water & sanitation

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WP 11004

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

WATER RESOURCE CLASS AND CATCHMENT CONFIGURATION REPORT

March 2018

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Bold indicates this report

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First draft	February 2018
Final report	March 2018

EXECUTIVE SUMMARY

BACKGROUND

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

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

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

The purpose of this report is to recommend operational scenarios and preliminary Classes for stakeholder evaluation for the relevant Integrated Unit of Analysis (IUAs). The report structure is outlined below.

STUDY AREA

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

INTEGRATED CONSEQUENCES EVALUATION APPROACH

Considering that the core purpose of the classification process is to determine the 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 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 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 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 (or IUAs), then defining and selecting the scenarios for evaluation and finally to assess the consequences with the aim to make a recommendation of which Class should be implemented. 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.

SCENARIO DESCRIPTION

The table below shows the scenario (Sc) summary matrix indicating the drivers of the scenario (different columns) for the list of scenarios provided by the rows. Various iterative scenarios were analysed and only the scenarios that were recommended to be considered for the decision-making and selection of the final scenario and associated Classes are presented in the table.

Mzimvubu River: Summary of operational scenarios

Scenario	Update water demands (2040)		EWRs			Development options*		
	Realistic projection (a)	Ultimate development projection (b)	MzimEWR4	MzimEWR1	EWR1 Lalini (scaled from MzimEWR1)	MWP[1] (Feasibility study, 2014)	MWP (Pro-plan configuration; 2017 Design phase)	Port St Johns proposed WWTW**
2a	Yes	No	No	No	No	Yes	No	No
2b	No	Yes	No	No	No	Yes	No	No
2c	No	Yes	No	No	No	No	Yes	No
53	No	Yes	REC low	REC low	No	Yes – Reduced Hydro further in dry months	No	No
54	No	Yes	REC low	REC low	Cat D low	Yes – Reduced Hydro further in dry months	No	No
61	No	Yes	REC low	REC low	Cat D low	No	Yes	No
62	No	Yes	REC low	REC low	Cat D low	No	Yes – Reduced Hydro in dry months (Pro-plan HEPP[2] Design Capacity)	No
63	No	Yes	REC low	REC low	Cat D low	No	Yes – Reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No
65	No	Yes	REC low	REC low	Cat D low	No	Yes – Further reduced Hydro in dry months (Pro-plan HEPP Design Capacity)	No
69	No	Yes	REC low	REC low	Cat D low	No	Yes – Further reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No
70	No	Yes	REC low	REC low	No	No	Yes – Further reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No

1 Mzimvubu Water Project.

* *Development options common to all scenarios:*

- *Revive Irrigation (T33A-T33G).*
- *New Municipal Dams / Abstractions.*

*** The impact of the proposed Port St Johns Waste Water Treatment Works (WWTW) was analysed separately by the estuary team.*

2 Hydro Electric Power Plant (HEPP)

ECONOMIC CONSEQUENCES

An economic baseline was established and the results for the different scenarios were measured against this baseline. In the following table the Gross Domestic Product (GDP) and employment are presented as a value after the baseline was brought into consideration. The table below shows that Sc 2b, 2c, 61, 63 and 69 provide an economic positive deviation from the economic baseline.

GDP and employment deviation per scenario from the economic baseline

Scenario	GWh*	GDP (R mil.)	GDP deviation (R mil.)	Employment	Employment deviation
54	355.78	R 1 983.76	R -41.56	14 051	-294
2c	415.36	R 2 315.99	R 290.67	16 404	2 059
61	417.54	R 2 328.13	R 302.81	16 490	2 145
62	353.42	R 1 970.59	R -54.74	13 958	-388
63	413.29	R 2 304.44	R 279.11	16 322	1 977
65	319.17	R 1 779.64	R -245.68	12 605	-1 740
69	378.80	R 2 112.13	R 86.81	14 960	615
2b	376.22	R 2 097.72	R 72.40	14 858	513

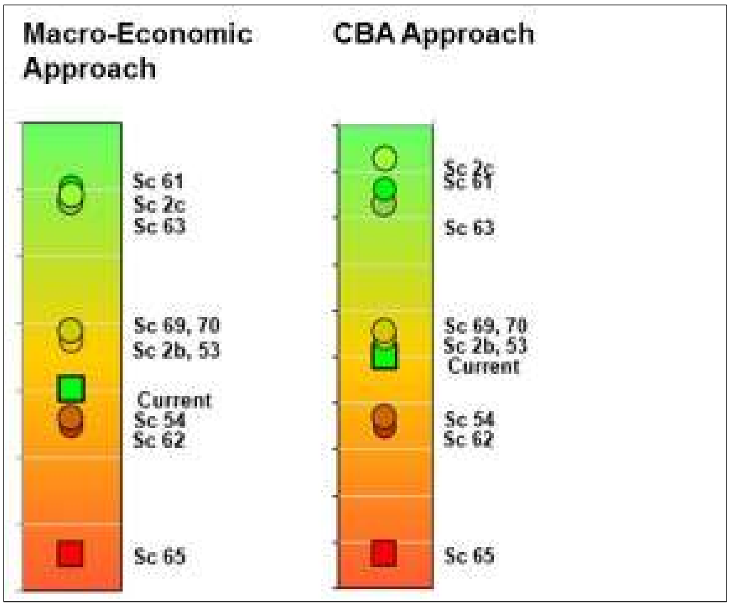
**Giga-watt hours*

The results of the CBA analysis are presented below. Keep in mind that the CBA was performed to express an opinion on the future economic and financial positive return on the capital invested in the HEPP system. The table shows that Sc 2c, 61, 63, 69 and 2b provide financial viability results. Scenario 54, 62 and 65 indicate a negative impact on financial viability.

Financial CBA results

Scenario	Tariff income (R mil.)	Net Present Value (NPV) (R mil.)	Internal Rate of Return (IRR) (R mil.)	Benefit Cost Ratio (BCR) (R mil.)	Viability criteria met?
54	R 373.57	R -132.66	7.0%	1.36	No
2c	R 436.13	R 425.45	11.0%	1.67	Yes
61	R 438.42	R 362.37	10.5%	1.63	Yes
62	R 371.09	R -151.61	6.9%	1.35	No
63	R 433.96	R 328.31	10.3%	1.61	Yes
65	R 335.13	R -426.09	4.8%	1.20	No
69	R 397.74	R 51.87	8.4%	1.46	Yes
2b	R395.03	R 41.16	10.9%	1.26	Yes

The ranking applied is based on the highest net benefit to society in terms of GDP and employment stimulation by applying the macro-economic approach. In the case of the CBA analysis it is a simple linear relationship where the highest NPV of each scenario or option transcends the other scenarios or options. The following figure shows the relationship between the GDP and NPV approaches in terms of the deviation of the two methodologies from the current economic baseline.



Relationship between the GDP (macro-economic) and NPV (CBA) approaches in terms of the deviation of the two methodologies from the current economic baseline

Conclusion

The following conclusions and recommendations are supported by the economic analysis.

- As previously discussed the hydro-power system and the building of the Lalini Dam will involve a large amount of capital and the financial viability of the system will be an important issue, with the results of the macro-economic and CBA results playing an important role in the final decision-making process.
- The results show that from a financial and economic viewpoint Scenario 65 is not viable and that Scenarios 54 and 62 could be viable if the Eskom tariffs increase faster than the official inflation rate. This should however be treated with caution as the present financial situation of Eskom is not desirable.
- The other scenarios are acceptable from an economic viewpoint, however Scenario 70 is problematic as the possibility exists that the Tsitsa Falls will run dry under this scenario.

ECOLOGICAL CONSEQUENCES: RIVERS

The ecological consequences on the three EWR sites are provided below.

MzimEWR4 (Mzimvubu River)

The ranking of the scenarios indicates that Sc 69 achieves the REC (and PES) requirements. Scenario 65 maintains the REC, with fish slightly deteriorating within the PES category. The rest of the scenarios result in a deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones, and ultimately the habitat availability for biota. As Sc 53 and 54 were not part of the 2017 design phase (Pro-Plan data), Sc 69 is recommended as the most suitable scenario.

MzimEWR1 (Tsitsa River)

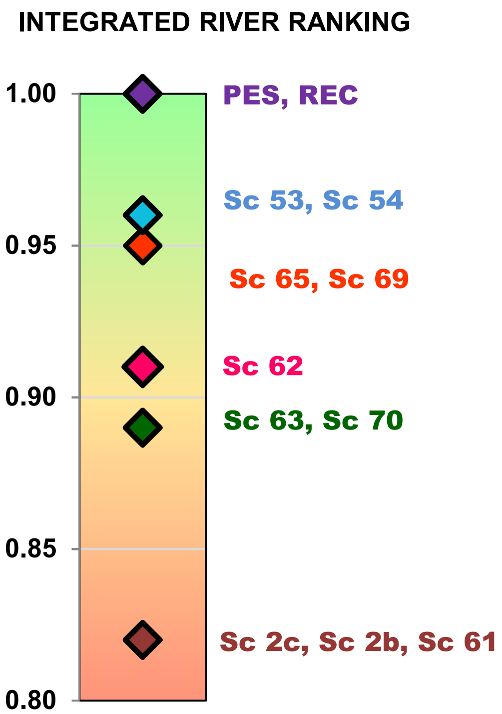
Scenarios 65 and 69 maintain the REC (and PES), with Sc 69 resulting in the riparian vegetation deteriorating due to increased baseflows. The rest of the scenarios result in deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones and ultimately the habitat availability for biota. As Sc 54 is not part of the Pro-Plan design, and Sc 69 is a better option at MzimEWR4, which is the driving river site, Sc 69 is recommended as the most suitable scenario.

EWR1 Lalini (Tsitsa River)

The DWS has indicated that management options associated with Sc 2b, 53 and 70, i.e. no flow over Tsitsa Falls, would be unacceptable. As some flow is therefore required in the reach immediately downstream of Lalini Dam, any of the other scenarios will be acceptable.

The first step in determining an integrated RIVER ranking (i.e. integrating MzimEWR1, EWR1 Lalini and MzimEWR4) was to determine the relative importance of these EWR sites occurring in the study area. The site weight indicated that the MzimEWR4 site carried the highest weight due to the site being the most downstream river site in the study area. The accumulated impact of the scenarios was therefore expected to be the highest within this river reach (distance from the outfall of Lalini Dam to the Mzimvubu Estuary is 137 km). The importance of the MzimEWR1 site was lower due to lower accumulated impacts of scenarios within the 76 km reach demarcated from Ntabelanga Dam to Lalini Dam. EWR1 Lalini had the lowest weight as the EIS is Moderate and the site is situated in a relatively isolated reach in the Tsitsa River (it is 18 km from Lalini Dam to the outfall). The weight was applied to the ranking value for each scenario at each EWR site and this provided an integrated score and ranking for the operational scenarios.

The above results are plotted on a traffic diagram to illustrate the integrated river ecological ranking of scenarios. Note that the colouring of the traffic diagram denotes an improvement from red through orange to green. Shading is therefore according to the colours of a traffic light; implying that the items at the top (in the green section) are better than the ones below.



Integrated ecological ranking of the scenarios on the Tsitsa and Mzimvubu rivers

ECOLOGICAL CONSEQUENCES: ESTUARIES

The Estuary Health Index (EHI) scores allocated to the various abiotic and biotic health parameters for the Mzimvubu and the overall PES for the system are calculated using the index as described in the official methodology for estuaries (DWAF, 2008). The PES of the Mzimvubu Estuary is estimated to be 81 (i.e. 81% similar to natural condition), which translates into Category B. The estuary therefore is still in a good condition. Modification from the reference conditions is primarily linked to following factors:

- Decrease in baseflow resulting an increase in periods of saline penetration during low flow periods;
- increased nutrient input and turbidity as a result of catchment activities (settlements and cattle herds), as well as diffuse runoff into estuary from the adjacent town.
- road construction and infilling around the bridge and loss of some intertidal habitat.
- fishing pressures; and
- human disturbance of birds.

Estimates of the contribution of non-flow related impacts on the level of degradation suggests that non-flow impacts have played a significant role in the degradation of the estuary to a D, but that flow-related impacts also contributed (e.g. reduction in baseflows). Key non-flow related pressures include road and bridge construction, diffuse pollution from catchment and town, fishing pressures and human disturbance of birds.

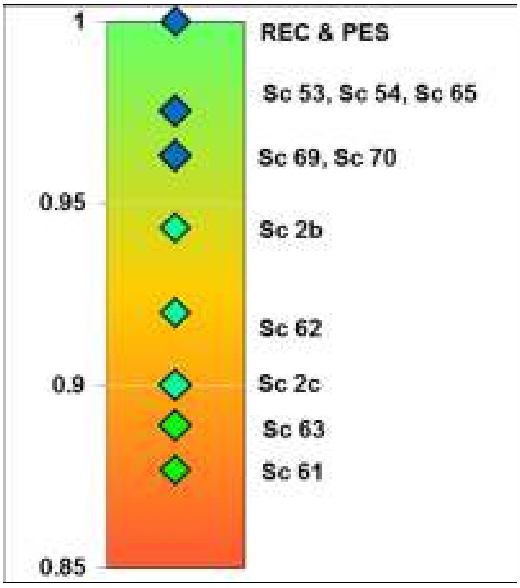
Applying the guidelines for the determination of the REC, based on an estuary's PES and importance, the REC for the Mzimvubu Estuary should be a **Category A** or at least **Best Attainable State**. However, consideration of the Mzimvubu Estuary's present state and related issues, led to a BAS being set at a **Category B**, i.e. within the PES category.

For the Mzimvubu Estuary the consequences of scenarios are as follows:

- Scenario 53, 54, 65, 69 and 70 maintains the REC (equivalent to the PES), that is Category B. Although baseflows (in the range <10 m^3/s) increase in all these scenarios, estuary ecology remains sufficiently resilient to these increases.
- Scenario 2b, 2c and 62 all reduce the ecological health of the system to a Category B/C. These scenarios result in a further increase in baseflows (in the range <10 m^3/s) reducing periods of saline intrusion that are critical to maintain certain estuarine faunal communities (especially with invertebrates and fish); and
- Scenario 61 and 63 reduce the ecological health of the estuary further to into a Category C. These scenarios not only further increase baseflows (in the range <10 m^3/s), thus reducing periods of saline intrusion (affecting faunal communities especially invertebrates and fish). It also results in a reduction in floods creating more stable sediment conditions, affect other estuarine biotic communities such as macrophyte vegetation.

The **'recommended Ecological Water Requirement' scenario** is defined as the flow scenario (or a slight modification thereof to address low-scoring components) that represents the highest change in river inflow that will still maintain the estuary in the REC. Where any component of the health score is less than 40 modifications to flow and measures to address anthropogenic impacts must be found that will rectify this.

The REC for the Mzimvubu Estuary has been recommended at a Category B. Applying the rules of selecting scenarios that will maintain/improve the systems to its REC, the recommended EWR scenario, could be allocated as Sc 53, 54, 65, 69 or 70.



Mzimvubu Estuary: Ranking of scenarios

ECOSYSTEM SERVICES

In terms of **MzimEWR1** the following is applicable:

- Scenario group 2a, 2b, 32, and 33 have potentially the most negative impact on ecosystems services
- This is followed by Scenario group 2c and 63, the Scenario group 69 and 70 and the Scenario 65 which all are negative.
- Scenario Group 41, 42, 51, 52 and 53 and Scenario 54 show no predicted change from the status quo.

In terms of **MzimEWR4** the following is applicable:

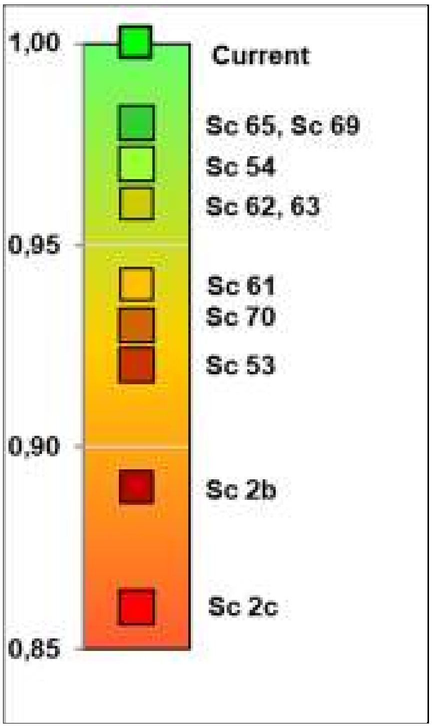
- Scenario Group 2c and 61 are marginally negative.
- All other scenarios are marginally positive with Scenario 53 the showing potentially the most positive change from status quo.

In terms of **MzimEWR1 Lalini** the following is applicable:

- All scenarios are negative with Scenario group 2c and 70 being particularly problematic for the production of ecosystem services.
- Scenario group 2a, 2b, 41, 51 and 53 is also problematically negative.
- Scenario groups 61, 63, 65 and 90 as well as Scenario 54 are moderately negative.
- Scenario group 33, 42 and 52 is marginally negative.

In terms of the **Mzimvubu Estuary** the scenarios are neutral or marginally positive.

The integrated overall ranking of the scenarios for all three EWR sites is as set out below.



Integrated scenario ranking of scenario impact on ecosystem services

WATER RESOURCE CLASS AND CATCHMENT CONFIGURATION

The Class and catchment configuration results are the recommendations that were presented to DWS in November 2017 and at the Project Steering Committee meeting held on 13 February 2018 for consultation with the stakeholders after which the final scenario and results will be prepared for gazetting.

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

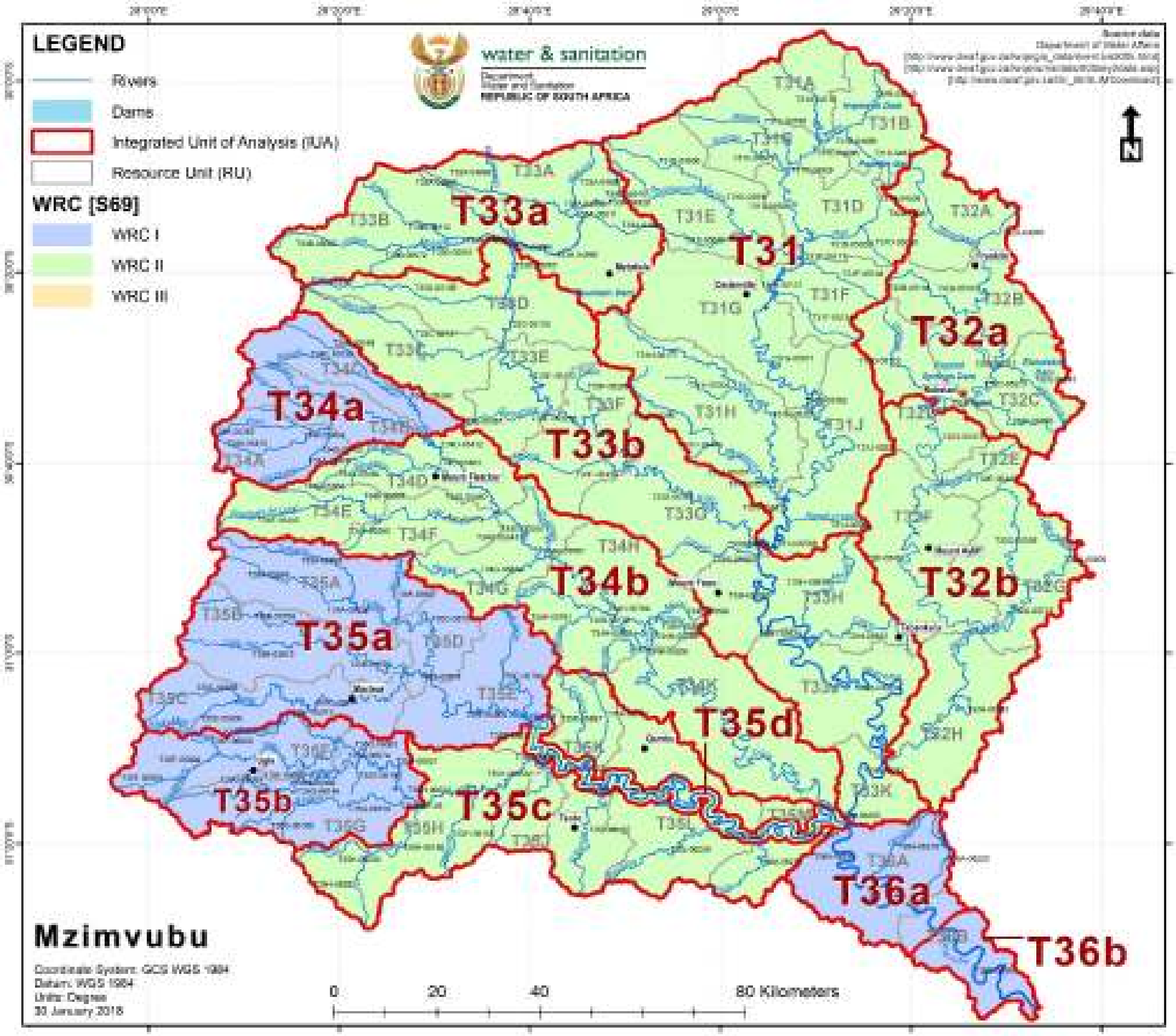
		% EC representation at units represented by biophysical nodes in an IUA				
		≥ A/B	≥ B	≥C	≥ D	< D
Class 1		0	60	80	95	5
Class 2			0	70	90	10
Class 3	**Either**			0	80	20
	Or				100	

The resulting Water Resource Classes for the recommended scenario/s (red text below) are provided in the following table.

Resulting IUA Water Resource Classes for each scenario

IUA	PES	REC	2b	53	54	61	62	63	65	69	2c	70
T31	II	II	II	II	II	II	II	II	II	II	II	II
T32_a	II	II	II	II	II	II	II	II	II	II	II	II
T32_b	III	II	II	II	II	II	II	II	II	II	II	II
T33_a	II	II	II	II	II	II	II	II	II	II	II	II
T33_b	II	II	II	II	II	II	II	II	II	II	II	II
T34_a	I	I	I	I	I	I	I	I	I	I	I	I
T34_b	II	II	II	II	II	II	II	II	II	II	II	II
T35_a	I	I	I	I	I	I	I	I	I	I	I	I
T35_b	I	I	I	I	I	I	I	I	I	I	I	I
T35_c	II	II	II	II	II	II	II	II	II	II	II	II
T35_d	II	II	III	III	II	III	III	III	II	II	III	III
T36_a	I	I	I	I	I	I	I	I	I	I	I	I
T36_b	I	I	I	I	I	I	I	I	I	I	I	I

All the above scenarios in red above meet the REC in all the IUAs. As Sc 69 is ranked first in both the rank order and the normalising method, the Classes associated with Sc 69 are recommended. It must be noted that as this scenario meets the REC, a final decision on whether the dams are constructed will not impact on the Classes. The resulting Classes configuration for the Mzimvubu catchment are shown below.



Representation of Classes in the Mzimvubu catchment

WATER RESOURCE CLASSES AND CATCHMENT CONFIGURATION

The table below provides respectively the proposed Water Resource Class and ECs for the IUAs and Resource Units. These ECs are now referred to as the Target EC (TEC). It must be noted that various RUs require improvements based on non flow-related/anthropogenic issues that have to be addressed. RUs with flow-related issues are shaded in blue. Where it is deemed that the REC is attainable, it has been included in the catchment configuration provided below.

Recommended ECs and Water Resource Classes

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

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
		T33-8	Somabadi	17.27	C	C	C
		MRU Kinira (MzimEWR3)	Kinira	103.24	C	C	C
		T33-9	Rolo	40.49	C	C	C
		T33-10	Ncome	29.9	C	C	C
		T33-11	Cabazi	23.12	C	C	C
		T33-12	Mnceba	35.88	C	B	B
		T33-13	Caba	30.52	C	B	B
		T33-14	Mzimvubu	161.92	B	B	B
T34_a	I	T34-1	Tinana	67.86	B	B	B
		T34-2	Zindawa	52.59	B	B	B
		T34-3	Khohlong	22.94	B/C	B/C	B/C
		T34-4	Nxotshana	69.88	B	B	B
T34_b	II	T34-5	Thina	18.6	C	B/C	B/C
		T34-6	Tokwana	56.15	C	C	C
		T34-7	Bradgate se Loop	57.81	B	B	B
		T34-8	Luzi	45.27	B/C	B/C	B/C
		T34-9	Qwidlana	60.89	B	B	B
		MRU Thina_B	Thina	62.97	C	C	C
		T34-10	Qhanqu	42.25	B	B	B
		T34-11	Ngcothi	18.41	B	B	B
		T34-12	Mvuzi	39.26	C	C	C
		MRU Thina C (MzimEWR2)	Thina	146.37	C	C	C
T35_a	I	T35-1	Tsitsana	108.14	B	B	B
		T35-2	Pot	93.73	B	B	B
		T35-3	Mooi	46.59	B	B	B
		T35-4	Mooi	68.57	C	C	C
		MRU Tsitsa B	Tsitsa	73.82	C	C	C
		T35-5	Gqukunqa	38.91	B	B	B
T35_b	I	T35-6	Inxu	40	B	B	B
		T35-7	Gqaqala	59.52	B	B	B
		T35-8	Kuntombizininzi	32.15	B	B	B
		MRU Inxu (EWR1)	Inxu	67.36	C	C	C
		MRU Gat (IFR1)	Gatberg	91.79	B	B	B
T35_c	II	MRU Inxu	Inxu	36.43	B/C	B/C	B/C
		T35-9	Umnga	58.55	B/C	B/C	B/C
		T35-10	Qwakele	21.48	C	B/C	B/C
		T35-11	Ncolosi	26.2	C/D	C	C
		T35-12	Culunca	27.66	C	B/C	B/C
		T35-13	Tyira	23.23	C/D	C/D	C/D
		T35-14	Xokonxa	36.12	C	C	C

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
		T35-15	Ngcolora	35.99	C	C	C
		T35-16	Ruze	25.59	B	B	B
T35_d	II	MRU Tsitsa Ca (MzimEWR1)	Tsitsa	79.89	C	C	C
		MRU Tsitsa Cb (EWR1 Lalini)	Tsitsa	19.17	C	C	C
		MRU Tsitsa_D	Tsitsa	47.15	B	B	B
T36_a	I	T36-1	Mzintshana	20.35	B	B	B
		T36-2	Mkata	30.57	B	B	B
		MRU Mzim (MzimEWR4)	Mzimvubu	56.93	C	C	C
T36_b	I	MRU Estuary	Mzimvubu	26.04	B	B	B

Mzimvubu River System nodes requiring improvements

RU	River	PES	REC comment	REC
T31-17		C	Possible sewage treatment required. Erosion control and improved agricultural practices. Alien vegetation removal.	B/C
T31-18	Mkemane	C/D	Water quality improvement required in terms of sedimentation, i.e. erosion control.	B/C
T32-1	Mzintlava	C	Flow only needs to improve as it relates to sensitivity. Control and management of dams.	**B/C**
T32-3		C	Flow only needs to improve as it relates to sensitivity. Control of, amongst others, pivot irrigation, to supply EWR.	**B/C**
T32-4	Mill Stream	C	Combination of flow and non-flows impacts.	**B/C**
T32-11	Mzintlava	C/D	Erosion control and improved agricultural practices. Alien vegetation removal.	C
T32-12	Mzintlavana	B/C	Erosion control. Alien vegetation removal.	B
T32-13	Mzintlava	C	Improve riparian continuity by improving riparian buffer zone (floodplain agriculture).	B
T33-13	Caba	C	Improvement of WWTW discharge quality, Erosion prevention, riparian buffer protection.	B
T34-5	Thina	C	Supply the EWR from the dam. Improve the WWTW discharge quality.	**B/C**
MRU Gat IFR1	Gatberg	B/C	Flow modification can only improve if dams are managed to ensure EWR.	**B**
T35-10	Qwakele	C	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	B/C
T35-11	Ncolosi	C/D	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	C
T35-12	Culunca	C	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	B/C

It is proposed to gazette the Classes and catchment configuration shown in bold above as short-term ECs.

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LIST OF ACRONYMS

BCR	Benefit Cost Ratio
BHNR	Basic Human Needs Reserve
CBA	Cost Benefit Analysis
Class	Water Resource Class
DWA	Department Water Affairs (Name change from DWAF applicable after April 2009)
DWAF	Department Water Affairs and Forestry
DWS	Department Water and Sanitation (Name change from DWA applicable after May 2014)
EC	Ecological Category
EHI	Estuary Health Index
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirement
GDP	Gross Domestic Product
GWh	Giga-watt Hours
HEPP	Hydro Electric Power Plant
IRR	Internal Rate of Return
IUA	Integrated Unit of Analysis
MCA	Multi Criteria Analysis
MRU	Management Resource Unit
MWP	Mzimvubu Water Project
NPV	Net Present Value
OCSD	Off-channel Storage Dam
PES	Present Ecological State
RBIG	Regional Bulk Infrastructure Grant
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological Category
RQO	Resource Quality Objective
RU	Resource Unit
Sc	Scenario
SQ	Sub-Quaternary
TEC	Target Ecological Category
ToR	Terms of Reference
WMA	Water Management Area
WRCS	Water Resources Classification System
WWTW	Waste Water Treatment Works

GLOSSARY

Cost Benefit Analysis (CBA)	A comparison of costs and benefits over time. CBA is considered an acceptable tool for ascertaining the financial and economic viability of public and public/private sector projects, and provides a logical framework by which development programmes can be evaluated, serving as an aid in the decision-making process.
EcoClassification	EcoClassification (or the Ecological Classification process) refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various physical attributes of rivers relative to the natural reference condition. A range of models are used during EcoClassification, each of which relate to the indicators assessed.
Ecological Category (EC)	ECs are determined for all components of the ecosystem for driver (abiotic) and response (biotic) components. These are integrated into an overall or integrated state called the EcoStatus. This level of information with the entire component ECs is only available when detailed studies are undertaken. For more desktop type studies, only a single EC may be available which represent the EcoStatus. **Whenever an EC is referred to without specifying that it is applicable to a specific component, this will always refer to the EcoStatus.**
Ecological Importance and Sensitivity (EIS)	Key indicators in the ecological classification of water resources. Ecological importance relates to the presence, representativeness and diversity of species of biota and habitat. Ecological sensitivity relates to the vulnerability of the habitat and biota to modifications that may occur in flows, water levels and physico-chemical conditions.
Ecological Water Requirements (EWR)	The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.
Economic analysis	The economic analysis consists of the status quo of the current economic activities as well as the situational analysis of the current prevailing socio-economic position.
EcoStatus	EcoStatus is defined as the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services.
Ecosystem Services	Natural assets which emerge from features or processes produced by the natural environment. Such services are directly utilised by surrounding communities and are thereby used to enhance human wellbeing as a direct result of such services.
EWR sites	Specific points on the river as determined through the 'hotspot' and site selection process. An EWR site consists of a length of river which may consist of various cross-sections assessed for both hydraulic and ecological purposes. These sites provide sufficient indicators to assess environmental flows and assess the condition of biophysical components (drivers such as hydrology, geomorphology and physico-chemical conditions) and biological responses (viz. fish, macroinvertebrates and riparian vegetation).
Gross Domestic	The monetary value of all the finished goods and services produced within a

Product (GDP)	country's borders in a specific time period.
Management Resource Units (Rivers)	The purpose of distinguishing MRUs from RUs is to identify a management unit within which the EWR can be implemented and managed based on one set of identified flow requirements. This means that an EWR site in the MRU, according to the EWR site selection criteria in context of the MRU, will provide for the whole MRU. MRUs are usually defined for river reaches only and differ from Resource Units in that the latter is a more detailed assessment.
Present Ecological State (PES)	The current state or condition of a water resource in terms of its biophysical components (drivers) such as hydrology, geomorphology, water quality and biological responses (viz. fish, invertebrates, riparian vegetation). The degree to which ecological conditions of an area have been modified from natural (reference) conditions.
Recommended Ecological Category (REC)	The Recommended Ecological Category is the future ecological state (Ecological Categories A to D) that can be recommended for a resource unit depending on the EIS and PES. The REC is determined based on ecological criteria and considers the EIS, the restoration potential of the system and attainability thereof.
Resource Quality Objectives (RQOs)	RQOs are numeric or descriptive goals that can be monitored for compliance to the Water Resource Class, for each part of each water resource.
Resource Units (RUs)	RUs are delineated during an Ecological Reserve determination study, as each will warrant its own specification of the Reserve, and the geographic boundaries of each must be clearly delineated. These sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach. RUs are nested within IUAs and may contain an Ecological Water Requirement site.
Revised Desktop Reserve Model (RDRM)	The output from the RDRM is an estimated EWR for each Ecological Category, at a desktop level for biophysical nodes other than EWR sites. Due to the large study area, additional EWRs are estimated for every Resource Unit identified which is not addressed by the more detailed EWR assessment at EWR sites. These EWRs are therefore estimated using the RDRM.
Scenarios	Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition.
Sub-quaternary catchments (SQ)	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary or quinary level.
Water Resource Class	The Water Resource Class is representative of those attributes that the DWS (as the custodian) and society require of different water resources. The decision-making toward a Water Resource Class requires a wide range of trade-offs to be assessed and evaluated at a number of scales. The final outcome of the process is a set of desired characteristics for use and ecological condition for each of the water resources in a given catchment. Three classes are defined, i.e. Class I, II, and III, based on the extent of use

and alteration of ecological condition from the predevelopment condition.

Water Resource Classification System (WRCS)	The Water Resource Classification System is a defined set of guidelines and procedures for determining the different classes of water resources (South African National Water Act (Act 36 of 1998) Chapter 3, Part 1, Section 2(a)). The outcome of the Classification Process will be the setting of the Class, Reserve and Resource Quality Objectives by the Minister or delegated authority for every significant water resource (river, estuary, wetland and aquifer) under consideration. This class, which will range from Minimally Used to Heavily Used, essentially describes the desired condition of the resource, and concomitantly, the degree to which it can be utilised.

1 INTRODUCTION

1.1 BACKGROUND

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

The Department of Water and Sanitation (DWS) has initiated a study to determine Classes and associated RQOs for the Mzimvubu T3 catchment in Water Management Area (WMA) 7.

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

- Coordinate the implementation of the Classes as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment, and
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes.

An additional aim is to consolidate and undertake additional work as required to improve the work previously done on Ecological Water Requirements (EWR) and the Basic Human Needs Reserve (BHNR) for the purposes of Classification.

1.2 STUDY AREA OVERVIEW

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

1.3 STUDY PROJECT PLAN

The Mzimvubu study is being undertaken according to the Project Plan in **Figure 1.1** with each step broken down into sub-steps. This report pertains to Step 5, the determination of Water Resource Classes based on catchment configurations for the identified scenarios.

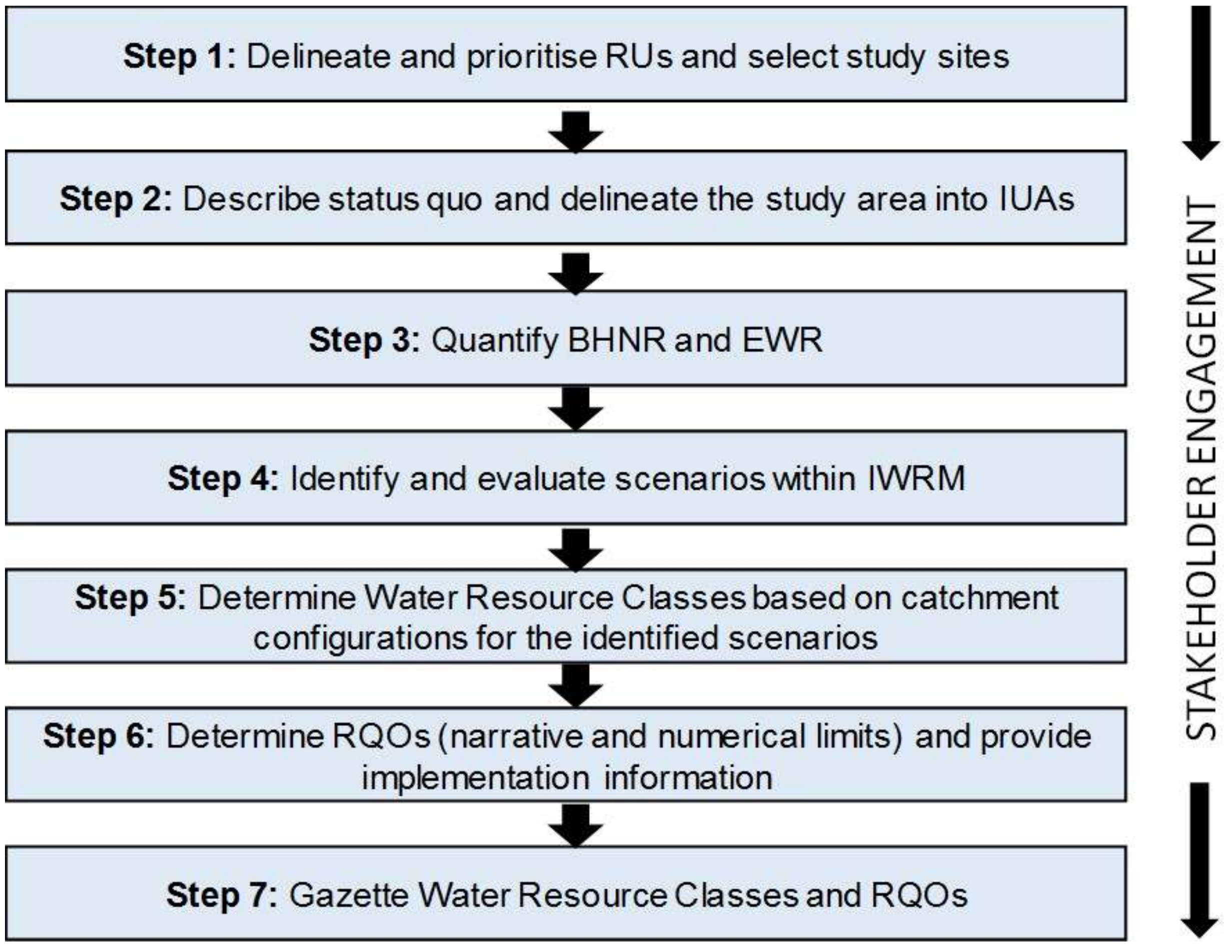


Figure 1.1 Project plan for the Mzimvubu Classification and RQO study

1.4 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to recommend operational scenarios and preliminary Classes for stakeholder evaluation for the relevant Integrated Unit of Analysis (IUAs). The report structure is outlined 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 results of the different scenarios, as they impact on the different economic sectors, are presented in this chapter. The impact on GDP, as well as labour, is provided for integration into the final results together with comparative Cost Benefit Analysis (CBA) indicators, Net Present Value (NPV) and Internal Rate of Return (IRR).

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

This section examines the results of the analysis of the potential consequences of scenarios on ecosystem services.

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 Classes among the scenarios are presented. Conclusions and recommendations are provided.

Chapter 10: References

Appendix A: 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 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 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 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 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 (or IUAs), then defining and selecting the scenarios for evaluation and finally to assess the consequences with the aim to make a recommendation of which Class should be implemented.

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

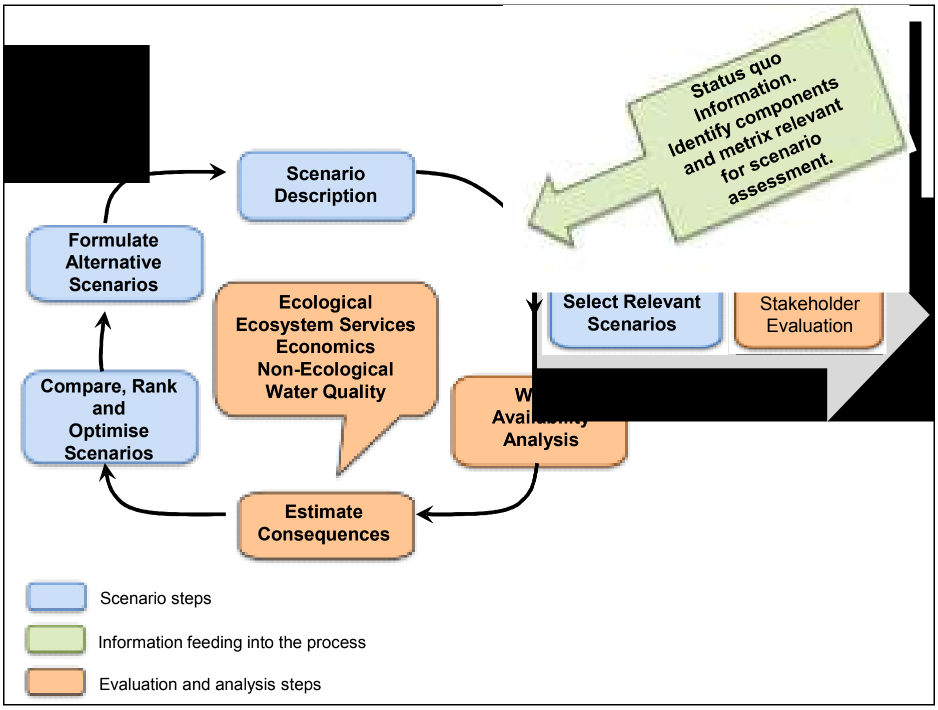


Figure 2.1 Schematic representation of the scenario evaluation process

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

2.1.1 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. The development options were already well established as part of several previous studies and the preliminary list was presented to stakeholders for their consideration (Discussion Document: Description of Operational Scenarios) 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 scenarios are defined, is primarily on identifying alternative operational aspects 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.

2.1.2 Assign attributes to EWR nodes (includes estuaries)

Applying the Status Quo information (DWS, 2016), 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.

2.1.3 Water resource 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.

2.1.4 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 current conditions.
Economy	Determine the economic benefit of utilising the available water (abstractions) in terms of Gross Domestic Product (GDP) and employment (jobs) and evaluate how this changes the status quo.
Non-ecological or user water quality	Consider the consequences of having to achieve elevated water quality standards for users other than the ecology (fitness for use or user specifications). This may involve determining the economic implications of such elevated standards. This was not brought into consideration for this catchment in terms of consequences as the scenarios did not have any influence on non-ecological or user water quality.

2.1.5 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 a 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).

2.1.6 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.

2.1.7 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 which achieves the REC and zero when the scenario is typically in an E or 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 were ranked on the basis of the degree to which the scenarios meet the REC.
- The impact of the scenarios at the different EWR sites was compared to determine a ranking from a system context. This 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 discussed below, and are presented generically in a step-by-step way.

Step 1: Rank scenarios at each EWR site

- Apply the EcoClassification process (Kleynhans and Louw, 2007) 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 are represented by the REC. That is, 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).
- A weighted average score is calculated 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 0 if the score (EC) is below the REC.

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

- Rank the scenarios in terms of a numerical scale with values 0 and 1 (typically, where one (1) indicates the scenario that achieves the REC and a zero (0) representing the situation where the scenario results in a F category).

Step 2: Determine the relative importance of EWR sites to each other

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 Transfrontier Park or a Wilderness Area or representing these 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. The following is then also rated:

- Length of the river reach represented by the respective EWR sites, i.e. the longer the reach, the higher the importance of the scenario impacts.
- Relative position of the EWR sites in the system and how they affect the simulated operation. The ranking of the sites is dependent on the key sites in the modelling context which dictates the driver EWR site in terms of the 'releases' in the model. These key sites are sometimes the most downstream site (as is the case in this study), or could be site which has a higher REC (or PES) than other sites and therefore a higher flow requirement.

The above values are then averaged again, including the averaging of the initial metrics, and the score is normalised out of 1.

Step 3: Rank the scenarios in a system context

All the scores from the EWR sites are then combined into a single score by accounting for the site importance ranking shown in Step 2. This is achieved by assigning different weights (factors) to each site to reflect the importance relative to the others. The individual ranking and consequences at each EWR site have therefore been integrated into one ranking and consequences applicable to the specific river system. Once all the scores for each scenario have been calculated, these can then be ranked and plotted on a traffic diagram illustrating the degree to which the REC is met.

b) Estuaries

Deriving a single metric (one number), that reflects the ecological health relative to the REC for the Mzimvubu Estuary, requires a number of steps. Broadly, the rationale is to achieve a single rating where each scenario is ranked on the basis of the degree to which the scenarios meet the REC for the estuary. The following approach was applied:

- Apply the Estuary Health Index (EHI) to each scenario that may influence the flow or water quality in the estuary by first determining individual health scores for each of the abiotic and biotic components, expressed as a percentage similarity to a reference condition (i.e. pristine state).
- Combine these individual scores into a single overall EC for the estuary linked to a scenario.

- Calculate the degree to which each scenario meets the ecological objectives for the estuary as represented by the REC (i.e. expressed as the percentage difference between the EC of the scenario and the REC).
- Normalise the score of each scenario to obtain a rating that is one (1) if the REC is achieved, above one if the REC is exceeded (e.g. 1.1), or between one and zero if the score (EC) is below the REC (e.g. 0.8).
- 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 '0' represents the situation where the scenario results in an EC of 'F').

Because the Mzimvubu Estuary is the only estuary in this catchment study area, it was not necessary to conduct normalisation of rankings across estuaries. This is typically done when there are more than one estuary in the catchment study area and where these need to be further normalised in terms of their relative ecological importance and ecological health.

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.

2.2.3 Ecosystem services

Natural habitats and ecosystems provide a range of environmental goods and services that contribute to human well-being. River systems and estuaries 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 and estuary was undertaken. Ecosystem services associated with the sites and estuary, 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 and estuary. As such the score given to each of the services when the SQs are evaluated is examined against the nature of the particular EWR site and associated area. In an instance where regulating services, for example are deemed to be important, then these services are given a higher weight. The same goes for the other services. All weightings are normalised against a base score of 1. For example, where all four services are deemed to be of equal importance then a score of 0.25 would be allocated to each.

2.2.4 Overall ranking metric

The first aspect considered 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.

2.2.5 Relative importance among variables

The relative importance (among the variables) was 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 2.2** for illustration purposes. The actual weight scheme applied in the study is discussed in **Chapter 8**.

Table 2.2 Explanation of the application of variable weights

Pre-selected importance bias	Weights assigned (Sum of weights for the four variables must add up to 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.

2.2.6 Normalising methods

The normalisation scheme applied in the calculations is to adjust the values for each scenario by scaling (adjusting) 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 Class 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.

It is recommended that the scheme presented in **Table 2.3** (adjusted from the guideline rules) is used as the criteria to determine the Class (modified from guidelines). 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 Class I if the following applies:

- 0% 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.
- 95% of the units should be greater or equal to and D EC.
- Less than 5% of the units can be in an E EC.

Table 2.3 Guidelines for the calculation of the IUA Class for a scenario (adjusted from DWAF, 2007)

		% 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 rule indicated in **Table 2.3** only refers to the full categories and does not include half categories (EC of a B versus an EC of a B/C). Half categories indicate categories that can be either a high C or a low B (in the B/C example). At the desktop level, the intensity of the assessment to determine the categories does not provide sufficient information to allocate a river reach to either to a B or a C. A sensitivity analysis is therefore carried out where half categories are distributed equally to full categories. The total length of half category river reaches in an IUA is split; 50% to the lower and 50% to the upper categories respectively. As an example, if there is 150 km of river in B/C categories, then 75 km will be added to the B categories and 75 km to the C categories. This will be relevant for the B/C, C/D and D/E half categories.

The results presented in **Chapter 9** lists the IUA Water Resource Classes for the indicated scenarios.

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 Classes. When identifying and formulating scenarios for analysis the following aspects are considered:

- Identify the pertinent operational water resource and developments in the system.
- Define a range of scenarios that 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 in 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.

3.2 MZIMVUBU RIVER SYSTEM SCENARIOS

Table 3.1 shows the scenario (Sc) summary matrix indicating the drivers of the scenario (different columns) for the list of scenarios provided by the rows. Various iterative scenarios were analysed and only the scenarios that were recommended to be considered for the decision-making and selection of the final scenario and associated Classes are presented in the table.

A note on scenario naming: Scenario modelling and analysis is an iterative process, meaning that the naming of scenarios may not be consecutive, but represent those scenarios finally selected for the determination of consequences. Numbering (e.g. the number of letters or numbers used) is also bound by the models used (both for modelling and by the scenario comparison tool used by the ecologists). It is more important to retain consistency throughout the steps of the evaluation process than attempt to reorganise scenarios in consecutive numbering order.

Table 3.1 Mzimvubu River: Summary of operational scenarios

Scenario	Updated water demands (2040)		EWRs			Development options*		
	Realistic projection (a)	Ultimate development projection (b)	MzimEWR4	MzimEWR1	EWR1 Lalini (scaled from MzimEWR1)	MWP[1] (2014 Feasibility study)	MWP (Pro-plan configuration; 2017 Design study)	Port St Johns proposed WWTW**
2a	Yes	No	No	No	No	Yes	No	No
2b	No	Yes	No	No	No	Yes	No	No
2c	No	Yes	No	No	No	No	Yes	No
53	No	Yes	REC low	REC low	No	Yes – Reduced Hydro further in dry months	No	No
54	No	Yes	REC low	REC low	Cat D low	Yes – Reduced Hydro further in dry months	No	No
61	No	Yes	REC low	REC low	Cat D low	No	Yes	No
62	No	Yes	REC low	REC low	Cat D low	No	Yes – Reduced Hydro in dry months (Pro-plan HEPP Design Capacity)	No
63	No	Yes	REC low	REC low	Cat D low	No	Yes – Reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No
65	No	Yes	REC low	REC low	Cat D low	No	Yes – Further reduced Hydro in dry months (Pro-plan HEPP Design Capacity)	No
69	No	Yes	REC low	REC low	Cat D low	No	Yes – Further reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No
70	No	Yes	REC low	REC low	No	No	Yes – Further reduced Hydro in dry months (Increased HEPP Design Capacity in wet months)	No

1 Mzimvubu Water Project.

* *Development options common to all scenarios:*

- *Revive Irrigation (T33A-T33G).*
- *New Municipal Dams / Abstractions.*

*** The impact of the proposed Port St Johns Waste Water Treatment Works (WWTW) was analysed separately by the estuary team.*

3.3 MZIMVUBU RIVER SYSTEM SCENARIO DESCRIPTIONS

3.3.1 Scenario 2a

Scenario 2a includes realistic estimates of increased water use and return flows for the domestic sector due to population growth and improved service delivery. The water requirement and return-flow projections were based on information sourced from the DWS All Towns study. The afforestation, alien invasive plants and irrigation water use were assumed to remain at the present day levels (presented in the *Systems Modelling Report (Volume 1)* – DWS (2017)), except for the irrigation in the T33 catchment, where it was assumed that the original irrigation that took place in the catchment (706 ha) will be revived (currently 28 ha).

The scenario also includes the implementation of the Mzimvubu Water Project (Ntabelanga and Lalini dams) with its associated developments (irrigation, domestic and hydropower supply) as well as the implementation of various proposed municipal dams and river abstractions. The dams include:

- Ntabelanga and Lalini dams (MWP).
- Ugie Dam.
- Kinira Dam.
- Siroqobeni River Dam (Mzintlava off-channel storage dam was another option but Siroqobeni River Dam recommended by the Regional Bulk Infrastructure Grant (RBIG) Study).
- Raising of Kempdale Dam.
- Mzimvubu-Ntsonyeni off-channel storage dam (OCSD).
- Other river abstractions and off-channel storage dams (river abstraction and Cengane-channel storage dams, river abstraction and Ngqeleni Dam-channel storage dams, etc.).

Raising of the Ntenetyana Dam was recommended by the RBIG Study but subsequent investigations by DWS confirmed the incremental increase in yield is minimal and the new Mkemane River Dam was recommended. It was however established that the Mkemane River Dam supply area overlaps with the MWP supply area and was thus not included. No EWR releases were included in Sc 2a.

3.3.2 Scenario 2b

An observation from Sc 2a was that the yields of the proposed new dams were not fully utilised, in some cases more than others. Scenario 2b is based on Sc 2a, but where the water requirements were increased to fully utilise the available yield of the new proposed dams (the ultimate development projection).

3.3.3 Scenario 2c

Scenario 2c was based on Sc 2b but with the incorporation of the 2017 MWP infrastructure design information and optimised hydropower operating rules from the design phase of the project (van Wyk and de Jager, 2016). The operating rules are significantly different to the rules applied in Sc 2a and 2b, which influences the flows at the EWR sites:

- Scenarios 2a and 2b: Lalini Dam was drawn down continuously and supported by Ntabelanga Dam when the water levels reached the dead storage level i.e. the water is held in the upper Ntabelanga Dam. A variable release pattern was applied for generating hydropower at the Main HEPP.

- Scenario 2c: Lalini Dam operated at ±75% nett storage in order to try to maintain a constant maximum capacity flow at the Main HEPP i.e., when the dam level was at ±75% nett storage, support is provided from Ntabelanga Dam up to a minimum in Ntabelanga Dam to avoid failure, i.e. Lalini Dam is 'kept full' for maximum head.

3.3.4 Scenario 53 and 54

These scenarios are the same as Sc 2b but included releases for EWRs as follows:

- Sc 53: MzimEWR1 (low) and MzimEWR4 (low) only.
- Sc 54: MzimEWR1 (low), EWR1 Lalini (low) and MzimEWR4 (low).

Previous modelled scenarios provided unnaturally high and constant baseflows in the dry winter months which was unacceptable from an ecological perspective. Various iterative scenarios were analysed with the hydropower generation reduced in the dry winter months at MzimEWR4 and especially the estuary. The hydropower generation was increased by a similar amount in the wet summer months. Scenario 53 and 54 were the final scenarios where an acceptable reduction in baseflows was achieved.

3.3.5 Scenario 61

Scenario 61 includes the latest MWP infrastructure design information and optimised hydropower operating rules from the 2017 design phase of the project as received from the design team. The hydropower operating rules are significantly different to the rules applied in the previous scenarios, which influences the flows at the EWR sites.

3.3.6 Scenario 62 and 65

Scenario 62 was based on Sc 61 but with the hydropower generation reduced in the dry winter months. The hydropower generation in the wetter summer months was as per the latest 2017 hydropower infrastructure capacities and operating rules received from the design team. The purpose of the scenario was to decrease the flows at MzimEWR4 and especially the estuary, as it could be seen that the previously modelled scenarios would provide unnaturally high and constant baseflow.

Scenario 65 was based on Sc 62 where hydropower generation was further reduced during the dry winter months. Initial analyses of Sc 62 showed that the baseflows in the dry winter months were still unacceptable from an ecological perspective and were thus reduced further.

3.3.7 Scenario 63 and 69

Scenario 63 was based on Sc 62 but with the hydropower generation design capacity increased in the wet summer months to utilise the additional storage gained (due to the reduced hydropower generation in the dry winter months) for additional hydropower generation in these months. Initial Sc 63 results showed that the increased hydropower generation design capacity with the associated increased hydropower releases in the wet summer months was acceptable from an ecological perspective, but that the baseflows due to hydropower releases in the dry months were still ecologically problematic and needed to be reduced further as with Sc 62. Scenario 69 was thus formulated, where hydropower generation was further reduced during the dry winter months.

3.3.8 Scenario 70

Scenario 70 was not modelled as flows are the same or very similar as Sc 69. The difference between Sc 70 and Sc 69 is that, as for Sc 53, Sc 70 excludes EWR1 Lalini (low) i.e. no EWR flow releases from Lalini Dam.

4 ECONOMIC CONSEQUENCES

The results of the different scenarios, as they impact on the different economic sectors, are presented in this chapter. The impact on GDP, as well as labour, is provided for integration into the final results together with comparative CBA indicators, NPV and IRR.

4.1 RESULTS PRESENTATION

An economic baseline was established and the results for the different scenarios were measured against this baseline. In the following table the GDP and employment are presented as a value after the baseline was brought into consideration.

Table 4.1 shows that Sc 2b, 2c, 61, 63 and 69 provide an economic positive deviation from the economic baseline.

Table 4.1 GDP and employment deviation per scenario from the economic baseline

Scenario	GWh*	GDP (R mil.)	GDP deviation (R mil.)	Employment	Employment deviation
54	355.78	R 1 983.76	R -41.56	14 051	-294
2c	415.36	R 2 315.99	R 290.67	16 404	2 059
61	417.54	R 2 328.13	R 302.81	16 490	2 145
62	353.42	R 1 970.59	R -54.74	13 958	-388
63	413.29	R 2 304.44	R 279.11	16 322	1 977
65	319.17	R 1 779.64	R -245.68	12 605	-1 740
69	378.80	R 2 112.13	R 86.81	14 960	615
2b	376.22	R 2 097.72	R 72.40	14 858	513

**Giga-watt hours*

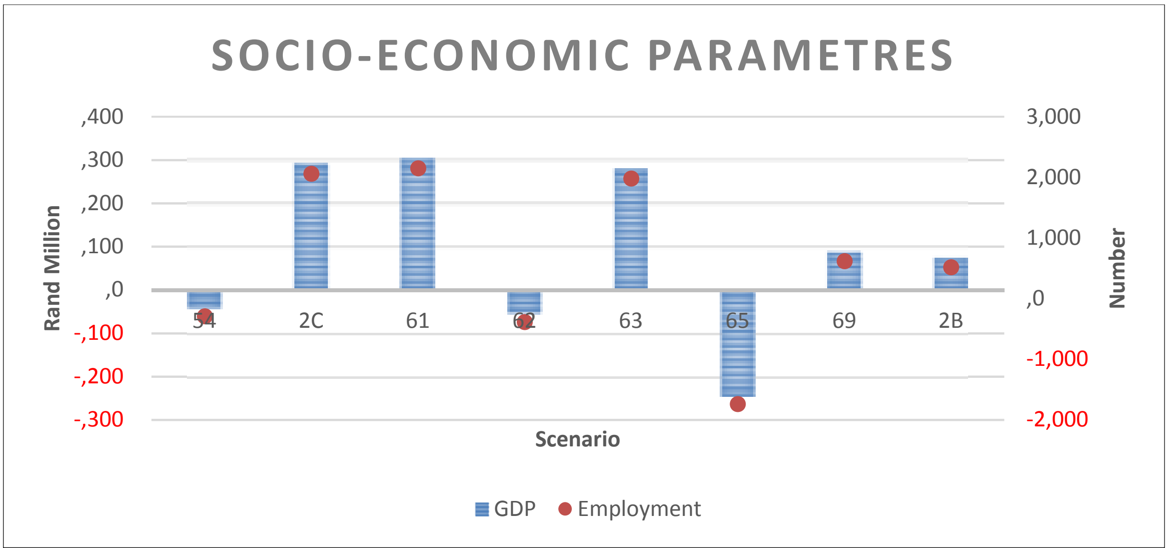


Figure 4.1 Comparison of the GDP and employment results in the socio-economic analysis

Figure 4.1 shows that the deviation for the GDP and employment are very close for all the scenarios. It also shows that negative impact Sc 54 and 62 are very marginal for both parameters. Scenario 65 shows a very large deviation for both parameters. Scenario 54, 62 and 65 provide a negative deviation from the economic baseline.

The results of the CBA analysis are presented in **Table 4.2**. Keep in mind that the CBA was performed to express an opinion on the future economic and financial positive return on the capital invested in the HEPP system. **Table 4.2** shows that Sc 2c, 61, 63, 69 and 2b provides financial viability results. Scenario 54, 62 and 65 indicate a negative impact on financial viability.

Table 4.2 Financial CBA results

Scenario	Tariff Income (R mil.)	NPV (R mil.)	IRR (R mil.)	Benefit Cost Ratio (BCR) (R mil.)	Viability criteria met?
54	R 373.57	R -132.66	7.0%	1.36	No
2c	R 436.13	R 425.45	11.0%	1.67	Yes
61	R 438.42	R 362.37	10.5%	1.63	Yes
62	R 371.09	R -151.61	6.9%	1.35	No
63	R 433.96	R 328.31	10.3%	1.61	Yes
S65	R 335.13	R -426.09	4.8%	1.20	No
69	R 397.74	R 51.87	8.4%	1.46	Yes
2b	R395.03	R 41.16	10.9%	1.26	Yes

4.2 RANKING

The ranking applied is based on the highest net benefit to society in terms of GDP and employment stimulation by applying the macro-economic approach. In the case of the CBA analysis it is a simple linear relationship where the highest NPV of each scenario or option transcends the other scenarios or options.

Figure 4.3 shows the relationship between the GDP (macro-economic) and NPV (CBA) approaches in terms of the deviation of the two methodologies from the current economic baseline.

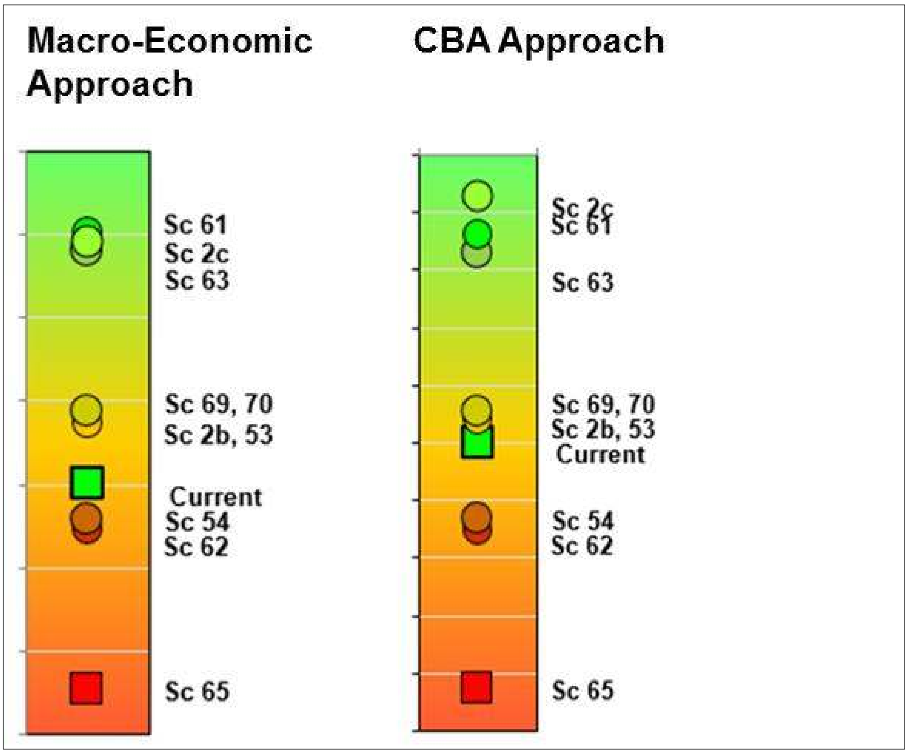


Figure 4.2 Relationship between the GDP and NPV approaches in terms of the deviation of the two methodologies from the current economic baseline

4.3 CONCLUSIONS

The following conclusions and recommendations are supported by the economic analysis:

- As previously discussed the hydro-power system and the building of the Lalini Dam will involve a large amount of capital and the financial viability of the system will be an important issue, with the results of the macro-economic and CBA results playing an important role in the final decision-making process.
- The results show that from a financial and economic viewpoint Scenario 65 is not viable and that Scenarios 54 and 62 could be viable if the Eskom tariffs increase faster than the official inflation rate. This should however be treated with caution as the present financial situation of Eskom is not desirable.
- The other scenarios are acceptable from an economic viewpoint, however Scenario 70 is problematic as the possibility exists that the Tsitsa Falls will run dry under this scenario.

5 ECOLOGICAL CONSEQUENCES: RIVERS

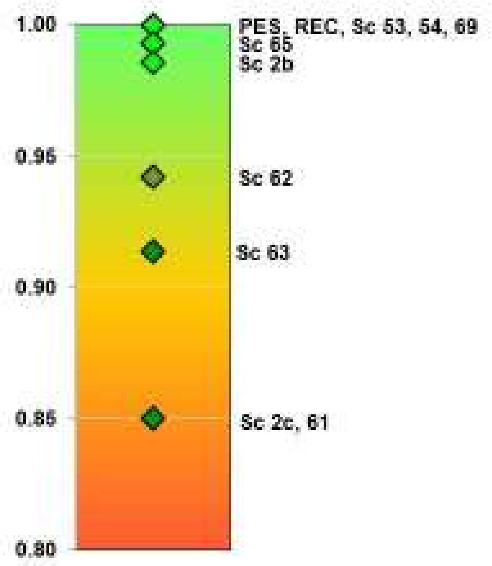
The ecological consequences on the three EWR sites are provided in the **Table 5.1**. Note that the colouring of the traffic diagram denotes an improvement from red through orange to green. Shading is therefore according to the colours of a traffic light; implying that the items at the top (in the green section) are better than the ones below.

5.1 SCENARIO CONSEQUENCES AT EWR SITES

Table 5.1 Summary of ecological consequences

MzimEWR4 (Mzimvubu River)

Component	PES and REC	Sc 2b	Sc 53	Sc 61	Sc 62	Sc 63	Sc 65
Physico-chemical	A/B	A	A/B	A	A/B	A/B	A/B
Geomorphology	C	C	C	C	C	C	C
Riparian vegetation	C/D	D	C/D	E	D	D	C/D
Fish	C	B/C	B	C	C	C	C
Invertebrates	C	C	B	C/D	C	C	C
EcoStatus	C (67.2%)	C (66.3%)	C (71.3%)	D (49.7%)	C/D (59.4%)	D (57.1%)	C (67.7%)

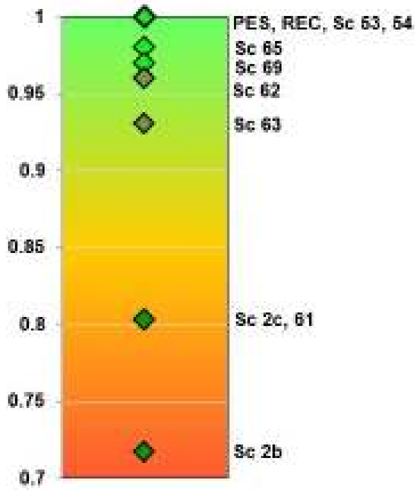


Ranking rationale:
For the purposes of evaluation, note the following:

- **Sc 53** = Sc 54 = Sc 69 = Sc 70
- **Sc 61** = Sc 2c

The ranking of the scenarios indicates that Sc 69 achieves the REC (and PES) requirements. Scenario 65 maintains the REC, with fish slightly deteriorating within the PES category. The rest of the scenarios result in a deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones, and ultimately the habitat availability for biota. As Sc 53 and 54 were not part of the 2017 design phase (Pro-Plan data), Sc 69 is recommended as the most suitable scenario.

MzimEWR1 (Tsitsa River)								
Component	**PES and REC**	**Sc 2b**	**Sc 53**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
Physico-chemical	B	C/D	B	A/B	B	B	B	B
Geo-morphology	C	C	C	D	D	D	D	D
Riparian vegetation	C/D	D/E	C/D	D/E	D	D	C/D	D
Fish	C	D	C	C	C	C	C	C
Invertebrates	C	D/E	C	C	C	C	C	C
EcoStatus	C (65.1%)	D (42.7%)	C (66.9%)	D (49.2%)	C/D (61.7%)	C/D (59.4%)	C (65.1%)	C (63.7%)



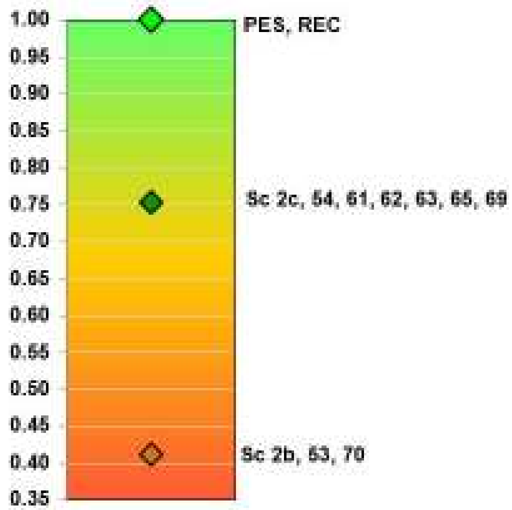
Ranking rationale:

For the purposes of evaluation, note the following:

- **Sc 69** = Sc 70
- **Sc 61** = Sc 2c

Scenarios 65 and 69 maintain the REC (and PES), with Sc 69 resulting in the riparian vegetation deteriorating due to increased baseflows. The rest of the scenarios result in deterioration from the PES and REC, mainly due to increased baseflows above natural in the dry season impacting the middle and lower riparian zones and ultimately the habitat availability for biota. As Sc 54 is not part of the Pro-Plan design, and Sc 69 is a better option at MzimEWR4, which is the driving river site, Sc 69 is recommended as the most suitable scenario.

EWR1 Lalini (Tsitsa River)			
Component	**PES and REC**	**Sc 2b**	**Sc 54**
Physico-chemical	B	E	C
Geomorphology	C	C	D
Riparian vegetation	C/D	F	D
Fish	C	D/E	D
Macroinvertebrates	C	F	D
EcoStatus	C (65.05%)	E/F (19%)	D (47.55%)



Ranking rationale:

For the purposes of evaluation, note the following:

- **Sc 2b** = Sc 53 = Sc 70
- **Sc 54** =Sc 2c=Sc 61=Sc62 = Sc 63 = Sc 65 = Sc 69

The DWS has indicated that management options associated with Sc 2b, 53 and 70, i.e. no flow over Tsitsa Falls, would be unacceptable. As some flow is therefore required in the reach immediately downstream of Lalini Dam, any of the other scenarios will be acceptable.

5.2 INTEGRATION OF CONSEQUENCES FOR RIVER SITES

The first step in determining an integrated RIVER ranking (i.e. integrating MzimEWR1, EWR1 Lalini and MzimEWR4) was to determine the relative importance of these EWR sites occurring in the study area. The site weight (**Table 5.2**) indicates that the MzimEWR4 site carries the highest weight due to the site being the most downstream river site in the study area. The accumulated impact of the scenarios is therefore expected to be the highest within this river reach (distance from the outfall of Lalini Dam to the Mzimvubu Estuary is 137 km). The importance of the MzimEWR1 site is lower due to lower accumulated impacts of scenarios within the 76 km reach demarcated from Ntabelanga Dam to Lalini Dam. EWR1 Lalini has the lowest weight as the EIS is Moderate and the site is situated in a relatively isolated reach in the Tsitsa River (it is 18 km from Lalini Dam to the outfall).

Site weights are based on the conversion of the PES and EIS to numerical values to determine the normalised weight.

Table 5.2 Weights allocated to EWR sites relative to each other

EWR site	PES	EIS	Locality in protected areas	Distance	Position	Normalised weight
MzimEWR1	C	Moderate	1	0.33	0.10	0.25
EWR1 Lalini	C	Moderate	2	0.07	0.10	0.17
MzimEWR4	C	Moderate	1	0.6	1.00	0.57

The weight was applied to the ranking value for each scenario at each EWR site and this provided an integrated score and ranking for the operational scenarios. The ranking of '1' refers to the REC (which is the same as the PES in this circumstance), with the rest of the ranking illustrating the degree to which the scenarios meet the REC. The results are provided in **Table 5.3**, i.e. once the weights have been taken into account.

Table 5.3 Ranking value for each scenario resulting in an integrated river score and site ranking

Site	PES and REC	Sc 2b	Sc 53	Sc 54	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69	Sc 2c	Sc 70
MzimEWR1	0.25	0.18	0.25	0.25	0.20	0.24	0.24	0.25	0.25	0.20	0.25
EWR1 Lalini	0.17	0.07	0.07	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.07
MzimEWR4	0.58	0.57	0.58	0.58	0.49	0.54	0.53	0.57	0.58	0.49	0.58
	1.00	**0.82**	**0.90**	**0.96**	**0.82**	**0.91**	**0.89**	**0.95**	**0.95**	**0.82**	**0.89**

The above results are plotted on a traffic diagram (**Figure 5.1**) to illustrate the integrated river ecological ranking of scenarios.

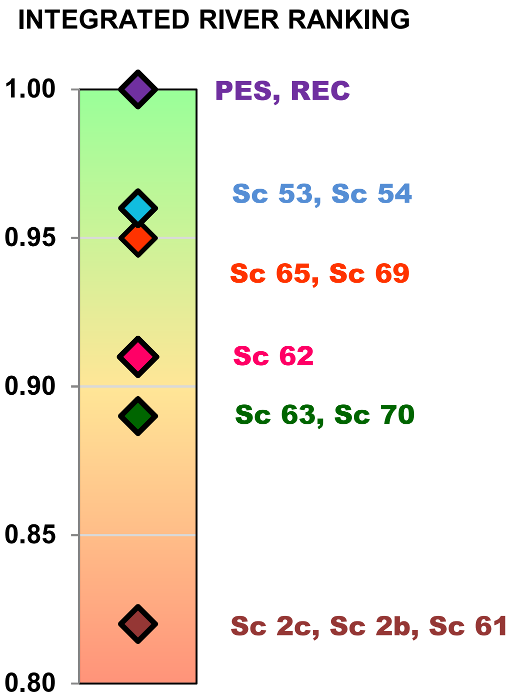


Figure 5.1 Integrated ecological ranking of the scenarios on the Tsitsa and Mzimvubu rivers

6 ECOLOGICAL CONSEQUENCES: ESTUARIES

6.1 PRESENT ECOLOGICAL STATE AND RECOMMENDED ECOLOGICAL CATEGORY

The EHI scores allocated to the various abiotic and biotic health parameters for the Mzimvubu and the overall PES for the system are calculated using the index as described in the official methodology for estuaries (DWAF, 2008). The PES of the Mzimvubu Estuary is estimated to be 81 (i.e. 81% similar to natural condition), which translates into Category B. The estuary therefore is still in a good condition. Modification from the reference conditions is primarily linked to following factors:

- Decrease in baseflow resulting an increase in periods of saline penetration during low flow periods;
- Increased nutrient input and turbidity as a result of catchment activities (settlements and cattle herds), as well as diffuse runoff into estuary from the adjacent town.
- Road construction and infilling around the bridge and loss of some intertidal habitat.
- Fishing pressures; and
- Human disturbance of birds.

Estimates of the contribution of non-flow related impacts on the level of degradation suggests that non-flow impacts have played a significant role in the degradation of the estuary to a D, but that flow-related impacts also contributed (e.g. reduction in baseflows). Key non-flow related pressures include road and bridge construction, diffuse pollution from catchment and town, fishing pressures and human disturbance of birds.

Applying the guidelines for the determination of the REC, based on an estuary's PES and importance, the REC for the Mzimvubu Estuary should be a **Category A** or at least **Best Attainable State**. However, consideration of the Mzimvubu Estuary's present state and related issues, led to a BAS being set at a **Category B**, i.e. within the PES category.

6.2 SCENARIO CONSEQUENCES

The individual EHI scores, as well as the corresponding ecological category under different scenarios are provided in **Table 6.1,** while **Figure 6.1** summarises the ranking of the scenarios applying the method described earlier.

Table 6.1 Mzimvubu Estuary Health Index score and corresponding ECs under the different runoff scenarios

Components	Scenarios							
	Pres	2b	2c	53, 54	61	62	63	65	69, 70
Hydrology	89	86	79	97	74	84	83	93	93
Physical habitat	94	90	79	89	74	84	74	84	82
Hydrodynamics/mouth condition	98	97	97	99	97	97	97	99	99
Water quality	75	67	67	77	68	66	68	75	76
Habitat health score	89	85	80	90	78	83	80	88	87
Microalgae	65	73	68	68	63	73	63	68	67
Macrophytes	63	62	59	62	59	59	56	59	58

Components	Scenarios								
	Pres	2b	2c	53, 54	61	62	63	65	69, 70
Invertebrates	95	75	74	75	75	73	75	90	85
Fish	77	64	62	72	62	62	62	76	74
Birds	61	62	62	62	62	62	62	62	62
Biotic health score	72	67	65	68	64	66	64	71	69
ESTUARY HEALTH SCORE	**81**	**76**	**73**	**79**	**71**	**74**	**72**	**79**	**78**
ECOLOGICAL CATEGORY	**B**	**B/C**	**B/C**	**B**	**C**	**B/C**	**C**	**B**	**B**

For the Mzimvubu Estuary the consequences of scenarios are as follows:

- Scenario 53, 54, 65, 69 and 70 maintains the REC (equivalent to the PES), that is Category B. Although baseflows (in the range <10 m^3/s) increases in all these scenarios, estuary ecology remains sufficiently resilient to these increases.
- Scenario 2b, 2c and 62 all reduce the ecological health of the system to a Category B/C. These scenarios result in a further increases in baseflows (in the range <10 m^3/s) reducing periods of saline intrusion that are critical to maintain certain estuarine faunal communities (especially with invertebrates and fish); and
- Scenario 61 and 63 reduce the ecological health of the estuary further to into a Category C. These scenarios not only further increase baseflows (in the range <10 m^3/s), thus reducing periods of saline intrusion (affecting faunal communities especially invertebrates and fish). It also results in a reduction in floods creating more stable sediment conditions, affect other estuarine biotic communities such as macrophyte vegetation.

The **'recommended Ecological Water Requirement' scenario** is defined as the flow scenario (or a slight modification thereof to address low-scoring components) that represents the highest change in river inflow that will still maintain the estuary in the REC. Where any component of the health score is less than 40 modifications to flow and measures to address anthropogenic impacts must be found that will rectify this.

The REC for the Mzimvubu Estuary has been recommended at a Category B. Applying the rules of selecting scenarios that will maintain/improve the systems to its REC, the recommended EWR scenario, could be allocated as Sc 53, 54, 65, 69 or 70.

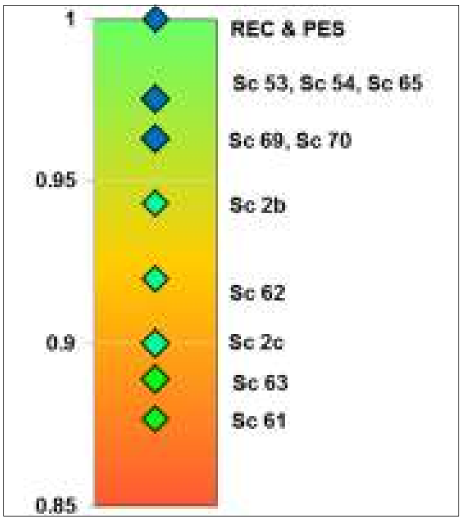


Figure 6.1 Mzimvubu Estuary: Ranking of scenarios

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**.

7.1 MZIMVUBU RIVER

7.1.1 MzimEWR4

Scenario 52, 53, 62, 63, and 65 were scored separately, however, the following scenarios were determined to be equivalent and scored according to the following grouping:

- Sc 2a = 2b.
- Sc 32 = 33 = 41 = 42 = 51.
- Sc 2c = 61.
- Sc 69 = 70.

Scores were weighted as follows for MzimEWR4 to produce the final results.

- Provisioning services = 40%.
- Regulating services = 20%.
- Cultural services = 25%.
- Supporting services = 15%.

Scores are reflected in **Table 7.1**.

Table 7.1 Ecosystem Services scenario scoring for MzimEWR4

Service	Sc 2a	Sc 32	Sc 52	Sc 53	Sc 2c	Sc 62	Sc 63	Sc 65	Sc 69
Normative score									
Provisioning	1.02	1.02	1.02	1.06	0.88	0.94	0.94	0.99	1.06
Regulating	1.07	1.09	1.09	1.04	1.10	1.04	1.06	1.06	1.06
Cultural	1.06	1.06	1.06	1.10	1.06	1.10	1.10	1.10	1.10
Supporting	0.89	0.89	0.89	1.00	0.88	0.90	0.90	0.95	0.95
Weighted score									
Provisioning	0.41	0.41	0.41	0.43	0.35	0.38	0.38	0.40	0.42
Regulating	0.21	0.22	0.22	0.21	0.22	0.21	0.21	0.21	0.21
Cultural	0.27	0.27	0.27	0.28	0.27	0.28	0.28	0.28	0.28
Supporting	0.13	0.13	0.13	0.15	0.13	0.14	0.14	0.14	0.14
Total	**1.02**	**1.02**	**1.02**	**1.06**	**0.97**	**1.00**	**1.00**	**1.03**	**1.05**

7.2 TSITSA RIVER

7.2.1 MzimEWR1

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. Scores were weighted as follows for MzimEWR1 to produce the final results.

- Provisioning services = 40%.
- Regulating services = 20%.
- Cultural services = 25%.

- Supporting services = 15%.

Scenario 54, 61 and 65 were scored separately, however, the following scenarios were determined to be equivalent and scored according to the following grouping:
- Sc 2a = 2b = 32 = 33.
- Sc 41 = 42 = 51 = 52 = 53.
- Sc 62 = 63.
- Sc 61 = 2c
- Sc 69 = 70.

Scores are reflected in **Table 7.2**.

Table 7.2 Ecosystem services scenario scoring for MzimEWR1

Services	Sc 2a	Sc 41	Sc 54	Sc 61	Sc 62	Sc 65	Sc 69
Normative score							
Provisioning	0.83	1.04	1.04	0.73	0.92	1.00	0.96
Regulating	0.54	1.03	1.03	1.11	1.04	1.01	1.06
Cultural	0.92	1.02	1.02	0.88	0.88	0.80	0.80
Supporting	0.70	0.84	0.84	0.60	0.64	0.85	0.66
Weighted score							
Provisioning	0.33	0.42	0.42	0.29	0.37	0.40	0.38
Regulating	0.11	0.21	0.21	0.22	0.21	0.20	0.21
Cultural	0.23	0.26	0.26	0.22	0.22	0.20	0.20
Supporting	0.11	0.13	0.13	0.09	0.10	0.13	0.10
Total	**0.77**	**1.00**	**1.00**	**0.83**	**0.89**	**0.93**	**0.90**

7.2.2 EWR1 Lalini

Scenario 54 was scored separately, however, the following scenarios were determined to be equivalent and scored according to the following grouping:
- Sc 2a = Sc 2b = Sc 41 = Sc 51 = Sc 53.
- Sc 33 = Sc 42 = Sc 52.
- Sc 61 = Sc 63 = Sc 65 = Sc 69.
- Sc 2c = 70.

Scores were weighted as follows for EWR1 Lalini to produce the final results:
- Provisioning services = 40%.
- Regulating services = 20%.
- Cultural services = 25%.
- Supporting services = 15%.

Scores are reflected in **Table 7.3**

Table 7.3 Ecosystem services scenario scoring for EWR1 Lalini

Services	Sc 2a	Sc 33	SC 61	Sc 54	Sc 2c
Normative score					
Provisioning	0.71	1.00	0.80	0.80	0.71
Regulating	0.54	0.97	0.80	0.80	0.54
Cultural	0.84	1.00	0.80	0.80	0.20
Supporting	0.70	0.85	0.80	0.80	0.70
Weighted score					
Provisioning	0.28	0.40	0.32	0.32	0.28
Regulating	0.11	0.19	0.16	0.16	0.11
Cultural	0.21	0.25	0.20	0.20	0.05
Supporting	0.11	0.13	0.12	0.12	0.11
Total	**0.71**	**0.97**	**0.80**	**0.80**	**0.55**

7.2.3 Mzimvubu Estuary

All scenarios were scored separately, except for the following:

- Sc 53, 54

Scores were weighted as follows for the Mzimvubu Estuary to produce the final results.

- Provisioning services = 20%
- Regulating services = 40%
- Cultural services = 40%

Scores are reflected in **Table 7.4.**

Table 7.4 Ecosystem services scenario scoring for the Mzimvubu Estuary

Services	Sc 53, 54	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
Normative score						
Provisioning	1.00	1.00	1.00	1.00	1.00	1.00
Regulating	0.99	0.99	1.01	0.99	0.99	0.99
Cultural	1.00	1.23	1.20	1.23	1.25	1.25
Weighted score						
Provisioning	0.20	0.20	0.20	0.20	0.20	0.20
Regulating	0.39	0.39	0.41	0.39	0.39	0.39
Cultural	0.40	0.49	0.48	0.49	0.50	0.50
Total	0.99	1.08	1.09	1.08	1.09	1.09

7.3 CONCLUSIONS

In terms of **MzimEWR1** the following is applicable:

- Scenario group 2a, 2b, 32, and 33 have potentially the most negative impact on ecosystems services
- This is followed by Scenario group 2c and 63, the Scenario group 69 and 70 and the Scenario 65 which all are negative.
- Scenario Group 41, 42, 51, 52 and 53 and Scenario 54 show no predicted change from the status quo.

In terms of **MzimEWR4** the following is applicable:

- Scenario Group 2c and 61 are marginally negative.
- All other scenarios are marginally positive with Scenario 53 the showing potentially the most positive change from status quo.

In terms of **MzimEWR1 Lalini** the following is applicable:

- All scenarios are negative with Scenario group 2c and 70 being particularly problematic for the production of ecosystem services.
- Scenario group 2a, 2b, 41, 51 and 53 is also problematically negative.
- Scenario groups 61, 63, 65 and 90 as well as Scenario 54 are moderately negative.
- Scenario group 33, 42 and 52 is marginally negative.

In terms of the **Mzimvubu Estuary** the scenarios are neutral or marginally positive.

Overall results suggest Sc 65 and Sc 69 show least impact on Ecosystem Services, with Scenarios 54, 62 and 63 being acceptable. The integrated overall ranking of the scenarios for all three EWR sites and the Estuary is as set out in **Figure 7.1** below.

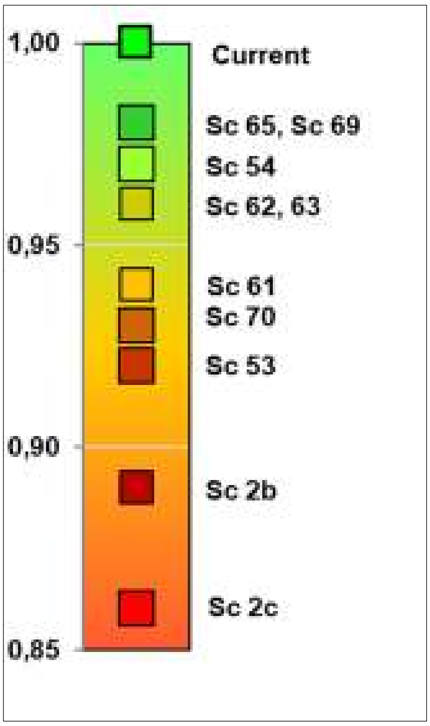


Figure 7.1 Integrated scenario ranking of scenario impact on ecosystem services

8 INTEGRATED MULTI-CRITERIA ANALYSIS RESULTS

The Integrated multi-criteria analysis model was compiled for the Mzimvubu River system. 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.

8.1 ECOLOGICAL AND ECOSYSTEM SERVICES SCORING MATRIX METHOD

The ecological and ecosystem services scoring calculations were undertaken to have a single metric reflecting the ecological and ecosystem services for each of the scenarios. The same approach as the methodology documented in the Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a (DWS, 2014) was followed.

8.2 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 **Chapter 3**. 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 61** (maximum hydropower generation/released in dry winter months) has the lowest ecological score while **Sc 54** and **69** the highest (reduced hydropower generation in the dry winter months).
- **Ecosystem services:** The score indicates to what extent each scenario changes the ecosystem services relative to the present day or PES conditions.
- **Economic indicator (GDP):** This metric represents GDP in Rand with **Sc 61** ranking the highest and **Sc 65** the lowest (hydropower generation reduced in dry winter months but not increased in wet months).
- **Employment:** The number of people employed follows the same relative ranking position as the economic indicator.

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 and a compromise between ecological protection and socio-economic benefits will most likely result in the optimum solution – the desired balance between protection and use.

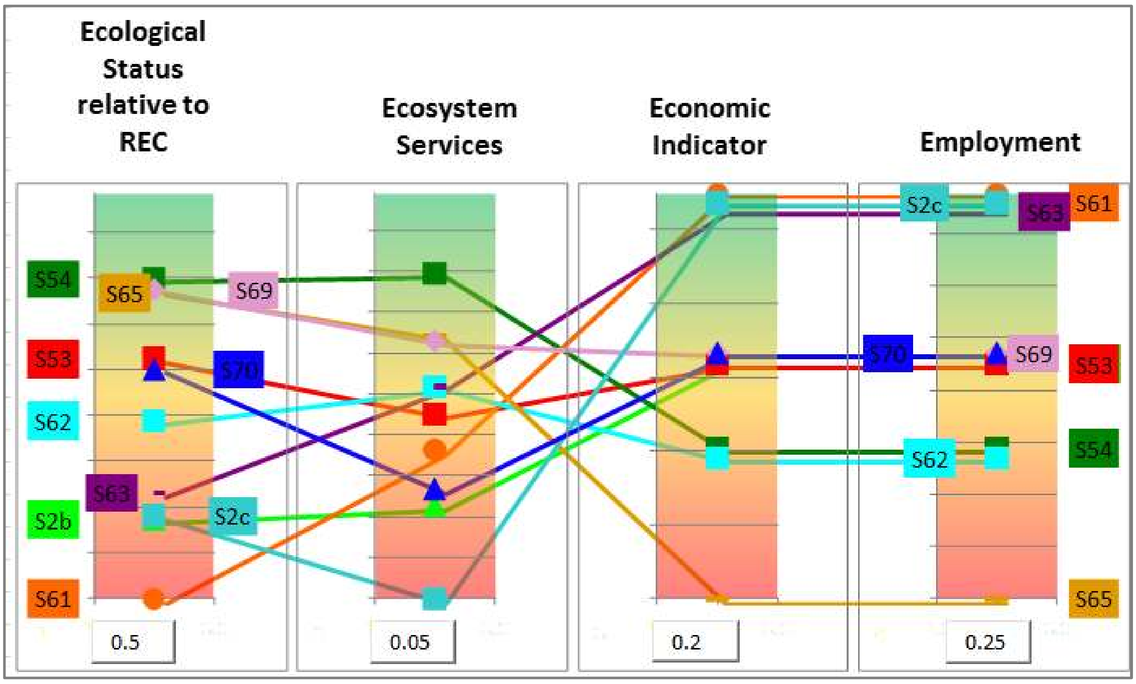


Figure 8.1 Graphical results of individual variables and all scenarios

The final step in the multi-criteria analysis was to determine the integrated and overall rank of the scenarios and this is depicted in **Figure 8.2a** and **Figure 8.2b** for the two 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 (5%), economy (20%) and employment (25%).

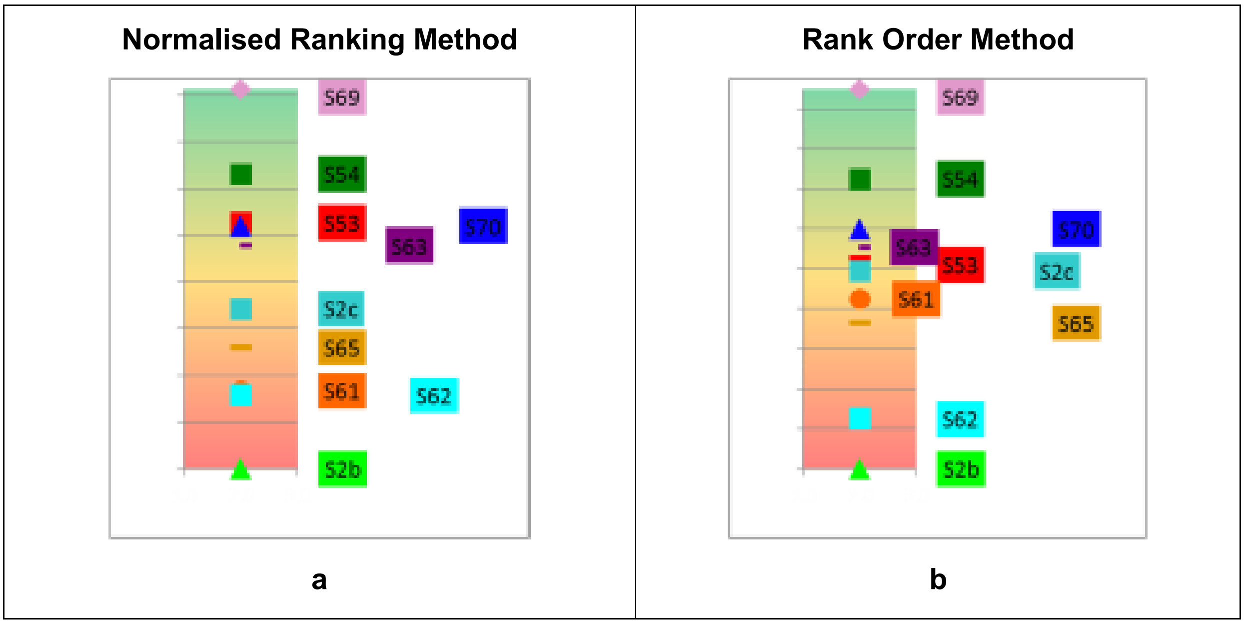


Figure 8.2 Graphical results of overall ranking from the multi-criteria analysis

Scenario 69 has overall the highest rank for both ranking methods.

The integrated ranking calculations which give rise to the ranking order shown in **Figure 8.2** are based on the same approach explained Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 7a (DWS, 2014).

In order to determine how sensitive, the ranking results are for alternative weight settings, **Table 8.1** provides scenario ranking results for a range of variable weights. Scenario 69 is ranked first for most of the alternatives and only differs where weight for the ecology is 0.20 or less. The analysis result is therefore not sensitive for different variable weights.

Table 8.1 Mzimvubu River System: Integrated ranking calculations for the two ranking methods

Weights					Rank position of scenario (Normalisation ranking method)									
Alter-native	Ecology	Ecosystem Services	GDP	Jobs	2b	53	54	61	62	63	65	69	2c	70
1	0.50	0.05	0.20	0.25	10.0	3.0	2.0	8.0	9.0	5.0	7.0	1.0	6.0	4.0
2	0.50	0.10	0.20	0.20	10.0	3.0	2.0	9.0	8.0	5.0	6.0	1.0	7.0	4.0
3	0.50	0.15	0.15	0.20	10.0	3.0	2.0	9.0	7.0	6.0	5.0	1.0	8.0	4.0
4	0.50	0.05	0.15	0.30	10.0	3.0	2.0	8.0	9.0	5.0	7.0	1.0	6.0	4.0
5	0.50	0.05	0.30	0.15	10.0	3.0	2.0	8.0	9.0	5.0	7.0	1.0	6.0	4.0
6	0.25	0.25	0.25	0.25	10.0	6.0	3.0	4.0	8.0	2.0	9.0	1.0	7.0	5.0
7	0.20	0.10	0.40	0.30	8.0	6.0	7.0	2.0	9.0	1.0	10.0	4.0	3.0	5.0
8	0.15	0.10	0.45	0.30	8.0	6.0	7.0	2.0	9.0	1.0	10.0	4.0	3.0	5.0
9	0.50	0.05	0.20	0.25	10.0	3.0	2.0	8.0	9.0	5.0	7.0	1.0	6.0	4.0
10	0.40	0.20	0.10	0.25	10.0	5.0	2.0	8.0	7.0	3.0	6.0	1.0	9.0	4.0
11	0.30	0.30	0.15	0.25	10.0	5.0	3.0	6.0	8.0	2.0	7.0	1.0	9.0	4.0
12	0.30	0.20	0.25	0.25	10.0	6.0	3.0	5.0	8.0	2.0	9.0	1.0	7.0	4.0

9 WATER RESOURCE CLASS AND CATCHMENT CONFIGURATION

The Class and catchment configuration results are the recommendations that were presented at the Project Steering Committee meeting held during 31 October 2017 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 Classes and catchment configuration are provided in the next sections.

9.2 MZIMVUBU RECOMMENDED CLASSES PER IUA

When applying the criteria presented in **Table 9.1** to the resulting ECs for each scenario, the Water Resource Classes IUAs are as listed in **Table 9.2**.

Table 9.2 Resulting IUA Water Resource Classes for each scenario

IUA	PES	REC	2b	53	54	61	62	63	65	69	2c	70
T31	II	II	II	II	II	II	II	II	II	II	II	II
T32_a	II	II	II	II	II	II	II	II	II	II	II	II
T32_b	III	II	II	II	II	II	II	II	II	II	II	II
T33_a	II	II	II	II	II	II	II	II	II	II	II	II
T33_b	II	II	II	II	II	II	II	II	II	II	II	II
T34_a	I	I	I	I	I	I	I	I	I	I	I	I
T34_b	II	II	II	II	II	II	II	II	II	II	II	II
T35_a	I	I	I	I	I	I	I	I	I	I	I	I
T35_b	I	I	I	I	I	I	I	I	I	I	I	I
T35_c	II	II	II	II	II	II	II	II	II	II	II	II
T35_d	II	II	III	III	II	III	III	III	II	II	III	III
T36_a	I	I	I	I	I	I	I	I	I	I	I	I
T36_b	I	I	I	I	I	I	I	I	I	I	I	I

All the above scenarios in red above meet the REC in all the IUAs. As Sc 69 is ranked first in both the rank order and the normalising method, the Classes associated with Sc 69 are recommended. It must be noted that as this scenario meets the REC, a final decision on whether the dams are constructed will not impact on the Classes. The resulting Classes configuration for the Mzimvubu catchment are shown in **Figure 9.1**.

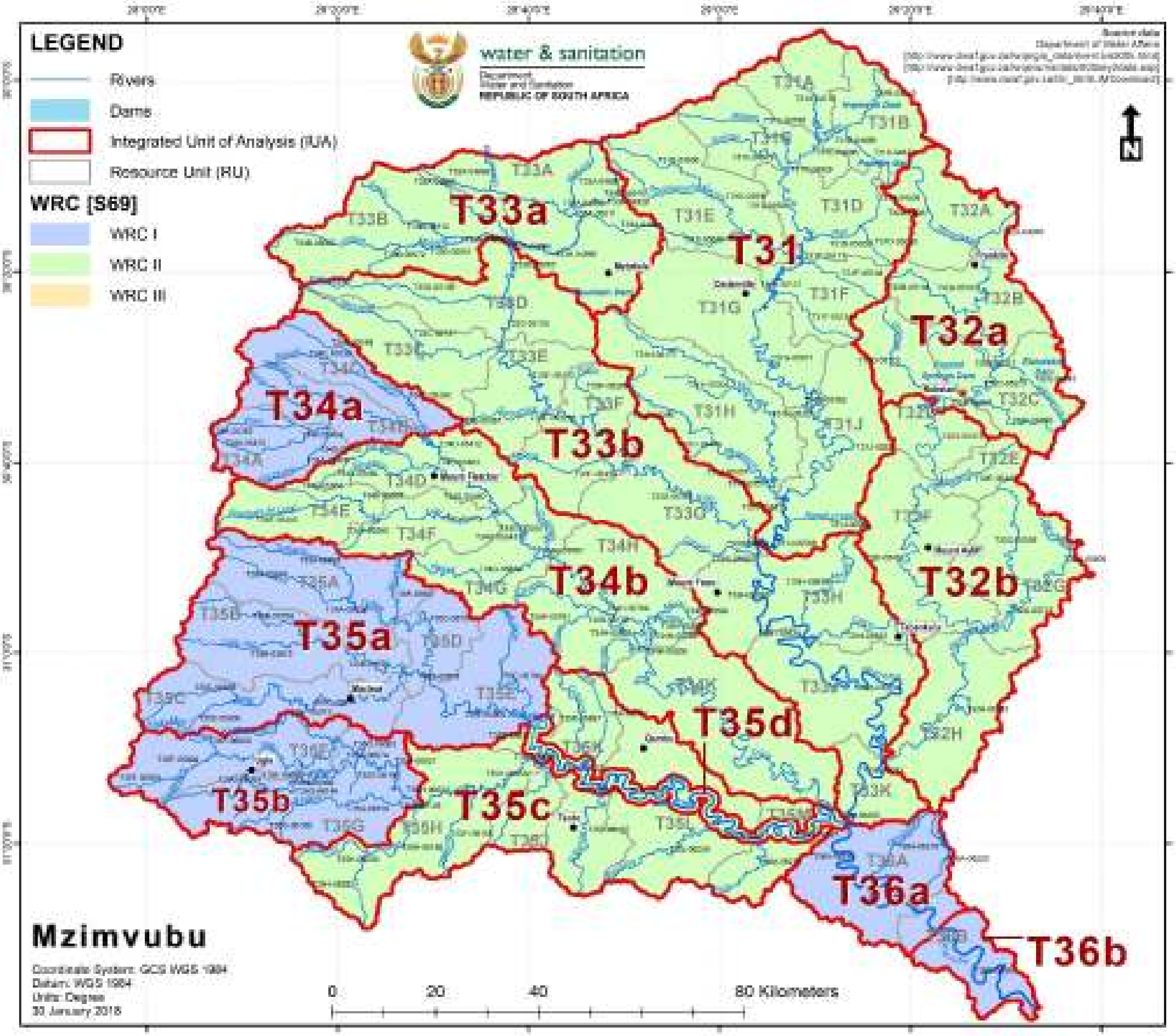


Figure 9.1 Representation of Classes in the Mzimvubu catchment

9.3 WATER RESOURCE CLASSES AND CATCHMENT CONFIGURATION

Given the results and scenario selections presented in the section above, **Table 9.3** provides respectively the proposed Water Resource Class and ECs for the IUAs and Resource Units. These ECs are now referred to as the Target EC (TEC).

It must be noted that various RUs require improvements (**Table 9.4**) based on non flow-related/anthropogenic issues that have to be addressed. RUs with flow-related issues are shaded in blue. Where it is deemed that the REC is attainable, it has been included in the catchment configuration (**Table 9.3**).

Table 9.3 Recommended ECs and Water Resource Classes

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

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
		T33-2	Kinira	45.68	B/C	B/C	B/C
		T33-3	Kinira	47.39	C	C	C
		T33-4	Jordan	40.4	B	B	B
		T33-5	Seeta	57.31	B/C	B/C	B/C
		T33-6	Mabele	37.06	C	C	C
T33_b	II	T33-7	Morulane	137.68	C	C	C
		T33-8	Somabadi	17.27	C	C	C
		MRU Kinira (MzimEWR3)	Kinira	103.24	C	C	C
		T33-9	Rolo	40.49	C	C	C
		T33-10	Ncome	29.9	C	C	C
		T33-11	Cabazi	23.12	C	C	C
		T33-12	Mnceba	35.88	C	B	B
		T33-13	Caba	30.52	C	B	B
		T33-14	Mzimvubu	161.92	B	B	B
T34_a	I	T34-1	Tinana	67.86	B	B	B
		T34-2	Zindawa	52.59	B	B	B
		T34-3	Khohlong	22.94	B/C	B/C	B/C
		T34-4	Nxotshana	69.88	B	B	B
T34_b	II	T34-5	Thina	18.6	C	B/C	B/C
		T34-6	Tokwana	56.15	C	C	C
		T34-7	Bradgate se Loop	57.81	B	B	B
		T34-8	Luzi	45.27	B/C	B/C	B/C
		T34-9	Qwidlana	60.89	B	B	B
		MRU Thina_B	Thina	62.97	C	C	C
		T34-10	Qhanqu	42.25	B	B	B
		T34-11	Ngcothi	18.41	B	B	B
		T34-12	Mvuzi	39.26	C	C	C
		MRU Thina C (MzimEWR2)	Thina	146.37	C	C	C
T35_a	I	T35-1	Tsitsana	108.14	B	B	B
		T35-2	Pot	93.73	B	B	B
		T35-3	Mooi	46.59	B	B	B
		T35-4	Mooi	68.57	C	C	C
		MRU Tsitsa B	Tsitsa	73.82	C	C	C
		T35-5	Gqukunqa	38.91	B	B	B
T35_b	I	T35-6	Inxu	40	B	B	B
		T35-7	Gqaqala	59.52	B	B	B
		T35-8	Kuntombizininzi	32.15	B	B	B
		MRU Inxu (EWR1)	Inxu	67.36	C	C	C
		MRU Gat (IFR1)	Gatberg	91.79	B	B	B
T35_c	II	MRU Inxu	Inxu	36.43	B/C	B/C	B/C
		T35-9	Umnga	58.55	B/C	B/C	B/C
		T35-10	Qwakele	21.48	C	B/C	B/C
		T35-11	Ncolosi	26.2	C/D	C	C
		T35-12	Culunca	27.66	C	B/C	B/C
		T35-13	Tyira	23.23	C/D	C/D	C/D
		T35-14	Xokonxa	36.12	C	C	C
		T35-15	Ngcolora	35.99	C	C	C

IUA	Class	RU	Main river	Length (km)	PES	REC	TEC
		T35-16	Ruze	25.59	B	B	B
T35_d	II	MRU Tsitsa Ca (MzimEWR1)	Tsitsa	79.89	C	C	C
		MRU Tsitsa Cb (EWR1 Lalini)	Tsitsa	19.17	C	C	C
		MRU Tsitsa_D	Tsitsa	47.15	B	B	B
T36_a	I	T36-1	Mzintshana	20.35	B	B	B
		T36-2	Mkata	30.57	B	B	B
		MRU Mzim (MzimEWR4)	Mzimvubu	56.93	C	C	C
T36_b	I	MRU Estuary	Mzimvubu	26.04	B	B	B

Table 9.4 Mzimvubu River System nodes requiring improvements

RU	River	PES	REC comment	REC
T31-17		C	Possible sewage treatment required. Erosion control and improved agricultural practices. Alien vegetation removal.	B/C
T31-18	Mkemane	C/D	Water quality improvement required in terms of sedimentation, i.e. erosion control.	B/C
T32-1	Mzintlava	C	Flow only needs to improve as it relates to sensitivity. Control and management of dams.	**B/C**
T32-3		C	Flow only needs to improve as it relates to sensitivity. Control of, amongst others, pivot irrigation, to supply EWR.	**B/C**
T32-4	Mill Stream	C	Combination of flow and non-flows impacts.	**B/C**
T32-11	Mzintlava	C/D	Erosion control and improved agricultural practices. Alien vegetation removal.	C
T32-12	Mzintlavana	B/C	Erosion control. Alien vegetation removal.	B
T32-13	Mzintlava	C	Improve riparian continuity by improving riparian buffer zone (floodplain agriculture).	B
T33-13	Caba	C	Improvement of WWTW discharge quality, erosion prevention, riparian buffer protection.	B
T34-5	Thina	C	Supply the EWR from the dam. Improve the WWTW discharge quality.	**B/C**
MRU Gat IFR1	Gatberg	B/C	Flow modification can only improve if dams are managed to ensure EWR.	**B**
T35-10	Qwakele	C	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	B/C
T35-11	Ncolosi	C/D	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	C
T35-12	Culunca	C	Improve the riparian zone condition (erosion control and limit cultivation in zone) to improve water quality.	B/C

It is proposed to gazette the Classes and catchment configuration shown in bold above as for the short-term ECs.

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APPENDIX A: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment
Nicky McLeod, ERS/UCPP – 13 March 2018				
Chapter 9; Classes map, Fig 9.1		We request that the delineation for T31 be split so that the upper reaches fall into a separate IUA, e.g. T31_a (upper reaches) and T31_b (lower section of the catchment); as for T33. We strongly feel that the characteristics in the higher altitude areas (from about 1600m up to the primary watershed) are different from the lower reaches, due to different impacts and land uses (limited roads, no input source pollution, and no settlements, resulting in less degradation of the ecological infrastructure)	No	The delineation into IUAs was done during Step 2 of the project plan according to standard procedures, with the results shown in the following report: *Status Quo and (RUs and IUA) Delineation Report, Report no. WE/WMA7/00/CON/CLA/0316.* As more information has not become available since report production in late 2016, it would not revise the delineation, although it would not be possible to revise the IUA delineation at this stage. However, should monitoring of the desktop nodes prove that the allocated half categories (for example) are actually higher than available data indicates (e.g. a B/C is shown to be a B category; and for enough nodes), it would force a re-assessment of the delineation of T31. It is therefore recommended that data be collected for the nodes identified on Table 9.4 that require improvement. A sensitivity analysis was undertaken (see revised text below Table 2.3) to check the delineation of T31, and showed that even if T31 were split, both the upper and lower reaches would still just fall into a Class II – based on currently available data. A revision can only happen should higher confidence (ground-truthed) become available and indicate an improvement of the upper reaches.

Page / Section	Report statement	Comments	Changes made?	Author comment
Chapter 9; Classes map, Fig 9.1		The analyses were done on a desktop basis following a particular method, which requires a minimum river length: this means that the classification has a low level of confidence, as it is not ground-truthed;	Yes	Text under Table 2.3 has been adjusted as follows to aid understanding: *The rule (to assign Classes) only refers to the full categories and does not include half categories (EC of a B versus an EC of a B/C). Half categories indicate categories that can be either a high C or a low B (in the B/C example). At the desktop level, the intensity of the assessment to determine the categories does not provide sufficient information to allocate a river reach to either to a B or a C. A sensitivity analysis is therefore carried out where half categories are distributed equally to full categories. The total length of half category river reaches in an IUA is split; 50% to the lower and 50% to the upper categories respectively. As an example, if there is 150 km of river in B/C categories, then 75 km will be added to the B categories and 75 km to the C categories. This will be relevant for the B/C, C/D and D/E half categories.*
Chapter 9; Classes map, Fig 9.1		The area along the SA/Lesotho border down to about 1750m is part of a proposed stewardship effort to protect the Strategic Water Source Areas along the watershed, and has support from ECPTA, SANParks, GEF, Green Trust, the relevent Chiefs, District and Local Municipality etc. We want to motivate for its declaration on the basis of its integrity and importance as a SWSA, and the need to closely monitor and maintain/improve its status.	No	It is recommended that this area be flagged for monitoring so as to check or prove its potential status as a Class I resource. One suggestion would be to evaluate whether DWS could extend their regional biological monitoring to include sites in this area.
DWS Project Management Committee, L Mulangaphuma – 14 March 2018				
Report		Editorial comments	Yes	Addressed throughout as required.