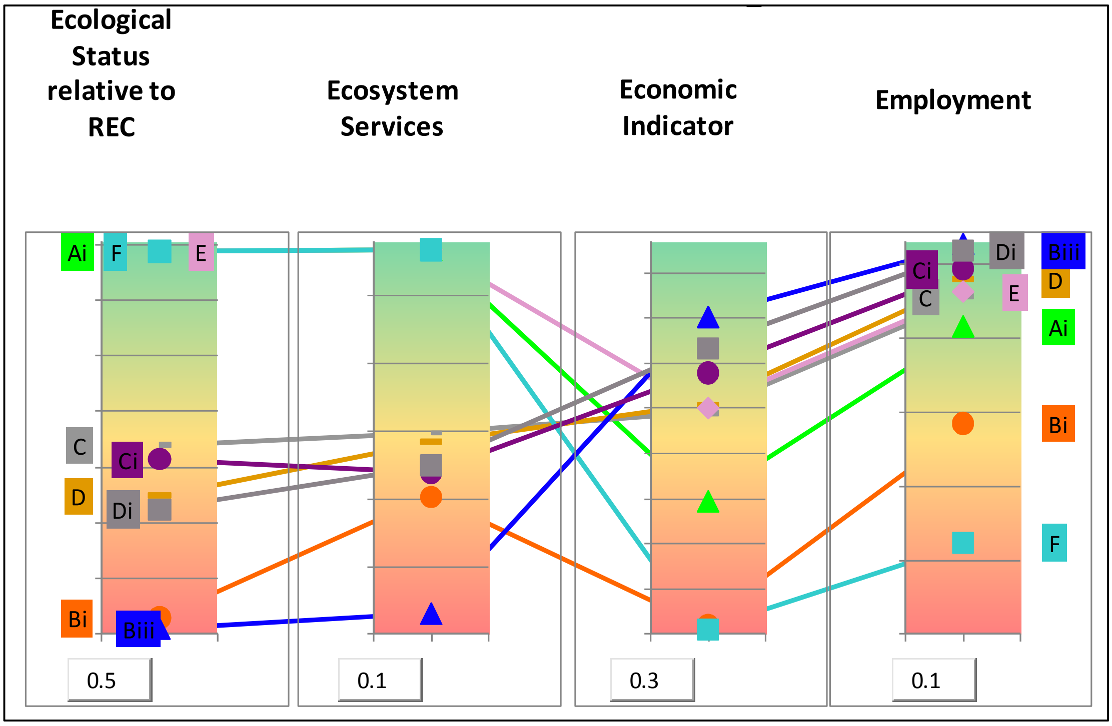


Figure 8.9 uThongathi and uMdloti: Graphical results of individual variables

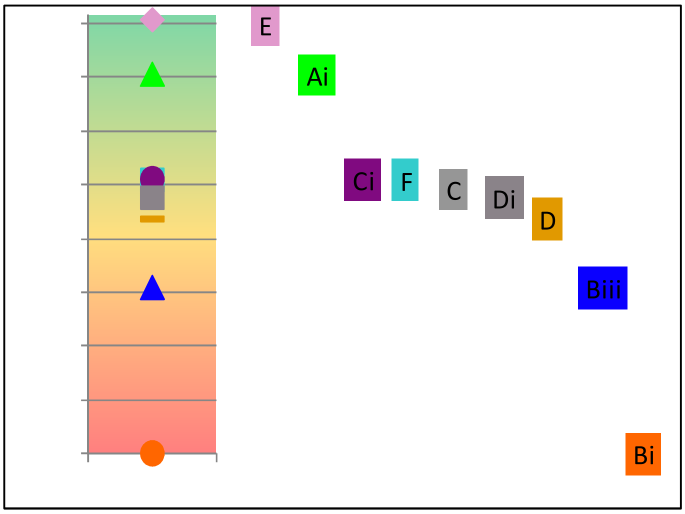


Figure 8.10 uThongathi and uMdloti: Graphical results of overall ranking from the MCA

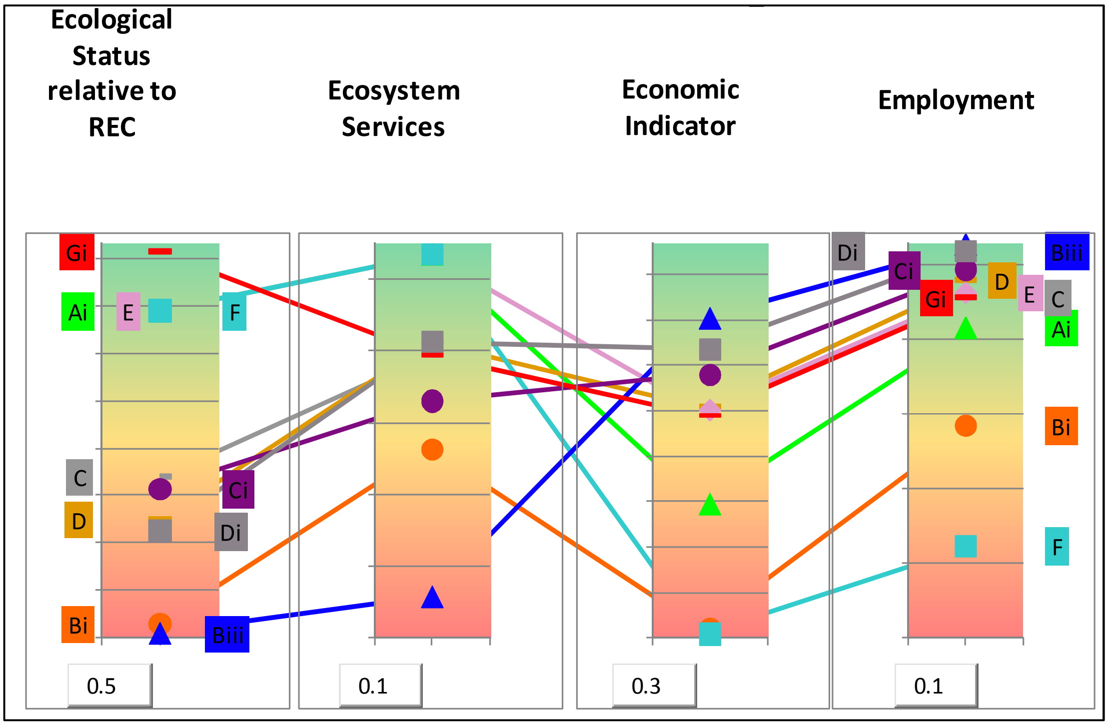


Figure 8.11 uThongathi and uMdloti: Graphical results of individual variables with Scenario Gi

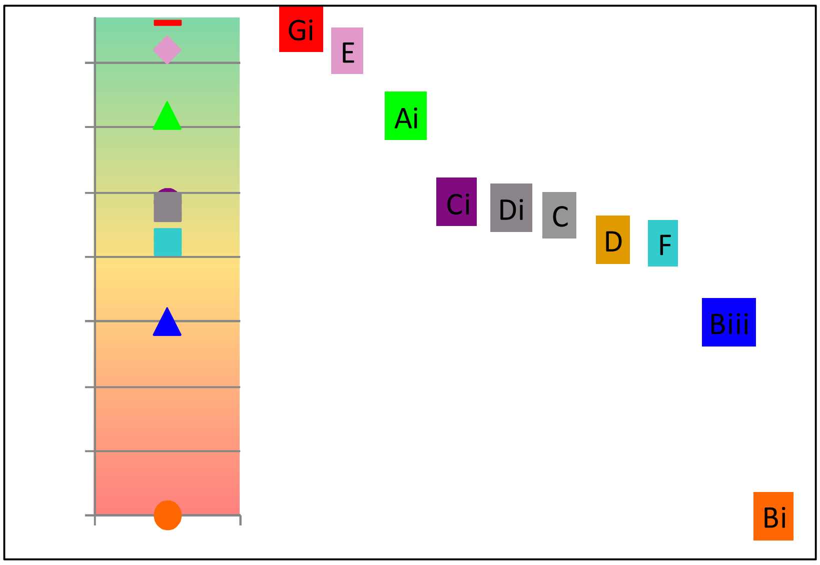


Figure 8.12 uThongathi and uMdloti: Graphical results of overall ranking from the MCA with Scenario Gi

Indirect reuse (**Sc E** and **Gi**) requires further planning (feasibility investigations) and will take several years to implement. However, the current pleasure for urban development in the uThongathi River area requires waste water management and disposal facilities in the short term. To bridge this planning gap it is therefore proposed that treatment and discharge into the uThongathi River takes place over the short term which may reduce the EC of the estuary to an E. Over the long term either indirect reuse or a marine outfall will be implemented to achieve an EC of a C/D.

The approach for the uMdloti estuary is that increased waste water can be discharged into the estuary towards the point where it starts degrading. In the short term, the EC may drop while

Hazelmere Dam is being raised and fully utilised and in the long term EC will be increased by adding additional treated waste water.

Further discussions on the proposed approach for the other estuaries affected by waste water discharges in the CC are provided in Section 9.4.

8.4 CONCLUDING REMARKS

When interpreting the results and considering the discussions of the MCA as presented in the previous sections, a strategic approach emerges where limited additional waste is allowed to be discharged over the short to medium term while current waste water management practices are adapted in order to provide protection of the estuaries over the long term. At a strategic level this approach gives water service providers and water service authorities the opportunity to adapt waste water management planning in order to comply with the proposed protection levels over the long term.

9 WATER RESOURCE CLASS AND CATCHMENT CONFIGURATION

The WRC and catchment configuration results are the recommendations that were presented at the Project Steering Committee Meeting held during September 2015 for consultation with the stakeholders after which the final scenario and results will be prepared for gazetting.

9.1 WATER RESOURCE CLASS CRITERIA TABLE

A range of alternative water resource criteria settings (alternative to the guideline criteria presented in Table 2.4) were evaluated by the study team leading to the recommended criteria parameters presented in Table 9.1.

Table 9.1 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 to both rivers and estuaries and the resulting WRCs and catchment configuration are provided in the next sections.

9.2 DETERMINATION OF THE CATCHMENT CONFIGURATION

The catchment configuration for an IUA is expressed as an EC for every biophysical node. These ECs are referred to as the Target Ecological Category (TEC). In the process to make recommendations regarding the WRC 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 socio-economic implications can result in the TEC being any category below the REC. According to the above guideline (Table 9.1), it could also be less than a D category. Any TEC less than a D is referred to as an EF.

The steps to decide on a recommended catchment configuration and TECs are as follows:

- Evaluate PES and REC and interventions required to achieve the identified REC.
- Evaluate implications of interventions.
- Identify best compromise/balance scenarios.
- Compare ecological consequences to the REC.
- Considering all consequences, derive a TEC (focus on immediate applicability).
- Provide implications of the TEC for future development and use in the system.
- Present for stakeholder input.

9.3 RIVER IUAs: WATER RESOURCE CLASSES AND CATCHMENT CONFIGURATION

9.3.1 Water Resource Classes: T4, T5, U2, U3, U6, U7, U8

When applying the criteria presented in Table 9.1 to the resulting ECs for the PES, REC and TEC, the WRCs for the 19 IUAs are listed in Table 9.2.

Table 9.2 Resulting IUA WRCs for each scenario: T4, T5, U2, U3, U6, U7, U8

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
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
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

The IUAs in the table are those where operational scenarios were either not evaluated, or had no impact. The table therefore includes only the PES and REC scenarios. Of the 19 IUAs indicated in this table, there are 21% Class I; 37% in Class II and 42% in Class III.

There are two IUAs in the uMngeni (U2-4) and the uMlazi (U6-3) where the WRC requires non-flow related improvements to achieve the WRC. Note that there are many other nodes in the catchment configuration that require improvements, but these did not impact on the WRC. The recommendations for the WRC are therefore set as a combination of the PES and REC. There are no implications for any users or the ecology.

9.3.2 Catchment Configuration: T4, T5, U2, U3, U6, U7, U8

Given the results and scenario selections presented in the section above, Table 9.4 provides respectively the proposed WRC and TECs for the IUAs and biophysical nodes. The red blocks in Table 9.4 indicate the TECs which are an improvement on the PES.

It must be noted that various river nodes require improvements (Table 9.3) based 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 (Table 9.4) and is then referred to as the TEC.

Table 9.3 River Nodes requiring improvements in T4, T5, U2, U3, U6, U7 and U8

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 (small).	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
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 (water quality) and town runoff.	B
	U20C-04190	Lions	B/C	B	Interbasin transfer 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 – reinstating wetland buffers.	B
	U20D-04151	Karkloof	B/C	B	Reinstate riparian buffer zone and wetland buffers.	B
U2-4	Mg_R_EWR4	uMnsunduze	D/E	D	Water quality improvement.	D
	U20J-04452	Mpushini	B/C	B	Water quality improvement from Ashburton amongst others.	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	uMdloti	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
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
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

The catchment configuration associated with the PES/REC combination is provided below. The TECs associated with the REC requires no new infrastructure development and is therefore immediately applicable.

Table 9.4 Catchment configuration: TECs and WRCs

IUA	WRC	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	Umzimkulu	27.4	B
		T51A-04522	Mzimude	34.2	B
		T51A-04608		3.0	B
		T51A-04551	Mzimude	16.1	B
		T51B-04421	Umzimkulu	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	Umzimkulu	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	Gungunu	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	Gungunu	30.7	B
		T51H-04884	Gungunu	10.1	B/C

IUA	WRC	Nodes	River	Length (Km)	TEC
		T51H-04908	Gungununu	3.1	B/C
		MzEWR3i	Umzimkulu	21.4	B
		T52B-04947	Cabane	46.4	B
		T52C-04880		15.9	C
		T52C-04960	Umzimkulu	4.8	B
		T52D-05024	Ncalu	20.4	B
		T52D-05061	Mgodi	26.3	B
		T52D-04948	Umzimkulu	50.6	B
		T52D-05137	Umzimkulu	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	Umzimkulu	133.2	A/B
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
		U20G-04215	Cramond Stream	3.8	B/C

IUA	WRC	Nodes	River	Length (Km)	TEC
		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
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

IUA	WRC	Nodes	River	Length (Km)	TEC
		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_Estuary	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	uMngeni	20.1	B

It is proposed to gazette the WRCs and catchment configuration as above for the immediate applicable TECs.

9.4 ESTUARY IUAs: WATER RESOURCE CLASSES AND CATCHMENT CONFIGURATION

9.4.1 Water Resource Classes: Estuary IUAs

When applying the criteria presented in Table 9.1 to the resulting ECs for each scenario, the WRCs for the four IUAs are as listed in Table 9.5.

Table 9.5 Estuary IUAs: Resulting WRCs

IUA	WRC		
	PES	REC	TEC
SC1	I	I	I
SC2	II	II	II
CC	XXX[1]	III	III
NC	III	II	III

1 XXX depicts that the IUA does not comply with a WRC of III.

9.4.2 Catchment Configuration: Estuary IUAs

Given the results and scenario selections presented in the section above, Table 9.10 provides respectively the proposed WRC and ECs for the Estuary IUAs. The red outlined TEC blocks indicates TECs which are an improvement of the PES.

It must be noted that various estuaries require improvements based on non flow-related/anthropogenic issues that have to be addressed to achieve the REC. The attainability of the improvement is considered and leads to the EC associated with the WRC. This EC is referred to as the TEC. All estuaries requiring improvement to achieve the REC is listed in Table 9.6 – 9.9. The improvements required are 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 9.6 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. ▪ Manage agricultural and industrial practices in the catchment.	**B**

Table 9.7 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.	**C**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						▪ 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 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 9.8 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:	**B/C**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						▪ 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.	
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	**EF**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						estuary does not become a health hazard and there is compliance to other relevant legal requirements.	
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. The restoration of this area requires a TEC of a D and is immediately applicable.	**D**
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	**D**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						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.	
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 9.9 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%. ▪ 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.	**C/D**
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.	**B**

Estuary	REC	PES		Sc C	Sc D	TEC motivation	TEC
						▪ 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.	

Table 9.10 Estuary IUAs: WRCs and Catchment Configuration

IUA	WRC	Nodes/Estuaries	River	Length / hectares[1] (km/ha)	TEC
SC 1	I	T40F-05666	Mbizana	6.7	B
		T40G-05616	Vungu	7.5	B
		Mtamvuna		54.15	A/B
		Zolwane		0.44	B
		Sandlundlu		4.73	C
		Ku-Boboyi		0.73	B
		Tongazi		0.73	B/C
		Kandandhlovu		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
		Uvuzana		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
		Mhlangamkulu		2.78	C
		Damba		3.57	D

IUA	WRC	Nodes/Estuaries	River	Length / hectares[1] (km/ha)	TEC
		Koshwana		1.01	C
		Intshambili		0.68	C
		Mzumbe		6.68	C/D
		Mhlabatashane		3.00	B
		Mhlungwa		5.94	C
		Mfazazana		1.08	C
		Kwa-Makosi		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 aManzimtoti	16.51	C
		Amahlongwa		7.64	B
		Mahlongwana		6.53	B
		uMkhomazi		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
		Mmbokodweni		8.75	EF
		Sipingo		0.00	EF
		Durban Bay		0.00	EF
		Durban Bay Shallow Zone		--	D
		uMngeni		84.54	D
		Mhlanga		11.21	B
		uMdloti		28.46	D

IUA	WRC	Nodes/Estuaries	River	Length / hectares[1] (km/ha)	TEC
		uThongathi		3.66	D
NC	III	U30E-04207	Mhlali	25.55	C
		Mhlali		19.26	D
		Bob 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

1 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 WRC.

It is proposed to gazette the WRCs and catchment configuration for the immediate applicable TECs.

9.5 CONCLUSIONS

9.5.1 Southern Cluster 1 IUA

- The TEC = REC at 18 of the 20 estuaries.
- The TEC is an improvement of the PES at three estuaries (i.e. Mtamvua, Mpenjati and Zotsha estuaries).
- Non-flow related measures must be applied to achieve the TEC at three estuaries.
- Zolwane, Tongazi: Scenarios that allow some increase in waste (e.g. Sc C and D) will meet the TEC.
- Mvutshini: Limited additional waste (as per Sc C) will meet the TEC.
- Vungu: Any planned increased waste water must be diverted.
- Kongweni and Mbango: The socio-economic cost will be significant to improve the estuaries (more than half the current waste must be removed) and the estuaries are of low ecological importance. The ecological cost of improvement can also be significant as it may imply that other more important estuaries will not achieve the REC or will degrade from its current state. Further waste can be accommodated in the Kongweni and Mbango estuaries, but estuaries must still comply with all required health standards. This means that criteria other than ecological become the driving criteria to be considered on the volume and quality of waste that can be accommodated.
- WRC is a Class I (based on the estuarine area that is in a B or higher).

9.5.2 Southern Cluster 2 IUA

- The TEC = REC at 16 estuaries of the 21 estuaries.
- The TEC is an improvement of the PES at two estuaries i.e. the REC is partially met (i.e. Koshwana and Mhlatatshane).
- The TEC = PES at three estuaries (Domba, Intshambili and Mfazazane).
- Non-flow related measures must be applied to achieve the TEC at five estuaries.
- Sezela: Limited additional water (as per Sc C) will meet the TEC.
- WRC is a Class II (based on the estuarine area that is in a C or higher).

9.5.3 Central Cluster IUA

- The TEC = REC at six of the 16 estuaries.
- The TEC is an improvement of the PES at four estuaries i.e. the REC is partially met (i.e. Lovu, Umgababa, uMkhomazi and Sipingo).
- This means that the TEC is an improvement of the PES for 10 estuaries (i.e. aMahlongwa, Mahlangwana, uMkhomazi, Umgababa, Lovu, aManzimtoti, Sipingo, Durban Bay Shallow water and intertidal zone, Mgeni and Mhlanga).
- The TEC is the same as the PES but does not meet the REC at four estuaries (i.e. Umgababa, Msimbazi, uMdloti and uThongathi).
- The TEC falls within the EF EC at four estuaries (all three estuaries have a PES of an EF).
- Non-flow related measures must be applied to achieve the TEC at the Umhlanga, uMngeni, aManzimtoti, Mahlongwana and Mhlungwa estuaries.
- The EWR must be implemented at uMngeni and the pumping scheme must be operated to achieve the existing EWR for Umhlanga.
- uMkhomazi: No further waste must enter the estuary. The proposed Smithfield Dam with appropriate operating rules will comply with the TEC.
- Little Manzimtoti and Mbokodweni: The cost to improve these estuaries to a D is significant and the estuaries are of lower importance than others. Further waste can be accommodated, but estuaries must still comply with all required health standards. This means that criteria other than ecology become the driving criteria.
- uMdloti: Increased waste water can be discharged in the estuary towards the point where it starts degrading. In the short term, the TEC is likely to drop while Hazelmere Dam is being raised and fully utilised and the long term TEC achieved (e.g. Sc Gi).
- uThongathi: Re-use all waste water (via Hazelmere Dam). In the long term, the TEC will therefore be met. In the short term, further discharge must be allowed in the estuary while alternative options for waste are being developed. This means that it the short term, the estuary will stay in the EF category, but will then improve in the long term to the TEC (e.g. Sc Gi).

In Summary:

- The WRC associated with the REC is also the recommended WRC of a III.
- The WRC under current conditions do not comply with a WRC III due to the large estuarine areas in a Category below a D.
- The WRC of a III can be achieved through the recommendations summarised in previous sections and it is especially important that a large estuary such as the uMngeni achieves the TEC. If not, the WRC will not be met.

9.5.4 Northern Cluster IUA

- The TEC = REC at four of the seven estuaries (i.e. Bobs Stream, Seteni, Mdlotane and Nonoti).
- The TEC is an improvement of the PES at three of the seven estuaries (one to a B TEC), i.e. the REC is partially met (Mhlali, Mvoti and Zinkwazi).
- The TEC falls below the PES at one estuary.
- Non-flow related measures must be applied to achieve the TEC at the Mvoti, Zinkwazi and Mdlotane estuaries.
- The WRC and TEC allow for increased waste water discharges in the short term to a specific point (e.g. Sc C and D) in the Nonoti and Mvoti. Then alternative measures for additional waste will be required.

- A combination of interventions on the Mvoti estuary must be investigated that will ensure the TEC is achieved when waste water is increased prior to future dam development.

In Summary:
The WRC associated with the REC would be a Class II. This could only be met by:

- Removing new infrastructure at uMhlali.
- Applying all interventions at the Mvoti and removing SAPPI effluent or applying very costly techniques to remove the high organic content.

The above two estuaries are the largest and carry a high weight. As such, to comply with a Class II requirement, they would have to improve from a C/D and/or D to at least a C EC. This would be the least desirable option from a socio-economic viewpoint.

10 REFERENCES

Department of Water Affairs and Forestry (DWAF), South Africa. 2007. Chief Directorate: Resource Directed Measures. Development of the Water Resource Classification System (WRCS) Volume 1 Overview and 7-step classification procedure. October 2006.

Department of Water Affairs and Forestry (DWAF). 2008. Water reconciliation strategy study for the KwaZulu-Natal Coastal Metropolitan areas: Water quality review report. Prepared by DMM Development Consultants, Golder Associates Africa, Kwezi V3 Engineers, WRP Consulting Engineers and Zitholele Consulting. DWAF Report No. PWMA 11/000/00/2609.

Department of Water Affairs (DWA), South Africa. 2011. Classification of Significant Water Resources in the Mvoti to Umzimkulu Water Management Area (WMA 11): Scoping Report. Report No: RDM/WMA11/00/INT/CLA/0112. September 2011.

Department of Water Affairs (DWA), South Africa. 2012. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area. Inception Report. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. September 2012. DWA Report: RDM/WMA11/00/CON/CLA/0112.

Department of Water Affairs (DWA), South Africa. 2013. 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 and Sanitation (DWS), 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 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. 2014b. 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. 2014c. 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 - Ecological Consequences of Operational Scenarios. Prepared by: Rivers for Africa eFlows Consulting (Pty) Ltd. September 2014. DWS Report RDM/WMA11/00/CON/CLA/0514.

eThekwini Metropolitan Municipality, 2015. Study to investigate waste water disposal options for eThekwini Metropolitan Municipality that are aligned with the Classification Process: Summary

Report. Prepared by: WRP Consulting Engineers, CSIR, Golder Associates and Rivers for Africa and supported by Mosaka Economic Consultants and Marine & Estuarine Research.

Kleynhans, C.J. and Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT329-08.

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.

Mullins, D., Botha, J.P., Mosaka, D.D., Jurgens, F.X., Majoro, T.J. and Conningarth Economists. 2014. A Manual for Cost Benefit Analysis in South Africa with Specific Reference to Water Resource Development. Third Edition (Updated and Revised). Prepared for the Water Research Commission. WRC Report No K8/1044/4.

11 APPENDIX A: OPERATIONAL SCENARIO DESCRIPTION

This appendix provides the definitions of all scenarios with the identification labels referenced in the main sections of this report and serves as a lookup reference.

Definition of scenario applied in the comparison and evaluation process

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

Scenario	Scenario Variables							
	Update Water Demands	Update Demands & Return Flows (2022)	Ultimate Development Demands & Return Flows (2040)	EWR	MMTS2	MWP	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[1]	No	Yes	No	No	No
UM42	Yes	No	Yes[2]	No	Yes	No	No	No
UM51	Yes	No	Yes[1]	No	Yes	No	Yes	Yes
UM52	Yes	No	Yes[2]	No	Yes	No	Yes	Yes

1 All future return flows from Phoenix and Mhlanga WWTW to the uMngeni System.
2 All future return flows from Phoenix, Umhlanga and uThongathi WWTW to the uMngeni System

Lovu River Scenarios

Scenario	Scenario Variables			
	Update Water Demands	Ultimate Development Demands & 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

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).

Mvoti River System 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).

Scenarios of levels of waste water 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

12 APPENDIX B: ESTUARY SYNONYM LIST FOR KWAZULU NATAL ESTUARIES

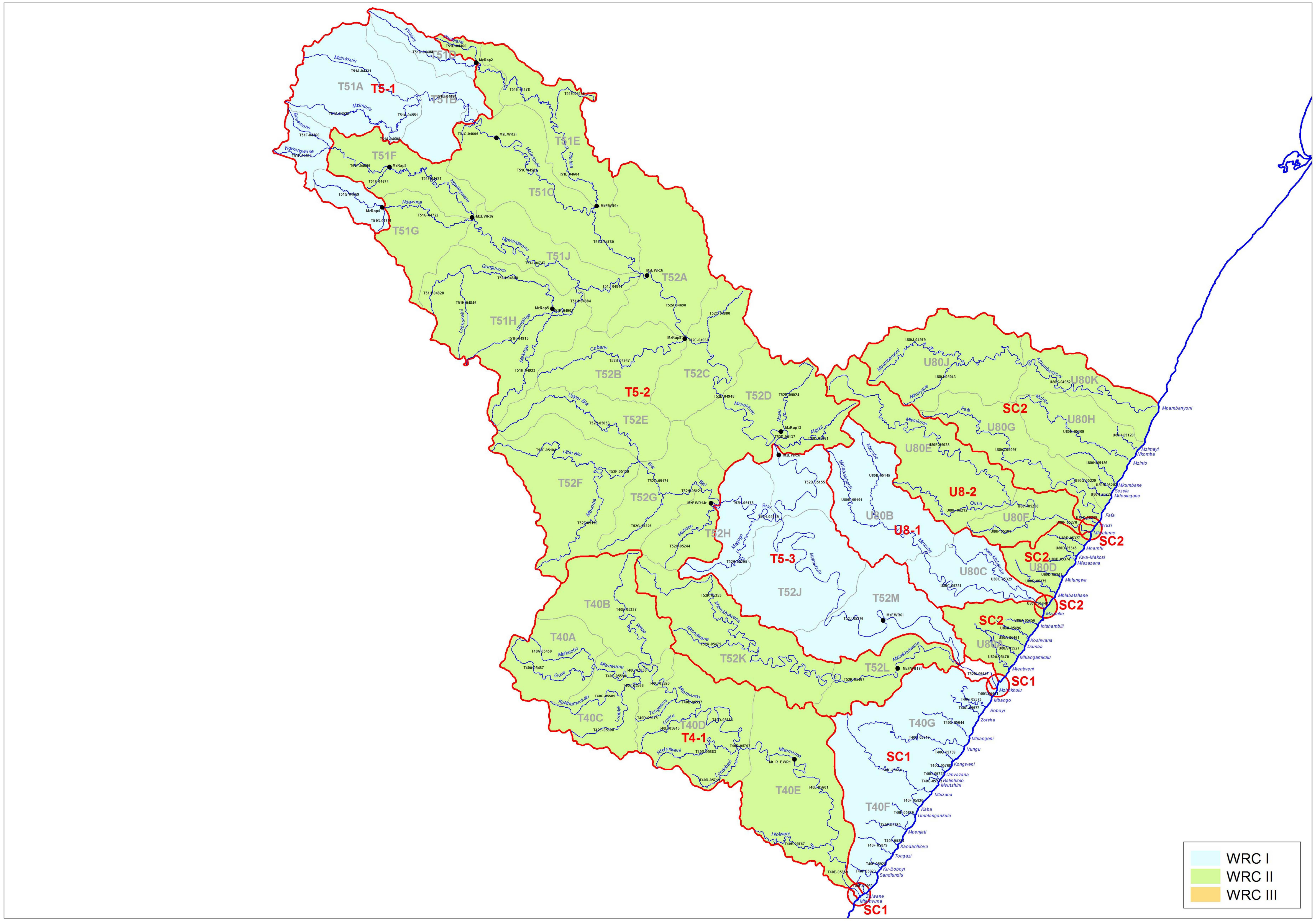
Estuary synonym list for KZN estuaries (Source: B Escott, Ezemvelo KZN Wildlife).

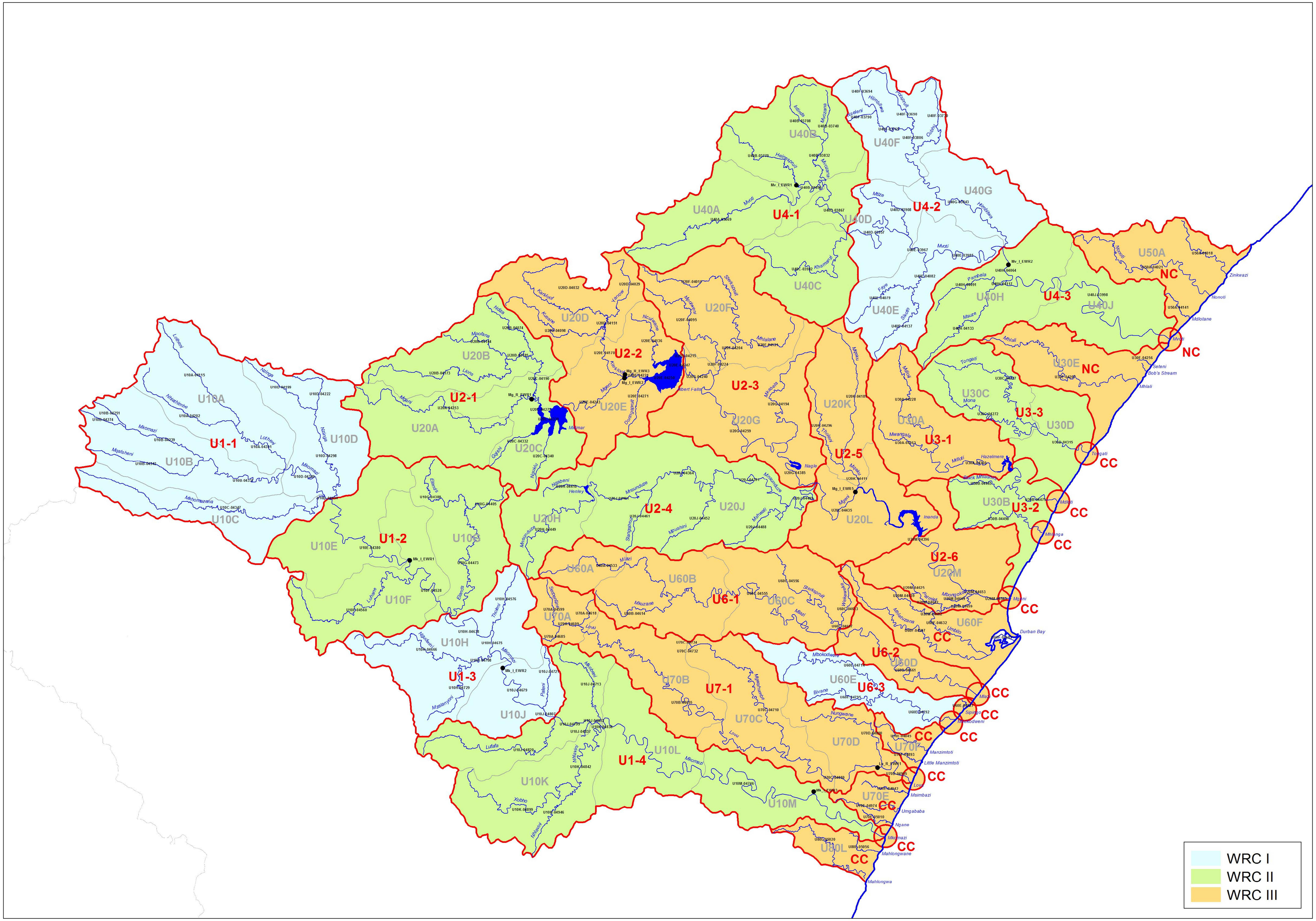
Estuary Name	Synonyms
Bilanhlolo	Ibilanhlolo; Big ibilanhlolo
Bobs Stream	Sharks Bay
Boboyi	Imboyboye
Damba	Domba
Durban Bay	Durban Bayhead
Fafa	iFafa
Intshambili	Ntshambili; Injambili
Isolwane	Zolwane
Kaba	Mkobi; Mkobe; Khaba
Kandandhlovu	Khandandlovu, Kandandlovu, Umkandanhlovu
Kongweni	Inkongweni
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

13 APPENDIX C: IUA MAPS

Two maps follow illustrating the IUAs (outlined in red) and shaded according to the WRC 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
U7-1
U10A
U10B
U10C
U10D
U10E
U10F
U10H
U10J
U10K
U10L
U10M
U20A
U20B
U20C
U20D
U20E
U20F
U20G
U20H
U20J
U20K
U20L
U20M
U30A
U30B
U30C
U30D
U30E
U40A
U40B
U40C
U40D
U40E
U40F
U40G
U40H
U40J
U50A
U60A
U60B
U60C
U60D
U60E
U60F
U70A
U70B
U70C
U70D
U70E
U70F
U80L
NC
CC
WRC I
WRC II
WRC III

14 APPENDIX D: REPORT COMMENTS

Page / Section	Report statement	Comments	Changes made?	Author comment
Bill Pfaff (eThekwini Municipality), (Item references are according to the document with the title: "Ethekwini Water and Sanitation Unit, 28 October 2015, The following is in response to the request for comments on the three reports, volumes 2D, 4 and 7 B."				
		Both suitable plans and tables need to be provided to enable the ready referencing of IUAs and SCs without having to search back through previous reports.	Yes	Maps will be added as appendices. List of tables re: scenarios will be included where relevant.
		The impact of Ingonyama Trust Lands on achieving RQOs has still not been appropriately dealt with. The area of the Ingonyama Trust Lands must be identified in respect of its effect on each 'unit of analysis', and the narrative both record this for each river and resource unit (RU) and how this will impact on the realistic achievement of any RQO set for any particular RU.	Yes	The impact of tribal lands and inadequate sanitation structures can only be considered by evaluating water quality monitoring data and trying to set immediately applicable RQOs with care. It has to be the responsibility of all relevant government departments and other institutions to manage the matter of inadequate infrastructure and impacts on water resources. The issue of tribal lands and their potential impact on non-compliance to RQOs has been highlighted in the report.
		RQOs need to take cognisance of "on the ground" realities. Promulgations can only be supported, and required feasibility and other studies required conducted, if premised by the identification of a set of viable and practical RQOs.	Yes	The practicality of implementing RQOs has been considered in the setting of immediately applicable RQOs, vs. those that cannot be applicable until data are collected and other factors have been considered (i.e. provisional RQOs). It is recommended that discussion around the feasibility and ability to "phase in" certain RQOs will have to be undertaken between DWS and other parties responsible for water resource management.
		1.1 General: Although DWS were always reluctant to give this study the due recognition that eThekwini would have wanted, there does need to be an acknowledgment as and where in these reports the eThekwini data / information is now used	Yes	DWS engaged with eThekwini at the onset of the study and through a joint exploratory (pilot) investigation identified that a key input to the scenario evaluations would be to consider alternative waste water management options in context of the ecological implication thereof on the estuaries. This gave rise to the study that was commissioned by eThekwini to identify and provide information on alternatives at a strategic level of detail which was incorporated in the scenario evaluations in the Classification Study. Relevant references to the eThekwini Study documentation were added to the report along with appropriate cross references in the text where applicable.
		2. Reserve methodology : ecological input to Balance Model 2.1Confidence in Reserve Determinations	No	As indicated in the comments, the need for long term monitoring data remains an objective for water resource management in general and estuaries in particular. However, in order for DWS to progressively implement the Water Resource Classification System in a reasonable timeframe the approach being followed is to apply all available data to

Page / Section	Report statement	Comments	Changes made?	Author comment
				Classify and give priority in setting appropriate levels of protection rather than leaving a void for longer. The alternative, that is to delay Classification until additional recorded data are available, will prevent DWS from giving effect to the water legislation and leave the ecology vulnerable for many more years. In summary, Classification was achieved in the study area by applying all available data and information along with innovative evaluation methods. Further monitoring objective are being defined as part of the Classification process which will allow enhancing current knowledge and future evaluations as to whether or not the objectives are being met or need to be reviewed.
		2.2 Impact of stormwater		Estimates were made of the increased runoff due to paved urban areas when developing the flow time series of the present day using standard hydrological simulation methods. Future storm water management will be different than in the past and highly dependent on future regulations such as the trend to manage and utilise storm water on development sites. The ecological evaluations of the estuaries identified that more detail investigation should be made of the origin and quality of the stormwater and overall catchment quality and relevant recommendations were be made in this regards. It was further recommended that the management approach of stormwater be amended as is the intent of the current legislation of coastal waters
		3. Multi-Criteria Assessment Tool – the Balance Model 3.1 Social input to Balance Model	No	The Employment metric is considered to be a reasonable proxy that provides appropriate differentiation in numeric terms of the implication of the scenarios on the population. This coupled with the Economic and the EcoSystem Services metric reflects the likely macro trends the scenarios will impose. The addition of other metric will most likely follow the same direction of change among the scenarios and since the 50/50 weighting between the ecology and the socio-economic variables remains applicable the outcome of the ranking of the scenarios is expected to be similar. It must be kept in mind that the 50/50 weighting establishes an acceptable precedent between the ecological and socio-economic parameters in a developed option. It is not recommended that this 50/50 guideline be abandoned
		3.2 Economic Input to Balancing model 3.2.1 Economic : General	No	As previously stated, an economic baseline was used as the foundation upon which the estimates were calculated. The value of the total economic activities per river section or zone (an arbitrary economic definition based on previous work) was calculated and expressed in terms of a number of economic activities. These values were converted into two metric namely Gross Domestic

Page / Section	Report statement	Comments	Changes made?	Author comment
				Product and Employment. The first metric is representative of economic growth while the second represents the social aspect of the analysis. The different operational scenarios presented different volumes of water per river section. The deviation from the baseline was then expressed in terms of GDP and employment.
		3.2.2 Economic Value of Re-Use	No	The request to determine the value of reuse as the benefit if it has to postpone the Isithindu Dam is a narrow view of the value of reuse and excludes the economic benefits that can be derived in terms of GDP when water is used for economic activities. The approach applied in the study was to consider both components (a) reuse as a substitute for other future water resource developments and (b) the economic 'production' from the water being made available in the current time.
		3.3 Application of the Multi-criteria assessment tool. 3.3.1 General	No	The approaches of how to find a balance between protection and water use is brought and a range of methods can be applied of which multi-criteria analysis is one. In situations where development is already in place (such as urban areas or water resource infrastructure) and it is apparent by inspection that removing those will be disruptive to the socio-economy a decision can be taken without explicitly deriving numerical metrics of what it would entail to change the existing land use practises. The ecological health targets (in the form of the Target Ecological Category) can be set to allow development to continue by deciding one resource should be managed to be highly use while another would remain minimally used -as a means to give effect to "finding a balance between protection and use". The Little aManzimtoti and Mbokodweni systems is therefore already highly used resources and the recommended TEC allow this to continue while another system such as the uMkhomazi is recommended to be protected as a moderately used resource i.e. targeted for dam development. This illustrates why it would not be wise to undertaken a catchment by catchment assessment as decisions that must be made at one estuary will impact on others.
		3.3.2 The Central Cluster	No	The approach regarding the Ohlanga and uMngeni estuaries was that the decision was taken historically and confirmed in this study that the Ohlanga should be protected by preventing waste water discharges into the system. This was the intent with the current infrastructure implemented by eThekwini to transfer treated waste water to the uMngeni catchment and estuary. The recommended TEC for the Ohlanga is therefore set accordingly - reflecting the decision to protect. The ecological status of the Ohlanga estuary

Page / Section	Report statement	Comments	Changes made?	Author comment
				therefore becomes a constant - not varying among the scenarios. The situation in the uMngeni system is that the ecological rating for the estuary will improve with additional treated waste water discharged (ref : eThekwini Study). The ecological health for both these resources are constant among the scenarios and does not influence the comparison. Both estuaries were included in the MCA model.
		4. Scenario Evaluation and Ranking. "For example Sc Ai, Aii, which details scenarios only for the northern and southern clusters, is then given a ranking in fig 7.2 (ranking of impact of scenarios in the central cluster). Similar examples are to be found throughout."	No	The reason for the inclusion of both Scenarios Ai and Aii in the ranking shown in Figure 7.2 was to indicate that these two scenarios rank the same for the Ecosystem Services Metric. Base on this outcome – that there is no difference (also for the other variables) only Scenario Ai was included in the Integrated Ranking for the Central Cluster – see Figure 8.5.
		NB there is no Sc AiV as per 6.2.2.	Yes	Changed AiV to Aiv.
		Even under Sc E and F, indirect and direct re-use, the respective volumes considered need to be identified and recorded for clarity.	Yes	Provided text on the volumes of treated reuse.
		In item 6.2.2 vol.7 B, when considering the central cluster, the comment is made that scenario E and F (which are both ways in which all – or the required amount – of waste water can be removed from the estuaries) will maintain the PES. However, the detailed ecological scenario analysis clearly shows that all the estuaries which receive waste water will benefit (and improve the PES) if that waste water were to be wholly or partially removed under future scenarios.	No	The scenarios that tested the impact of removing waste water from the individual estuaries had the following results: ▪ Little Amazintoti = Improve from E to D ▪ Mbokodweni Estuary = Improve from E to D ▪ Mdloti Estuary = Decline from D to D/E as result of poor catchment quality and closed mouth conditions ▪ uThongathi Estuary = Improve from D to C/D However, in the aggregation of the overall scenario by means of a weighting scheme this benefit is smoothed out in Scenario E and F as the systems are relatively small and do not significantly increase the total estuarine area in the region.
		Under item 8.3 various ranking procedures were applied. To be at all meaningful the preferred scenario – Gi – (in the order of 50 Ml/day of waste water discharged to uMdloti , remainder to a sea outfall, and all waste water from the uThongathi catchment piped and pumped to Hazelmere dam.) requires both a sea outfall AND a return pumping scheme to Hazelmere dam. This highlights the need for a very clear understanding of whether the economic assessment has been assessed at a catchment specific level , how the value of reuse water has been factored in and how the cost of the catchment specific engineering mitigation measures for scenario Gi have been included.	Yes	Added text to expand the description of Scenario Gi.
		When commenting on the economic assessment above in item 3.2.1, it was suggested that an example be used.	No	We made use of four identified economic regions as the baseline on which the scenarios are based. The construction costs were

Page / Section	Report statement	Comments	Changes made?	Author comment
		It is suggested that the scenario Gi be used as that example.		spread out over a period of years for all the different scenarios, followed by the operational costs which extended for a number of years. Various scenarios are made up of various options, depending on the specific scenario. As an example Scenario Gi, which is economically equivalent to Scenario E, is made up of the following options: Option 4b – Kingsburgh WWTW to Little Amanzimtoti (30Ml/d) to Estuary Outfall (8Ml/d) and Surf Zone (22Ml/d) Option 5c – Treated water from Tongaat (130Ml/d) to Hazelmere Dam. uMdloti (125Ml/d) to Northern marine outfall Option 8 – Treated waste water from Phoenix WWTW (100Ml/d) to uMngeni catchment Option 15c – WW treatment at Isipingo (25Ml/d) and Amanzimtoti (60Ml/d), transfer (55Ml/d) to Mbokodweni Option 21b – waste water treatment at Umkomaas (20Ml/d) and transfer to Estuary These options combined amounted to a total of R8 372 074 697 (R8.3bn) in capital expenditure and an annual operational expenditure of R710 727 964 (R0.7bn) in the case of Scenario Gi. The impacts of these amounts in terms of Gross Domestic Product (GDP) and employment were estimated using the KwaZulu-Natal provincial social accounting matrix (SAM) under multiplier sector ***13.1. Water - Water Resource Development***, sub-sector ***26. Building Construction.*** These macro-economic impacts, as well as the capital expenditure and operational expenditure, were then added to the baseline GDP (made up of the economic regions' GDPs added together) as well as the baseline employment (made up of the economic regions' employment figures added together). The sum of the economic region baseline figures, without the impacts of the options, remains the same; the differences come about when the costs of the options and their impacts are incorporated.
		5. Estuary nodes and TEC rationale In table 9.8, is it correct that the symbols in the columns marked Sc C and Sc D, are the envisaged ecological category under the scenarios C and D which are detailed in Table 3.6 ? (scenarios C and D generally deal with the short / medium term discharge of waste water) In which case the table is not understood. Using the Lovu as an example, an EC of C/D is identified in both columns Sc C and Sc D. However there is no current, or planned, discharge of waste	No	a) In order to comply with the principle of defining scenario to be coherent across all 64 estuaries the ratings were defined for all scenarios. In various estuaries (such as the Lovu) the ecological rating was the same for scenarios because the scenario settings did not result in a change in the estuary. As pointed out in the comment the ecological rating for the Lovu for Scenario C and D is the same.

Page / Section	Report statement	Comments	Changes made?	Author comment
		water to this catchment. So why are Sc C and Sc D relevant?		
		Of separate concern however is that , among the measures necessary to achieve the REC (of B) , or even the TEC (of B/C) , (for the Lovu) there needs to be an improvement (for some estuaries this is referred to as being a 'significant improvement) in water quality. This catchment is being considered for significant strategic development (by Toyota and others) which will inevitably result in a significant increase in hardened areas / roads with resulting runoff and pollutant load. As noted in the commentary under item 2.2 above the increasing impact of stormwater from developing areas has not been addressed at all in the reserve scenarios when considering the increase in waste water. **An estuarine reserve on the Lovu, to better inform the impacts on this estuary of development (excluding waste water) is under construction.** The implications of the TEC of B/C (and the associated need to improve not only existing, but future water quality in order to achieve this) implies that the containment and treatment of stormwater will be necessary. This has major implications (which in themselves should be built into the economic - and the missing - social components of the multi-criteria model) and would represent a radical change in "development" norms and standards and would simply be unaffordable for the Municipality. Any TEC, for any of the estuaries, which requires water quality improvements cannot therefore be accepted.		b) The Lovu form part of the core set of estuaries in need of protection to meet biodiversity targets (NBA 2012 conservation requirements gazetted as part of National Estuarine Management Protocol). Future development should therefore not degrade is current health state, with recommended improvements in line with conservation requirement. c) DWS's view is that detailed investigations (such as indicated in the comments – see bold text) are essential for urban planning. Classification would have benefited from such detailed study results which was however not available. It is recognised that planning processes are continuous and dynamic which requires ongoing coordination among institutions
		EThekwini would welcome further discussion with DWS with a view to this concern being resolved before any draft Classes and RQOs are proposed.		DWS will welcome further engagements with eThekwini relating to this and any other relevant development planning investigation.
		A further requirement often listed is to "restore baseflows". The term 'base flow ' is understood to refer to the' amount of flow in a river during dry or low flow conditions and which results from seepage of water from the ground into the channel over time'. Surely the whole point of the estuarine scenarios has been to consider the impacts of various discharges of waste water to an estuary and from these there is some understanding of the impact of various waste water flow scenarios. None of these has focused on or attempted to address an	No	In a number of systems the issue of modification in baseflows were highlighted as one of the major reasons for a decline in health. To achieve the REC this aspect would need to be addressed. If there were no detailed scenarios evaluated that show how this could be achieved, the TEC do not include this aspect.

Page / Section	Report statement	Comments	Changes made?	Author comment
		issue of ' baseflows', and it is not clear where there is justification for this generalised comment. It is also far from clear how any base flow could practically be restored.		
		The TEC motivations propose a number of interventions which do not appear to have been considered from a practical aspect. For instance the uMngeni requires 'creation of new wetland habitats in close proximity to the river banks'. If this is seriously proposing that the golf course is fully or partly altered to be a wetland then this needs to be tested both against the ecosystems services metric and then presented clearly for public comment.		The TEC recommendation comes from a detailed assessment done by MER indicating that restoration of some of the riparian habitat will show significant ecological gains, i.e. lead to overall improvement of condition and productivity. At this stage the recommendations are not site specific, but an aspect that would be picked up in the Development of an Estuary Management Plan for the system.
		6. Resource Quality Objectives. 6.1 RQO : General		The request is for a discussion between eThekwini and DWS, requiring a response from DWS.
		6.2 Identification of means of achieving proposed Class and RQO		See above.
		6.3 Estuaries affected by waste water flows **6.3.1 uMkhomazi**		EThekwini is requesting discussions with DWS involvement and this requires a response from DWS.
		In addition three substantial impacts on the functioning of the estuary are omitted from the text (Report volume 2 D, 6.1 et al). - Illegal sandwinning - The 'illegal' SAPPI weir referred to above (any authorisation appears to be for a weir upstream of the existing structure) - Limiting of recreational activities The work done under the eThekwini project identified that unless all three impacts are addressed then the REC will not be achieved even if all waste water is removed.	Yes	Table 9.8 of this report lists all of this information in this report as well as in more detail in the technical report (index number 8.2b which is the detailed report on the uMkhomazi Estuary EWR and scenario consequences. It is assumed that reference here pertains to the Estuary RQO report (numbers of reports have changed). However reference is made in table 6.3 to most of the commitments referred to. Adjustments have been made to the RQO report to ensure that it matches the recommendations in the WRC report. Please note that there has been no recommendation made for existing waste water to be removed.
		It should also be noted in the text that , under a scenario of 16 Ml/day waste water , with level 2 treatment (a high level of nutrient removal) , the assessment showed that the system will score " 58 ", (ecological category C/D) only marginally below a category C (score > = 60) In view of both the 'confidence' in the assessment, and the ability of the estuary to recover, a Recommendation (under 6.1) needs to be included that 16 Ml/day, level 2 treatment, in conjunction with a properly structured monitoring programme, is a viable option, at least in the medium term, possibly coupled with a policy of artificially opening the mouth under severe low flow conditions.		The Mkomazi Estuary is of high biodiversity and socio-economic importance (one of the few remaining good condition system that serves as a good fish nursery), i.e. its condition needs to be improved to meet conservation requirements Unlike most of the system in the Central Cluster the catchment water quality is also of a reasonable condition. The consequence report clearly states that even under the 5 Ml/day scenario, while there will be a low occurrence of mouth closure, the scenario holds a significant risk that if closure does occur during low flow and drought conditions. Nutrient enrichment and organic loading under these conditions may reduce dissolved oxygen levels below 4 mg/l putting the estuary's nursery function for high value recreational angling fish species (dusky cob,

Page / Section	Report statement	Comments	Changes made?	Author comment
				estuarine bream, spotted grunter) at high risk. The report also highlights that the assessment does not include detailed numerical modelling and assumes that the proposed WWTW discharges enter the estuary at the head. Therefore this assessment did not consider a WWTW discharge in the middle or lower estuary near the mouth (this will required more detailed numerical modelling studies). It is likely that WWTW effluent discharged in the middle or lower reaches of the estuary will cause disruption of the salinity gradient and cause deterioration of water quality, especially during low flow periods when assimilative capacity reduces markedly. Estuary mouths are not artificially open for low oxygen events. In fact, opening the mouth can drain the remaining oxygenated surface water leaving little buffer between the depleted bottom waters and fish. In addition invertebrates are not as mobile as fish and would have been severely impacted by the lead up to such an event. Based on the requirement to improve the estuary condition, its importance as a fish nursery area and following a precautionary approach the specialists cannot recommend an increase in waste water to the Mkomazi Estuary as it currently serves as an important refuge area that buffers against the significant loss of nursery function along the rest of the Central Cluster.
		6.3.2 Little Amanzimtoti and Mbokodweni –		
		The only proviso to the above being that the estuary complies with “all required health standards’. This expression needs to be clarified such that it refers to tertiary treatment with ‘disinfectant to a reasonable level’, and NOT to a contact recreation standard.		(a) The RQO definition of “all required health standards” is appropriate based on the recreation use of the water resource. Specific treatment options need to be evaluated in further planning investigations by eThekwini and as part of the required EIA processes. (b) The RQO is based on a legal requirement in line with the recommended targets proposed for South Africa’s coastal marine waters (DEA, 2012). The RQOs for recreational use are specified as risk-based ranges for intestinal enterococci and E. coli (microbiological indicator organisms). The report is not specific on how these needs to be achieved as it may require multiple interventions depending on the waste water and catchment quality.
		A separate ‘balance “(ecological, social, economic) needs to be done for each of these two catchments. Pending justification of the proposed TEC in this manner the proposed Class and proposed RQOs cannot be accepted.		Due to the binary nature of the estuary health response to the waste water scenarios, that is that only the complete removal of all waste water will improve the rating from the PES of a E to a D, the only alternative waste water management measure to achieve improvement will be a see outfall. Given that such a solution is

Page / Section	Report statement	Comments	Changes made?	Author comment
				costly and that the Integrated Environmental Importance of these two estuaries is low the derived balanced decision was to allow these two systems to be highly utilized while the other estuaries in the IUA are protected. Furthermore, it does not make logical sense to establish a balance looking at one estuary when the decision you take on one estuary affects other estuaries. One of the original reasons for the Little Amanzimtoti pilot study was to address the fact that the Reserve determination was done in isolation and did not consider the consequences of the recommendations potentially on other estuaries and the socio-economics. This is the whole purpose of Classification, i.e. not to evaluate areas in isolation. The recommendation regarding the TEC is based considering the socio-economics and specifically dealing with the waste water. If the Municipality therefore requires the TEC to be an improvement, then they have to remove all waste
		6.3.3 uMngeni		
		The EWR will be largely governed by the water release policy from Inanda dam both being defined, AND then implemented. In the past this has been a contentious issue within DWS which needs to be resolved. There needs to be considerable discussion around whether, in the light of the predicted shortfall in the bulk water resources in the uMngeni supply area (at least until Smithfield dam comes on line) this is practical.		This is a subject for discussion at the SSC of the Reconciliation Strategy.
		Again a specific “balance “(ecological, social, economic) needs to be done for the uMngeni. Pending this taking place the proposed Class and proposed RQOs cannot be accepted.		(a) The approach regarding the Ohlanga and uMngeni estuaries was that the decision was taken historically and confirmed in this study that the Ohlanga should be protected by preventing waste water discharges into the system. This was the intent with the current infrastructure implemented by eThekwini to transfer treated waste water to the uMngeni catchment and estuary. The recommended TEC for the Ohlanga is therefore set accordingly - reflecting the decision to protect. The ecological status of the Ohlanga estuary therefore becomes a constant - not varying among the scenarios. The situation in the uMngeni system is that the ecological rating for the estuary will improve with additional treated waste water discharged (ref: eThekwini Study). The ecological health for both these resources is constant among the scenarios and does not influence the comparison. Both estuaries were included in the MCA model.
		6.3.4 Ohlanga		See above and responses on Item 3.3.2.

Page / Section	Report statement	Comments	Changes made?	Author comment
		6.3.5 uMdloti		
		The commentary in report 7 B – in the section between figs 8.8 and 8.9 – correctly records that “ the ecological health rating for the uMdloti estuary would be improved by increasing the flow (discharging waste water) – in the order of 50 Ml/day.” , and later in the same report “ increased waste water can be discharged in estuary towards the point where it starts degrading. In the short term , the TEC may (*or should this read ‘will’ ??*) drop while Hazelmere Dam is being raised and fully utilized ………….”	Yes	Changed may to ‘is likely to’
		The section underlined above needs to be included in the RQOs.	No	It is included under table 5.15
		Also earlier in this same report – under Central Cluster IUA – “uMdloti estuary scenarios with increases in plant capacity (i.e. increased waste water flows) are significantly negative ………. and intermediate waste water development is less significant but still negative “, and under item &.4 in the same report “………………. the greater the WWTW discharges the greater the negative impact ……….” These comments, and others like them elsewhere in the various reports, all need to be corrected to reflect the conclusions of the expert scenarios carried out under the eThekwini study.	Yes	
		Also the RQO comment “ a scenario that includes more waste water to a specific limit must be investigated as this could achieve the TEC “ needs to be corrected as per the underlined section above as the investigation has take place.	Yes	Has been addressed in the RQO report
		This then raises the question whether the cost of a recycling scheme AND the cost of a marine outfall were BOTH included in the economic assessment for both the uMdloti and uThongathi catchments ?? The above all need to be addressed before the proposed Class and proposed RQOs can be considered further.	No	The costs of both the interventions were taken into consideration.
	The estuary is small with very little assimilative capacity	Report 7 B Table 3.5, gives an estuary area of 28.5 ha., although in item 6.1.2 the estuary is more correctly described as ‘small’. The area of this estuary - plus the others in the table – all need to be checked , together with the resulting ranking / rating/ weighting used in the ‘balance’ being corrected accordingly. [refer also to the total mismatch with the estuary data		This was changed in the Consequences report to: The estuary’s open water area is small with very little assimilative capacity. Added in MC Report text to Table 3.5: Total estuary area (size) is an important predictor of the biotic features of an estuary, hence the reason for its incorporation in the national estuary importance rating (DWAF 2008). To provide for addition resolution and to account for estuary resilience to flow modification and water quality changes, as well as key ecosystem services such as

Page / Section	Report statement	Comments	Changes made?	Author comment
		listed in annexure A vol 4]		nursery function, estuaries were also weighted by their open water area.
		In Report volume 2 D the estuary Importance score needs to be clarified. Viz: – the scoring was 61, only just inside the range of 60 to 80 for an important estuary.	No	The Estuary importance score is derived from national values determined by Turpie et al 2004. The DWS was approach to request access to the information. In the absence of the detail information the previous EWR study findings were not adjusted as the specialist did not have access to the raked information.
		It also needs to be noted the REC of C is unlikely to be obtained with the main contributor to the PES – and hence the inability of any scenario to raise to the REC - being the presence of Hazelmere dam (which is shortly to be raised with added abstraction and an acknowledged added ecological impact on the estuary)	No	The scenarios analysed included the upstream developments and the TEC reflects the planned raising.
		It needs to be noted that the assessment showed that the maximum achievable estuarine health score (of 45 : vs 46 for the PES) was obtained under the scenario of a 30 Ml/day waste water flow at level 2 nutrient removal, and that the estuarine health score of 42 (marginally less) was scored under the scenario of 60 Ml/day – level 2 (a) . Hence a Recommendation (under 6.4) for up to 60 Ml/day – level 2 (a) - in conjunction with a properly structured monitoring programme , is a viable option.	No	While the overall score for the 60 Ml/day – Level 2 (a) Scenario indicate that the system is in a D/E, all the biotic elements are in an E or F, i.e. this is not a viable option from an ecosystem perspective. Thus the reason for its exclusion.
		The Executive Summary provided **in** report volume 7 B, and the more detailed description in 6.1.2 et al, provides a less than complete record and needs to be corrected.	Yes	References were provided to the eThekwini Study where further information is provided regarding waste water management
		6.3.6 uThongathi		
		The RQO should be corrected to read “only scenario Aiii, coupled with the removal of the illegal causeway and dredging of build-up in the area of the causeway, will improve the estuary “.	Yes	
		In addition volume 4, item 8.3, correctly records that “the pressures for urban development in the uThongathi catchment requires waste water management and disposal facilities in the short term. To bridge this planning gap it is therefore proposed that treatment and discharge to the uThongathi take place over the short term which may reduce the Ecological Category (EC) of the estuary to an E.” The section underlined above needs to be included in the RQOs but with the proviso that the understanding of “short term” would cover the full period to the	Yes	Addressed in the RQO report. Have added a bullet that address this explicitly in RQO report : “Remove weir/causeway in upper reaches” Refer to statement in Estuary Consequences report “The removal of the weir midway up the uThongathi Estuary will restore some intertidal and water column habitat, but if the water quality conditions do not improve this is effectively “environmental accounting” in which habitat is made available, but is not viable for use. This expenditure is not recommended unless water quality is improved in the system to allow for use

Page / Section	Report statement	Comments	Changes made?	Author comment
		commissioning of any infrastructure mitigation measure.		of the restored habitat. This is especially the case in the future scenarios where increased WWTW volume and nutrient loading will further increase eutrophication and related risk of low oxygen events.”
		eThekwini will hope to engage further with DWS on both indirect re-use and a marine outfall but, pending such further interaction, this concern will add to the reasons why eThekwini cannot accept the proposed Class and proposed RQOs for the uThongathi estuary.		DWS to respond on the request for engagement.
		In report volume 2 D the Estuary Importance needs to be clarified Viz: – the scoring was 61, only just inside the range of 60 to 80 for an important estuary	No	The Estuary importance score is derived from national values determined by Turpie and Clark 2007, captured in DWAF 2008. The DWS was approach to request access to the information. In the absence of the detail information the previous EWR study findings were not adjusted as the specialist did not have access to the raked information.
		One conclusion which needs to be added is that, the REC (of category C) can only be achieved if all waste water is removed (Sc 1), AND the causeway is removed. In each case the scoring was increased by some 20 to 25%. i.e. under Sc 2 (treatment level 1) the score was increased from 42 (with the causeway) to 51 (with the causeway removed).	No	The reference to the 25% increase in condition if the old weir is removed stems from the 2007 EWR study (MER 2007) in which 1) the study overestimated the historical extend of the estuary (based on an incorrect map in Blaber et al. 1984) and 2) under estimated the impact of the water quality on the overall condition of the system. The current study warns that the increase in submerged habitat would not benefit the system much if it is not done in conjunction with an increase in water quality, as only the habitat scores will increase significantly, but not the biotic scores.
		The comment (under 6.5) that unless water quality conditions improve removal of the causeway will create habitat which is then ‘ not viable for use’ is noted but , the scenario of a waste water flow of between 18 and 28 Ml/day becomes more viable IF the (privately owned , and illegal /unauthorised) causeway is removed.	No	The assessment did not show a significant improvement in overall condition if water quality do not improve as the restored submerged habitat will not be viable. Without improvement in water quality it becomes environmental accounting, i.e. playing with the Estuary Health Index numbers versus actual improvement of the ecological condition, i.e. the biota scores do not increase just the habitat score. Also note that the previous study overestimated the extent of the system.
		As above, the Executive Summary provided in report volume 7 B, and the more detailed description in 6.1.2 et al, provides a less than complete record and needs to be corrected.	Yes	References were provided to the eThekwini Study where further information is provided regarding waste water management.
Mmaphefo Thwala: Received 20 November				
		Consistency with front page, document index and dates	Yes	
Exec Sum:	This task is associated	Specify the task	Yes	

Page / Section	Report statement	Comments	Changes made?	Author comment
Introductio n	with step 4 and 5 of the Water Resource Classification System			
		There is a great inconvenience and confusion having the WRC report for Mvoti and uMkhomazi in a separate report, please can you merge that report into this one so that we have ONE Water Resource Class report	No	This work was done separately as it was linked to the VO. To merge these reports now will have serious ramifications as every single reference to the different reports and report lists will have to be adjusted and it will be approximately a week's work to produce a word report. However, these two reports are merged in the Main report in one chapter and as that will be the report most people will read, it is probably the most important.
		U4 (uMngeni)?	Yes	Changed to Mvoti
Exec Summary: Scenario Description	The uMngeni River scenarios include variables that consisted of ultimate 2040 developments, the river EWRs, the uMkhomazi Water project, Darvill Re-use and eThekwini Direct Re-use.	Same comment as above, the info should not be in bits and pieces in the different reports. Integrate	No	The uMkhomazi Water Project is a variable in the uMngeni scenarios and does nto refer back to another report.
Exec Summary Economics		There are several systems in the cluster, refer to them as such, same comment for the 2 clusters below.	Yes	
Exec Summary Ecological Conseque nces		Provide a table with the full suite of scenarios in the annexure and refer to it. One should be able to look at this report without having to go source the full list of scenarios elsewhere	Yes	
2.2.2a	The PES percentage is used in this calculation.	indicate how the PES percentage is determined or calculated	No	Any PES has a percentage associated with it. This is standard and detailed processes described in the EcoStatus manuals.
4.6	The various operational scenarios all present positive answers and should all make a positive contribution to the economic growth and employment creation in the four catchments. The final preferred option will depend on the interaction between the economic values, the	Where are these specified?? Provide a table clearly indicting the final recommended scenarios for each system; or refer to where these are sitting.	Yes No	The operational scenarios and results were provided as Table 4.1. With regards to the second request, as state in the referred text the final preferred option is dependant on economics and other factors. The final recommendations are therefore part of later chapters.

Page / Section	Report statement	Comments	Changes made?	Author comment
	goods and services and the environmental impacts			
6.1.2	**Thonghati:** 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.	Briefly indicate in brackets what the different levels of waste water treatments are.	Yes	.
6.1.2	**Little Amanzintoti:** 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 Sc2a (8 Ml/d) at all three levels of effluent treatment, the system will maintain the PES. Under Sc3 (30 Ml/d) the estuary shows a severe decline in condition to Category E/F and F.	Somewhere in this report you have to indicate which of these scenarios is the recommended one and provide full motivation for that. This comment applies to all.	No	This chapter present only the ecological consequences of the scenarios and the discussion and rationale of the recommendations are provided in Chapters 8 and 9, where all the comparison variables are considered.
9.2	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	Explain what TEC is and how it differs from REC. Confusing, revise.	Yes	

Page / Section	Report statement	Comments	Changes made?	Author comment
	considered. The TEC could therefore be any Ecological Category.			
Table 9.3	Water quality from Ashburton and other aspects	Specify others	Yes	
Table 9.6		Provide further detailed motivations to defend all the E/F TECs.	No	These are recommendations and it creates the wrong interpretation having to be asked to defend recommendations. The reasons are supplied everywhere in the balance model output where scenarios were investigated that did not result in the EFs. If you need to improve the EFs, you have huge socio-economic costs, you also have other more important estuaries being negatively influenced, and i.e. fall below the PES and ones which are more important that require improvement will not achieve it.
Table 9.6		Changes of colour	Yes	
Mmaphefo Thwala: Received 15 January 2016				
All editorial comments were addressed.				
2.1.1	Visioning	So far the Visioning outcomes are not documented anywhere, hence the request to please attach as an annexure.	Yes	Catchment visioning was included as an appendix in the main report.
Table 3.9		Some names are still spelled wrong, see suggested changes below from my logic, do verify.	Yes	
Pillay Renelle: Received 18 January2016				
Page 1-1		Background – first sentence should be changed to read, 'There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management area (WMA) which is one of three WMA's that form part of the Pongola to Umzimkulu Proto Catchment Management Agency ……' Page 4-1: Catchment and river characteristics – first sentence makes refer to the Imkomati study area and must be amended.	Yes	
		There are still a few spelling and grammatical errors in the document and it is advised that it be reviewed in this light. e.g. Page 2-3: Sentence no. 3 'In the case of the estuaries, coordinated management instead of managed. Sentence 5 'Alignment with the activities of the Catchment Management waste water Forums also need to be (incomplete sentence).	Yes	
B Pfaff: Received 8 February 2016				

Page / Section	Report statement	Comments	Changes made?	Author comment
		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 uThongathi are.