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WP 11004

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

SCENARIO NON-ECOLOGICAL CONSEQUENCES REPORT

March 2018

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Bold indicates this report

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EXECUTIVE SUMMARY

BACKGROUND

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

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

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the 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.

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.

PURPOSE OF THIS REPORT

The purpose of this report is to document the non-ecological consequences, i.e. user water quality, ecosystem services and economic consequences of the various operational scenarios on the affected riverine water resources, i.e. the Tsitsa and Mzimvubu rivers and Mzimvubu Estuary. The modelling scenarios are shown as a scenario matrix in **Chapter 2**.

USER WATER QUALITY

Impacts on User Water Quality under operational scenarios were evaluated according to the methods outlined in the 2016 DWS document on operationalising Resource Directed Measures. No water quality pollution or protection areas were identified in the sub-quaternary catchments (SQs) potentially affected by dam building scenarios. As the EWR site, Resource Units (RUs) and Mzimvubu Estuary potentially affected by operational scenario are all High priority RUs, ecosystem water quality requirements are the driving role player and scenario impacts were evaluated in detail and reported on in the Ecological Consequences reports for the study.

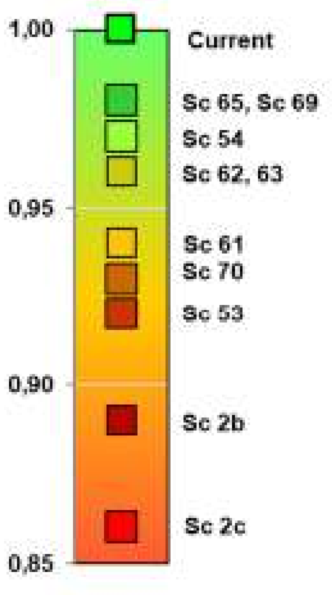
ECOSYSTEM SERVICES

According to the latest census conducted in 2011, a population of approximately 2 500 000 persons are located in the districts which either partially or completely fall within the Mzimvubu catchment. The Mzimvubu catchment plays a prominent role in the maintenance of the communities it intersects, due to the largely rural nature of these communities. As such, the catchment plays a significant role in maintaining important ecosystem services.

Ecosystem services are categorised into the following four groups, with the impact of scenarios at each EWR site and the estuary being evaluated for ecosystem services falling into these categories:

- Provisioning services
- Cultural services
- Regulating services
- Supporting services

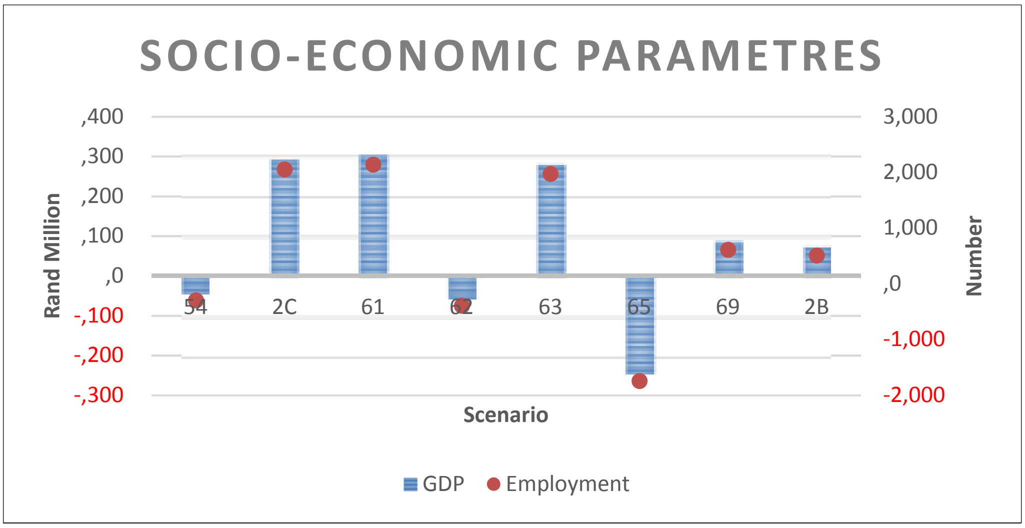
Scenario analysis at the EWR sites and the Mzimvubu Estuary showed that Scenarios 65 and 69 resulted in the least impact on ecosystem services, with scenarios 54, 62 and 63 being acceptable.

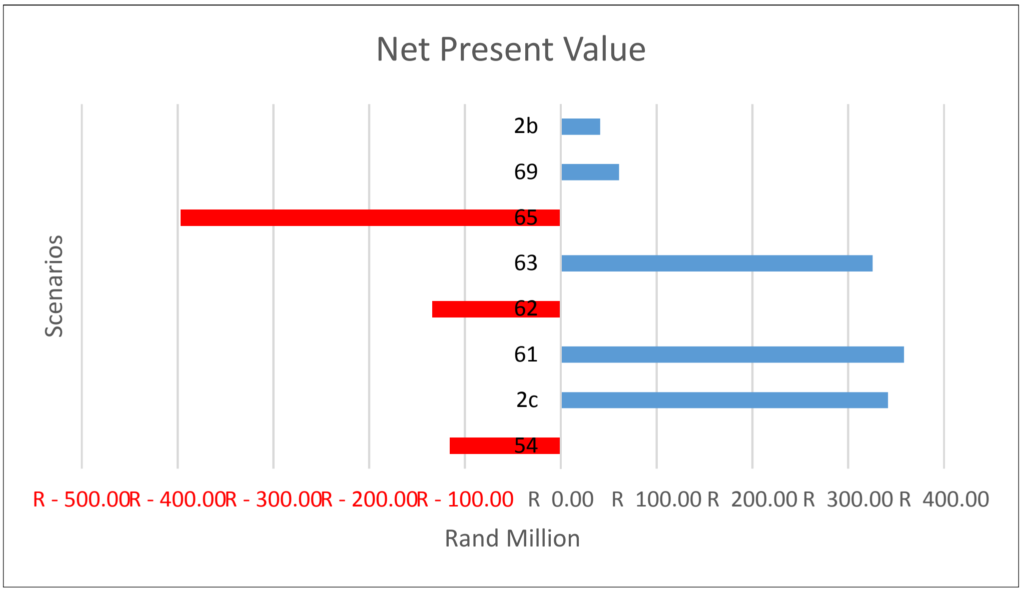


ECONOMIC EVALUATION

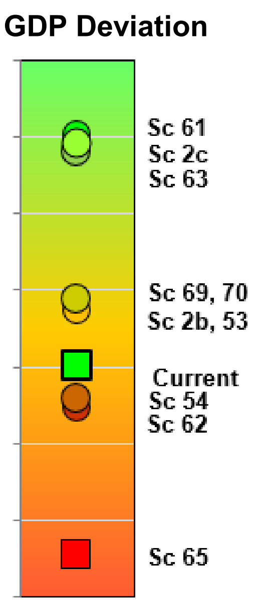
Both a socio-economic and Cost Benefit Analysis (CBA) modelling approach was undertaken for the economic assessment of scenario impacts.

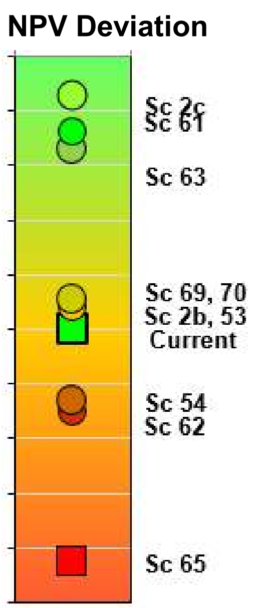
The following figures represent the deviation in the Gross Domestic Product (GDP) and employment results from the economic baseline, as well as the Net Present Value (NPV) of the different scenarios measured against the capital investment in the hydro-electric power plant (HEPP) system proposed for the study area and associated with dam developments.





The traffic diagrams show the relationship between the GDP and NPV approaches in terms of the deviation of the two methodologies from the current economic baseline.





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

- 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 (i.e. no EWR release over Tsitsa Falls) is problematic as the possibility exists that the Tsitsa Falls will run dry under this scenario, with a very negative impact on current activities but also on any future eco-tourism development and activities in the area, particularly around the Mzimvubu Estuary.

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LIST OF ABBREVIATIONS

BCR	Benefit Cost Ratio
BHNR	Basic Human Needs Reserve
CBA	Cost Benefit Analysis
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)
E.coli	*Escherichia coli*
EC	Ecological Category
EIA	Environmental Impact Assessment
EWR	Ecological Water Requirements
GDP	Gross Domestic Product
GIS	Geographic Information System
GWh	Giga watt hour
HEPP	Hydro Electric Power Plant
IRR	Internal Rate of Return
IUA	Integrated Unit of Analysis
KZN	KwaZulu-Natal
MEA	Millennium Ecosystems Assessment
MW	Mega watt
MRU	Management Resource Unit
MWP	Mzimvubu Water Project
NERSA	National Energy Regulator of South Africa
NPV	Net Present Value
OCSD	off-channel storage dam
PES	Present Ecological State
PES/EIS	Present Ecological State / Ecological Importance and Sensitivity
RDM	Resource Directed Measures
RBIG	Regional Bulk Infrastructure Grant
RQOs	Resource Quality Objectives
RU	Resource Unit
Sc	Scenario
SCI	Socio-Cultural Importance
SQ	Sub Quaternary
ToR	Terms of Reference
TTG	Technical Task Group
WMA	Water Management Area
WRCS	Water Resource Classification System
WRYM	Water Resources Yield Model
WWTW	Wastewater 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.
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 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.
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 Product (GDP)	The monetary value of all the finished goods and services produced within a country's borders in a specific time period.
Integrated Unit of Analysis (IUAs)	An IUA is a homogeneous area that can be managed as an entity. It is the basic unit of assessment for the Classification of water resources, and is defined by areas that can be managed together in terms of water resource operations, quality, socio-economics and ecosystem services.
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 and 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.
Resource Units (RUs)	RUs are delineated during an Ecological Reserve determination study, as each will warrant its own specification of the Reserve, and the geographic boundaries of each must be clearly delineated. These sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach. RUs are nested within IUAs and may contain an Ecological Water Requirement site.
Scenario	Scenarios, in the context of water resource management and planning, are plausible definitions (settings) of factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. Each scenario represents an alternative future condition, generally reflecting a change to the present condition.
Sub-quaternary catchments (SQ)	A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary or quinary level.

1 INTRODUCTION

1.1 BACKGROUND

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

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

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

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

1.2 STUDY AREA OVERVIEW

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributaries and the estuary at Port St Johns (**Figure 1.1**). The river reaches sizeable proportions after the confluence of these four tributaries in the Lower Mzimvubu area, approximately 120 km from its source, where the impressive Tsitsa Falls can be found near Shawbury Mission. The Mzimvubu catchment and river system lies along the northern boundary of the Eastern Cape and extends for over 200 km from its source in the Maloti-Drakensberg watershed on the Lesotho escarpment to the estuary at Port St Johns. The catchment is in Primary T, comprises of T31–36 and stretches from the Mzimkhulu River on the north-eastern side to the Mbashe and Mthatha river catchments in the south. The Mzimvubu river catchment is found in WMA 7, i.e. the Mzimvubu to Tsitsikamma WMA.

1.3 STUDY PROJECT PLAN

The Mzimvubu study is being undertaken according to the Project Plan in **Figure 1.2**. This report pertains to the Scenario evaluation process listed as Step 4.

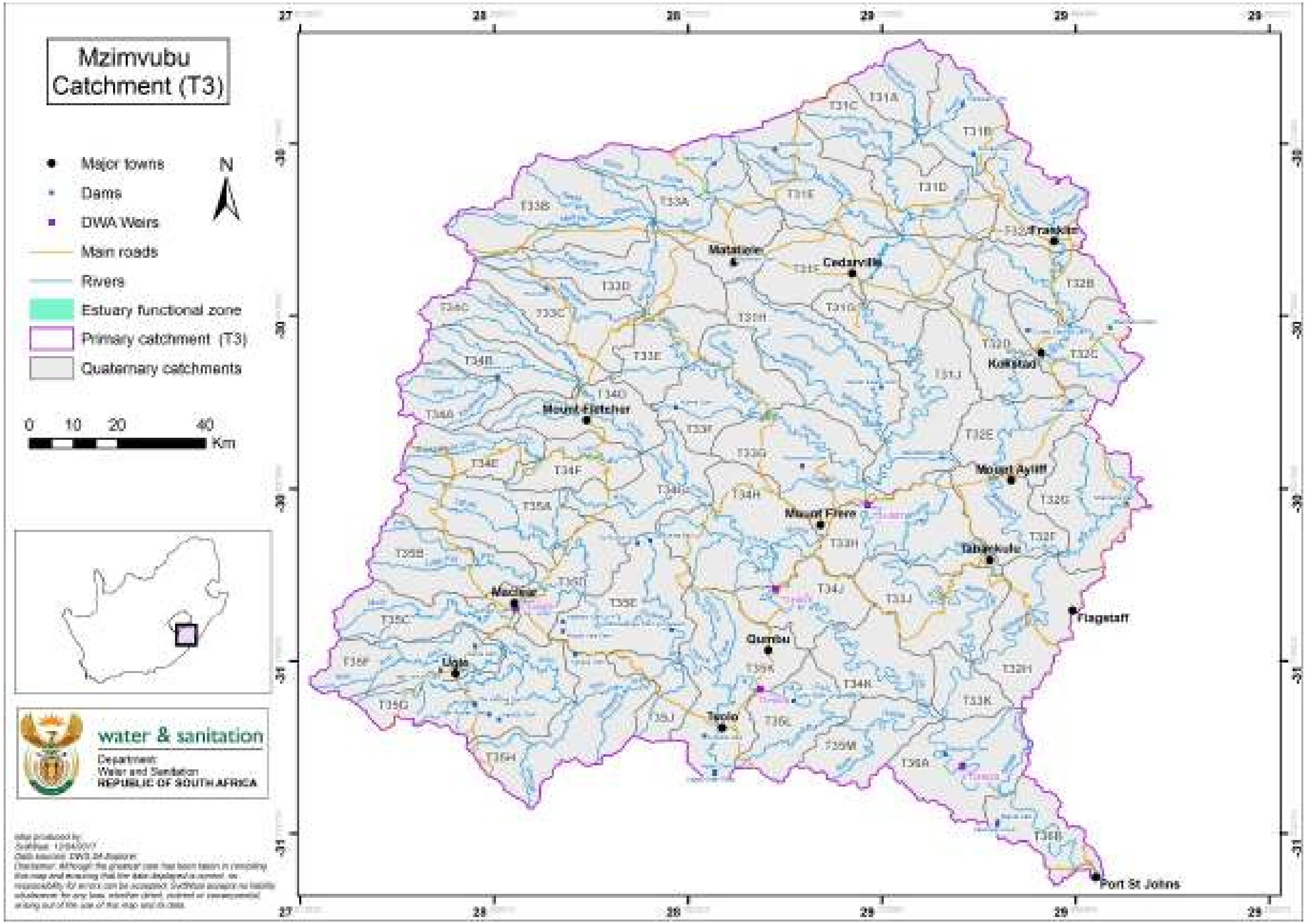


Figure 1.1 Map of the Mzimvubu catchment

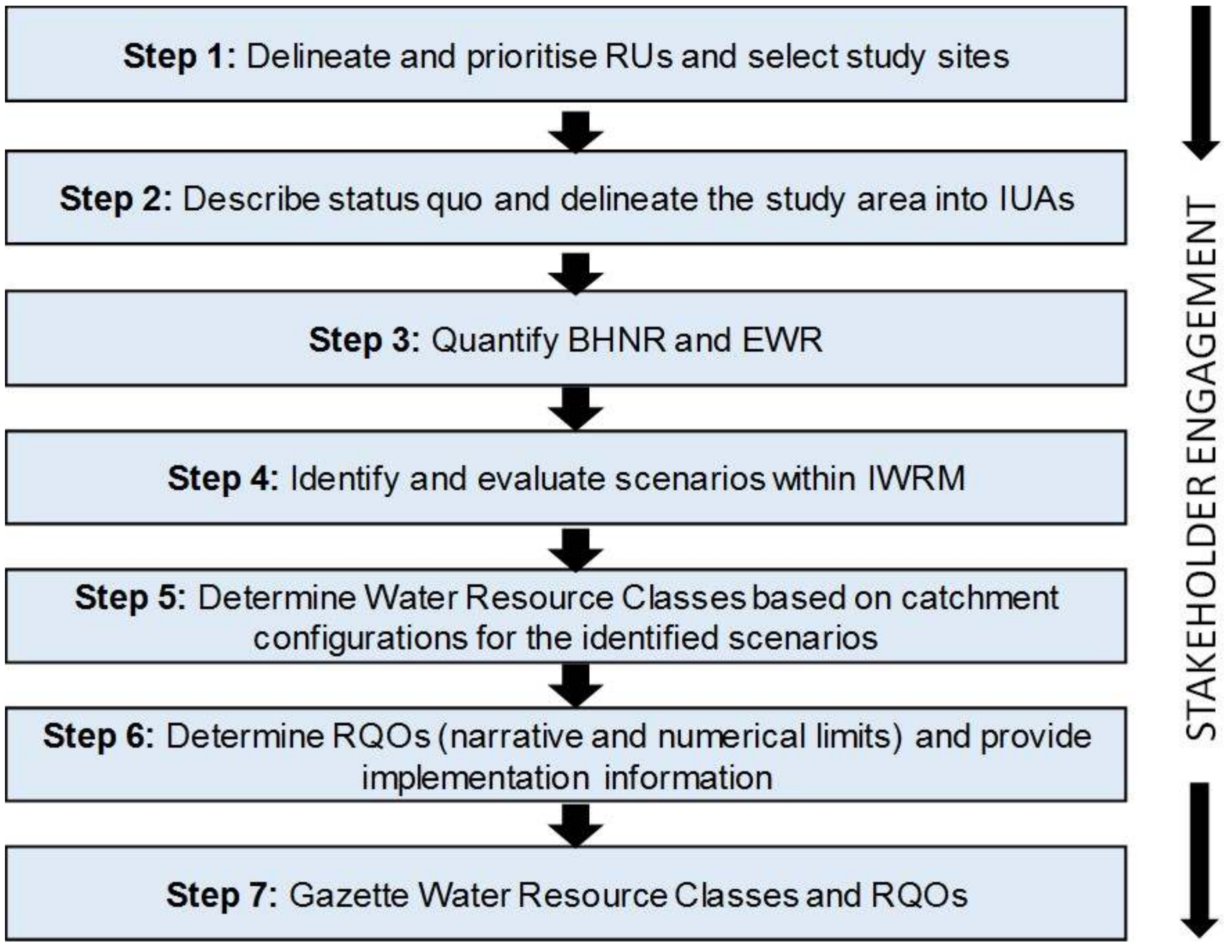


Figure 1.2 Project plan for the Mzimvubu Classification and RQO study

1.1 PURPOSE AND OUTLINE OF THIS REPORT

The purpose of this report is to document the economic, ecosystem services and user water quality consequences of the various operational scenarios on the affected riverine water resources, i.e. the Tsitsa and Mzimvubu rivers and Mzimvubu Estuary. The report structure is outlined below.

Chapter 1: Introduction
This chapter provides an overview of the study area and objectives of the study and specialist reports. The approach, data availability and results are presented per component in relevant chapters, while an overview of operational scenarios is shown in **Chapter 2**.

Chapter 2: Scenario descriptions
This chapter introduces the scenario matrix and provides some background on the operational scenarios modelled for the study.

Chapter 3: User Water Quality
The approach to User Water Quality tasks is encapsulated in DWS (2016), which is a document containing all water quality tools and standardized inputs and outputs currently used for the operationalising of Resource Directed Measures (RDM). The process is to identify priority water quality users or role players, identify the driving water quality variables and assess the impact of changing water quality under the operational scenarios.

Chapter4: Ecosystem Services

Impacts of operational scenarios on ecosystem services are evaluated by first identifying key provisional, regulating, cultural and supporting services for the key Ecological Water Requirement (EWR) sites, including the Mzimvubu Estuary. Changes in services at the key sites under scenarios were evaluated as a change away from the present state, scored as 1.

Chapter 5: Economics

Economic impacts under operational scenarios were evaluated using a socio-economic model with impacts on the GDP and employment numbers as its parameters, and a cost benefit analysis approach looking at deviation from NPV under each scenario. Tourism impacts under Scenario 70, which is a no EWR flow release over Tsitsa Falls, was also evaluated.

Chapter 6: Conclusions

The main conclusions related to impacts on user quality, ecosystem services and economics are listed.

Chapter 7: References

2 SCENARIO DESCRIPTIONS

The Water Resources Yield Model (WRYM) was used for the study and was updated with the latest catchment development and land-use information available in order to produce the best possible estimates of present day flow. Details regarding the modelling can be found in the following report: River Desktop EWR and Modelling Report: Volume 1 – Systems Modelling; Report no. *WE/WMA7/00/CON/CLA/0217, Volume 1* (DWS, 2017a).

The scenario analysis component of a Classification study is an iterative process, with this chapter representing the final list of scenarios evaluated for the study. This list includes the scenarios modelled in October 2017 as Phase 2 of scenario modelling, once dam design and operational information for Ntabelanga and Lalini dams became available from Pro-Plan. The first phase of evaluation is normally undertaken by the ecologists, so as to optimize the list of scenarios for the economic evaluation.

1.1 BACKGROUND AND SCENARIO MATRIX

Scenarios are described by means of a scenario matrix (**Table 2.1**). The matrix consists of columns which indicates the different drivers which are switched on or off for the different scenarios indicated in the rows. The descriptions of the three drivers (and its subsets) are provided below:

- **Updated water demands 2040:** The demands identified as part of the present day hydrology analysis were projected to increase from current development levels (present day) to the 2040 development level.
  1. **Ultimate development projection:** This is a projection where the demands were increased to fully utilise the available yield of the new proposed dams.
  2. **Realistic projection:** The realistic projection was based on the water requirement projection information sourced from the DWS Development of Reconciliation Strategies for All Towns in the Southern Planning Region (2015).
- **EWR:** These refer to the EWRs which are used as a demand in the model. There are different options which can be used at the different EWR sites, shown in the sub-columns under the EWR column. Note that in all cases the Present Ecological State (PES) category is the same as the Recommended Ecological Category (REC). Total EWRs refer to EWRs which include both the low (base) flows and the high (flood) flows and are all included as a demand. Low EWRs refer to only the low (base) flows provided as a demand, with the high flows (floods) provided by spills and tributary inflows.

  Note that EWR1 and EWR4 refer throughout to MzimEWR1 (on the Tsitsa River) and MzimEWR4 (on the lower Mzimvubu River). EWR1 Lalini refers to the EWR at MzimEWR1 scaled (hydrologically) to a point downstream of the proposed Lalini Dam and used as if the EWR site was situated downstream of the proposed dam.
- **Development options:**
  1. The Mzimvubu Water Project comprises the following:
     i. Proposed Ntabelanga Dam
     ii. Proposed Lalini Dam. The power generation from the Lalini Dam differs in terms of production in some of the scenarios and will be specified as such.
     iii. Revive irrigation (T33A–T33G)
     iv. New municipal dams / abstractions

2. Revive irrigation (T33A–T33G): It is also assumed that 706 ha of irrigation in T33 catchment will be revived (currently only 28 ha irrigation is active)
3. Planned municipal dams:
   - 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)
4. Other river abstractions and off-channel storage dams (river abstraction and Cengane-channel storage dams, river abstraction and Ngqeleni Dam-channel storage dams, etc.)
5. The proposed Port St Johns Waste Water Treatment Works (WWTW) is only to be evaluated at the estuary and looks only at the present day flows with the added output flows from the WWTW.

Notes:

- Development Option 2 (revive irrigation in T33A–T33G), 3 (planned municipal dams) and 4 (other river abstractions and off-channel storage dams) are included in all scenarios and have thus not been individually listed in the scenario matrix (**Table 2.1**)
- MzimEWR1 and MzimEWR4 are located on the Tsitsa River and the lower Mzimvubu River respectively. EWR1 Lalini refers to the EWR1 that was scaled (hydrologically) to a point downstream of the proposed Lalini Dam and used as if the EWR site was situated downstream of the proposed dam in the applicable scenarios.
- Refined infrastructure design information and optimised hydropower operating rules became available from the design phase of the MWP shortly after the first phase of the scenario analysis had been completed. Scenarios 61-69 were therefore run as the second phase of modelling and used the latest available dam design and operations information.
- Proposed hydro-electric power plants (HEPP) are as follows:
  1. Ntabelanga Dam HEPP: Located at the Ntabelanga Dam and ultilises the EWR releases and Lalini Dam support releases to generate electrical power.
  2. Lalini Dam HEPP: Located at the Lalini dam utilises the EWR releases from the Lalini Dam to generate power.
  3. Main HEPP: Located below the Tsitsa Falls and utilises releases from the Lalini Dam through a water conveyance system and the water is then discharged back into the river downstream of the falls.

Information regarding the design and proposed operation of the Ntabelanga and Lalini dams and HEPPs were taken from van Wyk and de Jager (2016); also referred to as Pro-Plan design information or *Design Phase (2017)* of the MWP. The study was conducted on behalf of DWS.

Table 2.1 presents the scenario (Sc) definition matrix indicating the identified variables as columns and the selected variable settings for the proposed scenarios in the respective rows. A qualitative description is provided below the table with further explanations on the scenarios. Details regarding the operational scenarios are provided in the Scenario Description Report (DWS, 2018), i.e. Report no. *WE/WMA7/00/CON/CLA/0517*. Note that this table presents the scenarios evaluated by the entire team, i.e. the ecologists, economists and impacts on ecosystem services.

Table 2.1 Scenario matrix

Scenario (Sc)	Updated water demands (2040)		EWR			Development options		
	Realistic projection (a)	Ultimate projection (b)	Mzim EWR4	Mzim EWR1	EWR1 Lalini (scaled)	MWP (Feasibility Study, 2014)	MWP (Design Phase, 2017)	Proposed Port St Johns 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
32	No	Yes	Total	No	Total	Yes	No	No
33	No	Yes	Low	No	Low	Yes	No	No
41	No	Yes	Low	Low	No	Yes	No	No
42	No	Yes	Low	Low	Low	Yes	No	No
51	No	Yes	Low	Low	No	Yes – Reduced hydro in dry months [1]	No	No
52	No	Yes	Low	Low	Low	Yes – Reduced hydro in dry months	No	No
53	No	Yes	Low	Low	No	Yes – <u>Further</u> reduced hydro in dry months	No	No
54	No	Yes	Low	Low	D Low	Yes – <u>Further</u> reduced hydro in dry months	No	No
61	No	Yes	Low	Low	D Low	No	Yes	No
62	No	Yes	Low	Low	D Low	No	Yes – Reduced hydro in dry months	No
63	No	Yes	Low	Low	D Low	No	Yes – Reduced hydro in dry months (<u>Increased</u> hydro capacity in wet months)	No

Scenario (Sc)	Updated water demands (2040)		EWR			Development options		
	Realistic projection (a)	Ultimate projection (b)	Mzim EWR4	Mzim EWR1	EWR1 Lalini (scaled)	MWP (Feasibility Study, 2014)	MWP (Design Phase, 2017)	Proposed Port St Johns WWTW*
65	No	Yes	Low	Low	D Low	No	Yes – Further reduced hydro in dry months	No
69	No	Yes	Low	Low	D Low	No	Yes – Further reduced hydro in dry months (Increased hydro capacity in wet months)	No
70	No	Yes	Low	Low	No	No	Yes – Further reduced hydro in dry months (Increased hydro capacity in wet months)	No

Hydro: hydrology

** The impact of the proposed Port St Johns WWTW was analysed separately by the estuary team.*

[1] Reduced hydropower implies a reduction in the hydropower output initially envisaged. This reduction is undertaken to minimise the impact of increased baseflows in the downstream river in an attempt to reach ecological targets.

2.1 BRIEF DESCRIPTION OF SCENARIOS

Below is a brief description per scenario listed in **Table 2.1**.

Scenario 2a tested the realistic projection and the design of the MWP Feasibility study of 2014. This scenario was tested during Phase 1 and the realistic projection not adopted again for any other scenarios.

Scenario 2b fully utilises the available yield of the new proposed dams, following the design of the MWP Feasibility study of 2014. This scenario was assessed during Phase 1 and is included for comparison purposes.

Scenario 2c was based on Scenario 2b but with the latest MWP infrastructure design information and optimised hydropower operating rules from the design phase of the project incorporated, i.e. the MWP Design Phase of 2017.

Scenario 53 forms part of Phase 1 scenario modelling and was based on Scenario 51 but with the hydropower generation further reduced in the dry winter months. There is no EWR release from Lalini Dam under this scenario.

Scenario 54 was an optimisation of Scenario 53, but with a Category D low flow EWR release from Lalini Dam to ensure no zero flows from the dam to the outlet. The flow to be provided in the reach downstream of Lalini Dam can be further adjusted, but further optimisation of Scenarios 53 and 54 will depend on the outcome of the economic analysis.

Scenario 61 includes the 2017 MWP design phase information and EWR releases. The hydropower operating rules are significantly different to the rules applied in Scenario 2b, which influences the flows at the EWR sites.

Scenario 62 was based on Scenario 61 but with the hydropower generation reduced in the dry winter months. The purpose of the scenario was to decrease the flows at MzimEWR4 and especially the estuary, as it could be seen Sc 61 would provide unnaturally high and constant baseflow.

Scenario 63 was based on Scenario 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 the wet summer months.

Scenario 65 was based on Scenario 62 where hydropower generation was further reduced during the dry winter months. Initial analyses of Scenario 62 showed that the increased baseflows due to hydropower releases were still a problem and needed to be reduced further.

Scenario 69 was based on Scenario 63, where hydropower generation was further reduced during the dry winter months. The aim would be to come as close as possible to Scenario 54 which was the optimised scenario evaluated during the first round of assessments. Initial analyses of

Scenarios 63 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 a problem and needed to be reduced further, as with Scenario 62.

Scenario 70 was not modelled (and therefore does not appear in the scenario matrix table) as flows are the same or similar to Scenario 69. The difference between Scenario 70 and Scenario 69 is that, as for Scenario 53, Scenario 70 does NOT include an EWR flow release from Lalini Dam. The 4.8 km river reach between the Lalini Dam and Tsitsa Falls will be dry except when the dam spills, which will be of aesthetic, socio-cultural, tourism and recreational concern. The rest of the reach (13.5 km) to the outfall will also be dry except for spills and inflows of some tributaries (but not that there are no significant tributaries between the dam wall and the falls). The evaluation was therefore for a NO EWR flow over the falls, and the impact thereof. The ecological impact of this situation is the same as for Scenario 53 and will therefore not be evaluated. Ecosystem services, recreation and tourism impacts were evaluated for this scenario.

3 USER WATER QUALITY

3.1 APPROACH

The approach to User Water Quality tasks is encapsulated in DWS (2016), which is a document containing all water quality tools and standardized inputs and outputs currently used for the operationalizing of RDM. It is understood that water quality consists of the following two broad components:

- **Ecological**, i.e. as part of the EWR or Reserve process. A standard process is followed for scenario evaluation. Ecological Specifications or EcoSpecs are the output of the Reserve process.
- **Users**, i.e. water quality related to users or role players other than ecology, for example: Domestic Use, Agriculture - Stock Watering, Agriculture – Irrigation, Industrial - Category 3 and Recreation - Intermediate Contact. UserSpecs are defined.

Water quality is therefore incorporated in the consequence assessment as:

- Part of ECOLOGICAL consequences;
- a service identified in ECOSYSTEM SERVICES;
- indirectly in the ECONOMICS in terms of water treatment costs (if applicable); and
- USER WATER QUALITY consequences assessment (this document).

Impacts on user water quality are not included in the multi-criteria analysis approach used for determining integrated scenario consequences and Water Resource Classes, as the multi-criteria approach uses the three components listed above, i.e. ecological consequences, ecosystem services consequences and economics consequences (if applicable). Water quality would be double-accounted if included as an additional separate component.

3.2 OVERVIEW AND DATA COLLECTION

3.2.1 Steps 1 and 2: User data collection

During Steps 1 and 2 and associated sub-steps of the Integrated framework (DWS, 2016) and Project Plan for the Mzimvubu study (**Figure 1.2**), data is gathered on the following to inform the water quality process for both ecological water quality and users:

- Identify water quality users or role players and associated uses, and water quality issues/problems that impact on use (Step 1.2.3 and Step 2.3.1).
- Identify pollution priority areas, or water quality hotspots (Step 1.2.3).
- Identify driving variables responsible for water quality state (Step 1.2.3).
- Gather information on users, issues and driving variables from stakeholders at Technical Task Group (TTG) and information meetings and prepare water quality users spreadsheet (Step 2.1.3).
- Test information with stakeholders (this information feeds into Integrated Step 6, the selection of RQOs for water quality) (Step 2.1.3).
- Catchment water quality (status quo) and processes (Step 2.1.6).

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

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

These spreadsheets appear as preliminary information at the end of Step 2 as more information may become available as the study progresses. Spreadsheets are finalized by Steps 4 and 6 of the Project Plan or Integrated Framework, i.e. consequences of scenarios and preparation of RQOs.

3.2.2 Step 4: Consequences of operational scenarios

The objective of Step 4.6 of the Integrated Framework (DWS, 2016) is to determine the consequences of operational scenarios on identified non-ecological users or role players.

The bullets below describe the actions required by this step.

- **Set WQ requirements for non-ecological water quality users**

The significant step here is to (1) link the condition of the resource to user water quality targets (e.g. as per industrial or agricultural water quality guidelines), and (2) determine or confirm water quality requirements for identified priority user driving variables.

- **Assess changes in water quality state under scenarios**

The change in water quality state has to be determined under each scenario for impacted areas or users.

- **Determine consequences by linking expected changes in water quality state to requirements of priority driving variables**

Changes in water quality state under each scenario will be linked to changes in driving variables resulting in the changed overall state. These changes are evaluated against the requirements of identified users or role players.

The user water quality approach for assessing consequences to scenarios, is represented in **Figure 3.1**.

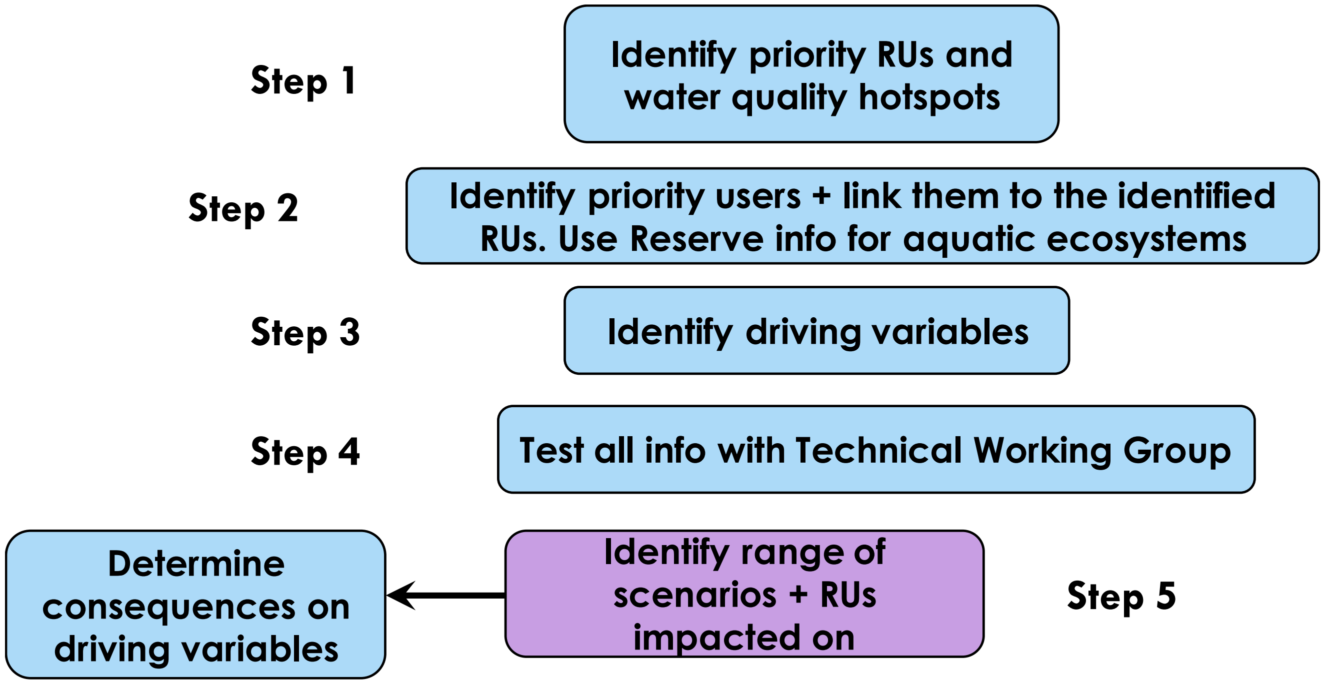


Figure 3.1 Diagrammatic representation of the User Water Quality process for evaluating consequences of operational scenarios

3.3 RESULTS

3.3.1 Water quality overview

The following summary is taken from the Status Quo and Delineation Report for the study (DWS, 2017b), i.e. Report No. *WE/WMA7/00/CON/CLA/0316*.

Water quality in T3 secondary catchment is generally good, with little contamination by nutrients and other toxins, probably due to the dispersed nature of the settlements and their sheer size, and very little industry. There are localised problems related to urban settlements. The most serious form of pollution or water quality impacts in the catchment are high turbidities due to soil erosion. This has reached very serious proportions in the rivers on the eastern side. The cause of this is primarily oversettlement and poor agricultural and overgrazing practices, that are exacerbated by the steep catchments and severe storms that occur. The high silt loads are also due to the numerous road crossings and cultivation along river banks and in the wider catchment. The many mountain streams which arise in mountain areas are of very good quality.

3.3.2 Water quality hotspots, sources/users and driving variables

Water quality hotspots have been identified for secondary T3 (**Table 3.1**). Note that the ratings come from the PES/EIS (Present Ecological State / Ecological Importance and Sensitivity) (DWS, 2014a) database (physico-chemical metric) in the first instance, where impacts are rated as follows:

0: No impact
1: Little impact
2: Moderate impact
3: Large impact

4: Serious impact
5: Critical impact

Impact ratings above a 3, i.e. a Large impact, are used to identify water quality hotspots or pollution areas. These hotspots are refined throughout the study using additional information gathered and stakeholder input, and are shown in **Table 3.1**. Water quality issues linked to the hotspots and driving variables are also listed on the table.

For the consequences step, the RUs and SQs which may be affected by the scenarios first need to be identified. As can be seen in Chapter 2, the primary developments in the catchment are the proposed dams of the Mzimvubu Water Project (MWP), i.e. the Ntabelanga and Lalini dams along the Tsitsa River. An EWR site (MzimEWR1) is located between the two dams, and one (MzimEWR4) on the mainstem of the Mzimvubu River downstream of the Mzimvubu/Tsitsa confluence. SQs potentially affected by the development are shown below with their associated overall Ecological Category:

- T35E-05977 (Ntabelanga Dam at upstream end of SQ; MzimEWR1): B Ecological Category
- T35K-06037: C Ecological Category
- T35K-06098: B/C Ecological Category
- T35L-05976 (Lalini Dam): B Ecological Category
- T35L-06190: B Ecological Category
- T35M-06205: B Ecological Category
- T36A-06250: C Ecological Category
- T36A-06354 (MzimEWR4): C Ecological Category
- T36B-06391: C Ecological Category

As can be seen from **Table 3.1**, there are only three water quality hotspots or *pollution priority areas* in the T35 and T36 tertiary catchments. The Mooi River (T35C-05874) hotspot is upstream of the proposed dams; while the other two hotspot SQs are tributaries. The Inxu (T35F-06020) hotspot is in the vicinity of Ugie town, well upstream of the proposed dam development, although the Inxu joins the Tsitsa River downstream of Ntabelanga Dam. The Xokoxa tributary (T35K-06067) is the third water quality hotspot, which meets the Tsitsa River between the two proposed dams.

The area has also been checked for water quality *priority protection areas*; none were identified in this stretch of river. Note that other than the SQs listed on **Table 3.1** as water quality hotspots, none were flagged as either moderate or high priority from a water quality user perspective.

Table 3.1 Water quality hotspots and identified sources and associated driving variables in the T3 Mzimvubu catchment

SQ reach	River name	Water quality impact (rating)	Water quality sources/users	Driving variables
T31F-05112	Mzimvubu	Moderate (2) - Large (3)	Pivot irrigation; erosion + sediment impacts. Potential Cedarville impacts.	Nutrients, turbidity
T32C-05273	Mzintlava	Large (3)	Pivot irrigation; settlements; urban pressures; erosion; elevated nutrient loads expected.	Nutrients, turbidity, toxics, *Escherichia coli (E. coli)* / faecal coliforms
T32D-05352	Mzintlava	Large – Serious (3.5)	Kokstad WWTW non-compliant; urban pressures; and extensive irrigation.	Nutrients, salts, turbidity, toxics, *E.coli*/faecal coliforms
T32D-05373	Mzintlava	Large (3)	Effect of urban impacts; irrigation return flows.	Nutrients, salts, toxics, *E.coli*/faecal coliforms
T32F-05464	Mzintlava	Serious (4)	Discharges from Mount Ayliff high risk WWTW; extensive erosion; rural settlements; dryland cultivation; Insizwa (nickel) Mine (status unknown).	Nutrients, turbidity, *E.coli*/faecal coliforms, salts
T33A-04990	Kinira	Large (3)	Matatiele WWTW discharge into streams; piggery north of WWTW; sand mining.	Nutrients, turbidity, *E.coli*/faecal coliforms
T33A-04991	Unknown	Large (3)	Extensive erosion; large number of villages; crossings; dryland cultivation; possibly elevated nutrient levels.	Nutrients, turbidity, *E.coli*/faecal coliforms
T34D-05463	Tokwana	Large (3)	Mount Fletcher WWTW high risk; urban impacts; crossings.	Nutrients, turbidity, toxics, *E.coli*/faecal coliforms
T35C-05874	Mooi	Moderate (2) - Large (3)	Maclear WWTW; urban impacts; cultivation/irrigation. Reports of poor water quality around Maclear.	Nutrients, toxics, *E.coli*/faecal coliforms
T35F-06020	Inxu	Large (3)	Low risk WWTW in Ugie; urban impacts; irrigation + cultivation downstream.	Nutrients, toxics, *E.coli*/faecal coliforms
T35K-06167	Xokonxa	Large (3)	Tsolo WWTW (critical risk); urban impacts (including Tsolo Agricultural College, St Lucy's and Dr Maliza Mphehle Memorial hospitals); crossings; dryland cultivation.	Nutrients, turbidity, toxics, *E.coli*/faecal coliforms

3.3.3 Consequences of operational scenarios on user water quality

As detailed water quality analyses and impact on water quality-related ecosystem services were conducted for the two EWR sites - results are shown for these sites in **Table 3.2** as background. All potentially affected SQs are in the RUs or MRUs associated with the three EWR sites and the Mzimvubu Estuary, meaning that aquatic ecosystems are the drivers of water quality at these sites and the primary water quality role players.

Table 3.2 Results for ecological water quality for MzimEWR1 (Tsitsa River) and MzimEWR4 (Mzimvubu River)

	MzimEWR1 (T35E-05977)	**MzimEWR4 (T36A-06354)**	**EWR1 Lalini (T35L-05976)**
Water quality description (PES)	Few water quality issues are seen in this part of the catchment, where land-use is primarily dryland farming, rural settlements and limited irrigation along the rivers. Water quality impacts are seen around towns such as downstream Tsolo (T35K) and upstream Ugie and Maclear, and the WWTW at Nessie Knight Hospital, but little evidence of these issues are prevalent at the site. Main water quality issues are erosion and elevated turbidities.	Few water quality issues are seen in this part of the catchment, where the terrain is rugged with scattered rural settlements. Small agricultural plots are seen on the floodplains. Sedimentation from upstream erosion is evident but the overall erosion status in the immediate vicinity of the site is lower than expected due to storage in the large catchment. Fine sediment deposition takes place on boulder bars but there is little instream deposition.	The scenario is designed to achieve a D Ecological Category for the stretch of river below Tsitsa Falls. The associated water quality category is a C. The site is immediately downstream of the proposed Lalini Dam, with results extrapolated from MzimEWR1, with few perceived water quality impacts in the reach, other than erosion.
Water quality PES	B: 86.4%	A/B: 88.3%	B: 86.4%
Sc 2b category	C/D: 61.8%	A: 93.5%	D (53.5%) – E (26.5%)
Sc 2c category	A/B: 90.0%	A: 93.5%	C
Sc 61 category	A/B: 90.0%	A: 93.5%	C
Sc 62 category	B: 87.3%	A/B: 90.0%	C
Sc 63 category	B: 87.3%	A/B: 90.0%	C
Sc 65 category	B: 86.4%	A/B: 90.0%	C
Sc 69 category	B: 87.3%	A/B: 91.85%	C

3.4 CONCLUSIONS

No water quality pollution or protection areas were identified in the SQs potentially affected by dam building scenarios. Impacts on ecological water quality at the EWR sites (MzimEWR1 on the Tsitsa River and MzimEWR4 on the Mzimvubu River), Mzimvubu Estuary and associated and affected RUs and MRUs were covered in the Ecological Consequences reports for the study. As these are all High priority RUs, ecosystem water quality requirements were the driving role player and scenario impacts were evaluated in detail and reported on in the Ecological Consequences Report and associated Appendix for the study, i.e. Report No. *WE/WMA7/00/CON/CLA/1117*.

4 ECOSYSTEM SERVICES

4.1 INTRODUCTION

According to the latest census conducted in 2011, a population of approximately 2 500 000 persons are located in the districts which either partially or completely fall within the Mzimvubu catchment. Census data is made available on a decade basis, and thus the next report will be available in 2021. Furthermore, it must be noted that there are no centres of urban or industrial demand within comfortable reach of the Mzimvubu River.

Dryland cultivation is a prominent feature in this region, with other sectors of the basin being used for commercial agriculture, predominately livestock farming in the western sections around Ugie and Maclear, as well as the portion of the basin which falls in KwaZulu-Natal (KZN). Agricultural activities that exist in what was once known as the Transkei are largely based on subsistence practises, where the cultivation of maize and vegetables, as well as livestock rearing, are dominant subsistence practises in this region. As such, a large portion of this section of the basin can be classified as degraded, largely as a result of overgrazing, which has caused severe soil erosion.

The Mzimvubu catchment plays a prominent role in the maintenance of the communities it intersects. This is fundamentally due to the nature of these communities, that is, largely rural. As such, the catchment plays a significant role in maintaining important ecosystem services. Furthermore, ecosystem services are natural assets that 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. However, it must be noted that natural capital and associated ecosystem services are becoming increasingly scarce. The Millennium Ecosystems Assessment (MEA) categorises ecosystems into the following four groupings:

- Provisioning services – these are the most familiar of the services and are often referred to as ecosystem ‘goods’. Such goods include foods, fuels, fibres, bio-chemicals, medicine and genetic material. Such assets are, in many cases, directly consumed subject to reasonably well-defined property rights (even in the case of genetic or biochemical material where patent rights protect novel products drawn from ecosystems); and are priced in the market. These services are provided directly from environment and thus the nature and integrity of the environment, as well as its ability to support these services, is of critical importance to numerous households[1]. Wetlands, for example, provide countless services to both the natural environment (local habitats for various species) and local communities through water purification, water retention during floods, and support of livelihoods etc.
- Cultural services – these less familiar services such as religious, spiritual, inspirational and aesthetic well-being derived from ecosystems, recreation,[2] and traditional and scientific knowledge that are: mainly passive or non-use values of ecological resources (non-consumptive uses); that have poorly-developed markets (with the exception of ecotourism);

[1] The direct use of water for domestic purposes is important but not considered here as it is the subject of a separate study that examines the Basic Human Needs. Ecosystem services are, in effect, concerned with water that remains in the system and not extracted. Small-scale irrigation is part of economic considerations, even if used for subsistence purposes and strictly speaking not part of ecosystem services considerations.

[2] Recreational use is particularly important in the context of the Mzimvubu and this is captured per zone where it is relevant.

and poorly-defined property rights (most cultural services are regulated by traditional customs, rights and obligations); but are still used directly by people and are therefore open to valuation.

- Regulating services – these are services used to regulate the natural environment to the benefit of surrounding communities. Such services may include, but are not limited to, water purification, air quality regulation, climate regulation, disease regulation, or natural hazard regulation. Such services affect the impact of shocks and stresses to socio-ecological systems and are public goods (globally in the case of disease or climate regulation) meaning that they "offer non-exclusive and non-rival benefits to particular communities" (Perrings, 2006); and are thus frequently undervalued in economic markets; many of these are indirectly used being intermediate in the provision of cultural or provisioning services.
- Supporting services – these are an additional set of ecosystem services referred to in the MEA, such as nutrient and water cycling, soil formation and primary production. These services are fundamental in that they capture the basic ecosystem functions and processes that underpin all other services and thus: are embedded in those other services (indirectly used); and are not evaluated separately (DWAF, 2004).

4.2 APPROACH

The most important aspect whilst generating data for this report was to ensure that an integrated assessment of the current population was undertaken. As such, analysis was undertaken with the use of the following three primary tools:

- Geographic Information System (GIS) overlays of quaternary catchments and census data. This process enables the population for each quaternary unit to be calculated and a profile of the population for each unit to be analysed. Secondly, the analysis of typology was undertaken for this report. The purpose of this was to gain a deeper understanding of the settlements in the area and their level of dependence on goods and services used for sustaining their livelihoods. This information was sourced from Statistics South Africa and cross referenced with aerial photography; a vast majority of which was sourced from Google Earth^{TM}. This allowed for an analysis of land-use types associated with the settlement typology.
- Cross check of the GIS data sets with available mapping to determine likely livelihood styles and profiles within these respective areas.
- The analysis of Socio-Cultural Importance (SCI) was under taken for each SQ within the Mzimvubu catchment. SCI was determined from the analysis of mapping and cross referencing of secondary sources, where available. A key component of the SCI model is the category *Resource Dependence*. This concept refers to the goods and services which are supplied by the river, and the level of dependence which scores of people have on these resources. This is largely attributed to level of local dependence on the ecological services category of *Provisioning Services*. This is a critical component of the SCI score and is designed to cater for river resource dependence, particularly for those who rely directly on such services (from the river) for their survival. Furthermore, *Recreational Use* and *Ritual Use* were also categories examined within the analysis of socio-cultural importance.

4.3 STATUS QUO ASSESSMENT

The model of socio-cultural importance plays a significant role as it allows for the development of a spatial matrix. This matrix is used to compare SQ catchments with one another for the purpose of establishing a profile of the current status quo within each unit. The profile of these units is largely a narrative description which concentrates on the drivers of socio-economic profiles in the respective units, based on the data available. Furthermore, the SQ catchments have been amalgamated within ecosystem service zones which have similar ecosystem service profiles. As such, the Mzimvubu catchment has 15 ecosystem service zones (**Figure 4.1**), each of which is briefly discussed in the section below. More information can be found in the Status Quo and Delineation Report (DWS, 2017b) for the study, Report No. *WE/WMA7/00/CON/CLA/0316*.

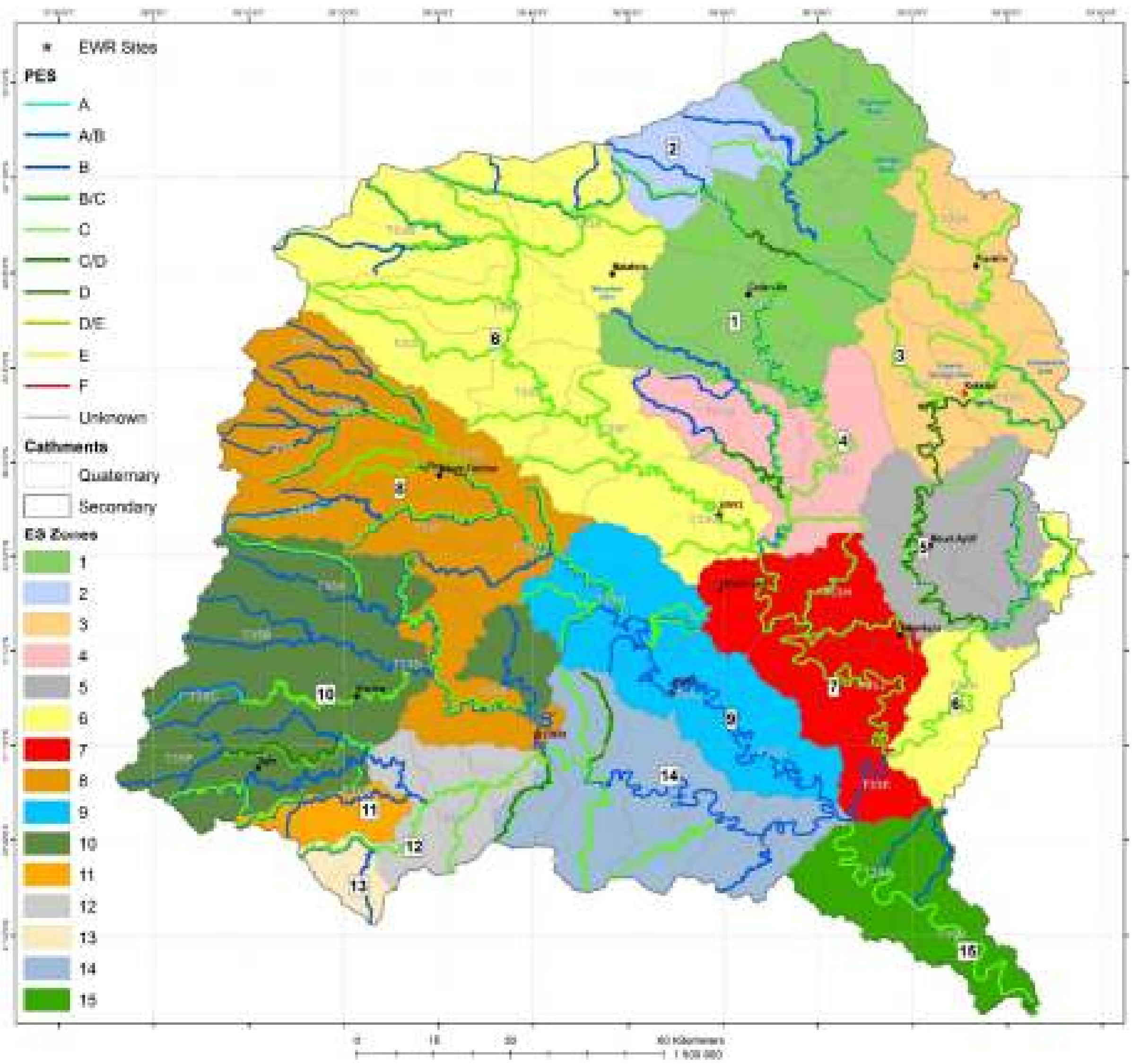


Figure 4.1 Ecosystem service zones

4.3.1 Zone 1

This zone is comprised of either the whole of, or sections of, T31A, T31B, T31C, T31D, T31E, T31F, T31G and T31H. A large majority of the area is utilised for commercial fishing purposes. Within this zone is the main stream of the Upper Mzimvubu River, in which a substantially large commercial fishing area, a small commercial forestry area, and the town of Cedarville, are present. The north-eastern section of the zone falls within the province of KZN, whilst the remainder of the zone rests in the Eastern Cape. Important ecosystem services present in this zone include the following:

- Recreational fishing.
- Some limited subsistence fishing and other recreational aspects associated with the rivers.

- Waste water dilution.
- The aesthetic value of the river and associated aquatic systems in their intersection with the recreation value of the upper catchment areas.

4.3.2 Zone 2

Zone 2 is comprised of parts of T31C and T31E. The dominant land-use activity in this region is subsistence farming, and the area includes a portion of what was formerly known as the Transkei. There are few towns in this zone and most settlements found here are of a rural nature, where subsistence fishing, harvesting of thatch grass, reed harvesting and the usage of other riparian vegetation are all fundamental ecosystem services. Furthermore, ritual use is also deemed important within certain sections of this zone.

4.3.3 Zone 3

This zone comprises of T32A, T32B, T32C, and T32D in their entirety. Within this zone is the town of Kokstad and the smaller satellite area of Franklin. The former constitutes the most developed area in the eastern section of the Mzimvubu catchment and is reliant on the agricultural sector. Furthermore, a large majority of the zone is comprised of commercial farming practises, with irrigation being a significant component in this zone. As with zone 1, important ecosystem services in this zone include:

- Recreational fishing and other recreational usage.
- Waste water dilution.
- The aesthetic value of the river and associated aquatic systems in their intersection with the recreation value of the upper catchment areas.

4.3.4 Zone 4

Zone 4 is made up of T31H and T31J. The area is hilly with scattered rural populations and some closer settlement associated with the extended village of Colona. Land use is almost exclusively given over to subsistence farming. Subsistence fishing, harvesting of thatch grass, reed harvesting and the usage of other riparian vegetation are all fundamental ecosystem services. Furthermore, ritual use is also deemed important within certain sections of this zone.

4.3.5 Zone 5

Zone 5 is made up of T32E, T32F, T32G and T32H. The administrative centre is the town of Mount Ayliff that is included in this zone. Land use is almost exclusively given over to subsistence farming although there are pockets of small scale forestry. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.6 Zone 6

Zone 6 is made up of T33A, T33B, T33C, T33D, T33E, T33F, T33G. The town of Matatiele is on the eastern-most part of the zone. In addition to Matatiele and the satellite settlements of Maluti, Dengwane and Newlands, there are several dense rural villages. These villages are a dominant feature of the northern portions of the zone and this means that population density in these areas is relatively high for a zone that is predominately rural. Land use is almost exclusively given over to subsistence farming although there are pockets of small scale forestry. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.7 Zone 7

Zone 7 is made up of T33H, T33J, T33K. The zone is similar in many respects to Zone 5 but is characterised by deeply incised valleys with most settlement clustered around villages and points of closer rural settlement on the plateaus that overlook the valleys. Notable settlements include, Rwantsana, Sipetu, Sidakeni and Mangqa. Land use is almost exclusively given over to subsistence farming although there are pockets of small scale forestry. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.8 Zone 8

Zone 8 is made up of all, or parts of, T34A, T34B, T34C, T34D, T34E, T34F, T34G and T35E. The most notable town is Mount Fletcher. Although the remainder of the area would be classified as rural there are pockets of high density closer settlement. Land use is predominantly subsistence agriculture and extensive degradation due to overgrazing is evident. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.9 Zone 9

Zone 9 is made up of all, or parts of, T34H, T35J, T35K. There are pockets of forestry developed by the old Transkei authorities but for the main part it is subsistence agriculture that is the dominant land-use. As with Zone 8 extensive degradation due to overgrazing is evident. There are few major settlements but there are several pockets of high rural densities associated with the settlements of Cabane, Mpemba, Barkerville, eMarhambeni, eDangwane, Lwandlana and Lucingweni. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.10 Zone 10

Zone 10 is made up of T35A, T35B, T35C, T35D, T35F, and forested sections of T35G. Land-use is predominantly for commercial agriculture and particularly forestry. The town of Ugie and Maclear are the most important settlements and these are heavily dependent on both agriculture and forestry-related industry. The upper part of the zone is mountainous. Key ecosystem services important in the zone include the following:

- Recreational fishing
- Some limited subsistence fishing and other recreational aspects associated with the rivers
- Waste water dilution
- The aesthetic value of the river and associated aquatic systems in their intersection with the recreation value of the upper catchment areas

4.3.11 Zone 11

Zone 11 is made up of the non-forestry parts of T35G. Land use is predominantly for commercial agriculture and is similar to Zone 10 except that forestry does not play a role in this zone. Key ecosystem services important in the zone include the following:

- Recreational fishing
- Some limited subsistence fishing and other recreational aspects associated with the rivers
- Waste water dilution

4.3.12 Zones 12 and 13

Zones 12 and 13 are made up of parts of T35G as well as T35H and T35J. There are no major towns but the most notable settlements include Mbidlana, eLalini, Ncembu and Lathuthu. For the main part subsistence agriculture is the dominant land use. As with Zones 8 and 9, extensive degradation due to overgrazing is evident. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.13 Zone 14

Zone 14 is made up of all, or parts of, T35J, T35K, T35L, T35M. The towns and urban centres of Qumbu and Tsolo are the most important settlements. There are pockets of forestry developed by the old Transkei authorities but for the main part it is subsistence agriculture that is the dominant land-use. As with Zone 8 extensive degradation due to overgrazing is evident. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Ritual use is also deemed to be important in some areas.

4.3.14 Zone 15

This zone includes the Mzimvubu catchment downstream of all the tributaries to the estuary and is made up of T36A and T36B. Parts are very inaccessible but there are some areas where access is available and where provisioning services are important. Subsistence fishing, thatch grass harvesting, reed harvesting and other riparian vegetation usage are all important in terms of ecosystem services. Some floodplain agriculture and limited sand mining is also evident. Ritual use is also deemed to be important in some areas. Port St Johns is the major settlement and this is a relatively popular tourist destination. Recreational aspects are key ecosystem services for the Mzimvubu estuary.

4.4 SCENARIO IMPACTS

The method that was employed is essentially linked to EWR sites as the detailed information is available at these sites, and then scenario-based. Assessment of the impacts of the various scenarios – in this case largely hypothetical notions of deviation from PES at the EWR sites – essentially identifies the direction of change (either positive or negative) and estimates the “relative magnitude” of the change in benefits and costs that may be experienced within the Mzimvubu River system. The process adopted is as follows:

- The analysis of potential economic changes is based on the present day situation, that is, the value of the goods and services currently provided by the water in the Mzimvubu River system. The present day state is scored as 1 for each service.
- Ecosystem services are listed in a spreadsheet and categorised in terms of services as defined by the MEA, i.e. provisioning, supporting, regulating, cultural.
- The biophysical specialists then identify the potential change that each of the key goods and services may undergo in each of the scenario clusters. The potential change is noted as a factor and used in later calculations. For example, no change = 1; a 50% increase = 1.5; and a 20% decrease = 0.8.
- A populated spreadsheet/table with analysis of changes to key ecosystem services per scenario with narrative description of reasons for change have been produced. These are categorised into provisioning, supporting, regulating, cultural services and a normative score is generated per service.

- Ecosystem services and their categories are then weighted within a total value of 100% to reflect importance within the context of the geographical areas (EWR sites and the reach they represent) under consideration to produce a weighted score.
- A final score per scenario (Total) expressed against the status quo value of 1 has been produced.

4.4.1 MzimEWR1 (Tsitsa River)

Scenarios 54, 61 and 65 were scored separately, however, the following scenarios were determined to be equivalent and scored together:

- Sc 2a, 2b, 32, 33
- Sc 41, 42, 51, 52, 53
- Sc 62, 63
- Sc 69, 70

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

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

Scores are reflected in **Table 4.1**.

Table 4.1 Ecosystem services scenario scoring for MzimEWR1

Services	Sc 2a, 2b, 32, 33	Sc 41, 42, 51, 52, 53	Sc 54	Sc 2c, 61	Sc 62, 63	Sc 65	Sc 69, 70
Normative score:							
Provisioning	0.3	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,.1	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**

4.4.2 MzimEWR4 (Mzimvubu River)

Scenarios 52, 53, 62, 63, and 65 were scored separately, however, the following scenarios were determined to be equivalent and scored together:

- 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 4.2.**

Table 4.2 Ecosystem services scenario scoring for MzimEWR4

Services	Sc 2a, 2b	Sc 32, 33, 41, 42, 51	Sc 52	Sc 53	Sc 2c, 61	Sc 62	Sc 63	Sc 65	Sc 69, 70
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

4.4.3 MzimEWR1 Lalini (Tsitsa River)

Scenario 54 was scored separately, however, the following scenarios were determined to be equivalent and scored together:

- Sc 2a, 2b, 41, 51, 53
- Sc 33, 42, 52
- Sc 2c, 70

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

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

Scores are reflected in **Table 4.3.**

Table 4.3 Ecosystem services scenario scoring for MzimEWR1 Lalini

Services	Sc 2a, 2b, 41, 51, 53	Sc 33, 42, 52	Sc 61, 63, 65, 69	Sc 54	Sc 2c, 70
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

4.4.4 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 4.4.**

Table 4.4 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

4.5 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 4.2** below.

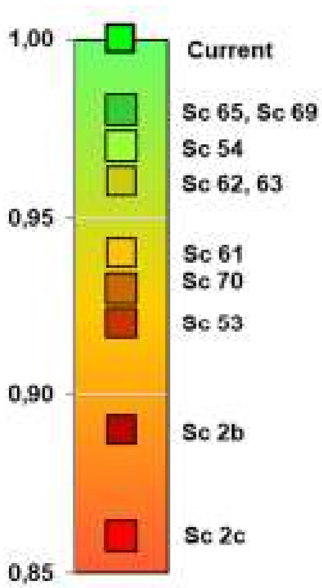


Figure 4.2 Integrated ranking of scenarios for ecosystem services

5 ECONOMICS

5.1 BACKGROUND

The Mzimvubu catchment has been prioritised for implementation of the WRCS in order to determine appropriate Water Resource Classes and RQOs in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity. These activities will guide the management of the T3 primary catchment in order to meet 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.

As far as the macro-economics of the catchment is concerned, a significant uncertainty is associated with the proposed construction of the Ntabelanga and Lalini dams. The EIA for the two dams have been completed, however, no funds have been made available in the short term for dam construction. The EIA found that the project was economically viable as a developmental project, but financially it will be very difficult to reach feasibility. The success or not will depend in a large way on the proposed hydro-electric power unit to be installed at the Lalini Dam, which will involve the participation of Eskom.

The possibility exists that if the proposed Hydro Electric Power Plants (HEPPs) are fully operational the character of the river sites and estuary may be significantly changed. With the HEPPs in full operation the volume of water released during the winter months will have to be considerably higher than during the rest of the year, which will impact negatively on the natural operation of the downstream river sites and estuary.

The role of the economic analysis is therefor to determine the positive or negative impact of the scenarios on the economic and social structure along the river and also the estuary. The possible eco-tourism impact on the estuary is also discussed.

5.1.1 Mzimvubu Estuary

Port St. Johns is situated on the Wild Coast, a coastline of about 270 km long, boasting some of the most beautiful natural scenery in the country. It lies at the mouth of the Mzimvubu River, a river flowing through an impressive gorge known as the "Gates of St John" into an estuary located on the Indian Ocean. Port St. Johns is known as the centre of tourism on the Wild Coast. It is famous for deep sea fishing, shore angling and the annual sardine run. The majority of the tourist accommodation is located along the banks of the Mzimvubu River followed by accommodation in the town of Port St. Johns and then along the coast, mainly to the north, in the vicinity of Agate Terrace. The accommodation along the river banks cater for the upmarket tourist.

Currently the estuary functions with higher water levels in summer and lower levels in winter. The estuary mouth is open for most of the time, except in times of severe drought in the catchment area. From November through to April muddy water pours out to sea. Should the flow of the Mzimvubu River be reduced during winter it will increase the chances of a sand bank building at the mouth of the river which will prohibit the launching of boats and the sardine fishermen will have to find another area from which to operate.

The holiday tourists include overseas visitors. Both the estuary and ocean are very popular fishing fields with the result that anglers frequent the accommodation facilities over weekends and public holidays. Another attraction is the Silaka Nature Reserve which is within 7 km from Port St Johns.

The accommodation facilities along the river have in total 443 beds with an estimated annual bed occupation of 80%. According to the data provided by the different facilities, holiday makers and eco-tourists make up 30% and business visitors (which includes government officials, representatives and contractors) make up 70% of the clientele. The estimated amount spent by tourists on accommodation using the river facilities is R13.6 million per annum, with a further estimated R8.9 million spent on food and other activities such as boat trips, etc.

The in-town facilities have a total of 445 beds with an estimated annual occupation of 70%. An estimated 75% of the visitors are business (including government officials, representatives and contractors) and 25% holiday and eco-tourists. The estimated amount spent by the tourists is estimated at R6.3 million per annum on accommodation and a further R5.8 million on food and other activities.

According to the facility managers the area is very popular with anglers and in winter the sardine run from mid-June to mid-August is a great attraction. A large number of boats are then also launched on the river for entering the sea.

The following is quoted from Wikipedia.Org: *The recent interest in the sardine run has had significant impact on the local economy. International and domestic divers join local tour operators on sardine run diving expeditions. Such expeditions run from Eastern Cape towns, including East London, Port Saint Johns, and Port Elizabeth. The run has become important to tourism and is considered to be one of the main attractions in KwaZulu-Natal during the winter holiday period. Both local and international tourists are attracted to the spectacle and are provided with opportunities to participate in activities such as dive charters and boat-based predator viewing tours.*

During the data collection process it was evident that the river and surrounding sea area is very popular with the fishermen. According to some of the managers of tourism establishments, the peak season is over the winter months.

To put a value to the fish and sardines caught is problematic due to the lack of data from official sources. The latest estimate is that the annual sardine catch along the Eastern Cape coast is around 4 000 tons between Cape St Francis, Port Elizabeth, Port Edward, East London and Port St Johns. The tonnage caught at Port St Johns varies between 400 tons and 1 200 tons, depending on which source you use. The value of the catch varies between R4 million and R11 million expressed in 2016 prices. Locals are of the opinion that the value of the other variety of fish is around R5 million annually, but no confirmation could be found for this amount. In total it therefore appears that the river, the mouth and the sea contribute over R50 million per annum to the economy of the town.

What has, however also emerged from the investigation is that for the river and the estuary, the quality of the water is an important element in sustaining the economic activity in the town and for future growth.

The accommodation facilities located along the coast, immediately north and south of Port St Johns, were not included in the survey as they serve the beaches and ocean fishing enthusiasts.

5.2 APPROACH

In this section the approach to the economic impact of the different identified scenarios are discussed in terms of accepted economic parameters. The assumption is that the generation of electricity by hydro-electric power plants (HEPP) due to the dams of the MWP, will contribute to the economic growth in the Eastern Cape Province which will be measured in terms of the gross domestic product (GDP) contribution and the maintenance or creation of employment opportunities. The operational scenarios are therefore evaluated in terms of the projected economic impact of these scenarios using a cost benefit analysis (CBA) approach. The CBA approach will assess the impact of scenarios on the HEPP system and the retention of financial feasibility of the system.

Firstly, an economic baseline was established for comparative purposes. This was done by taking the current four economic contributing industries (agriculture, mining, construction and manufacturing) demanding electricity generation, and to convert the contribution of the four activities to GDP and labour multipliers respectively, as this will contribute to the future economic growth of the economy. The analysis is shown in the methodology section.

5.2.1 Cost benefit analysis approach

The complicating factor in this scenario analysis is the fact that the Lalini Dam and the HEPP system will involve considerable capital investment and the possibility exists that some of the scenarios could negatively impact on the financial viability of the HEPP system. It was therefore decided to construct a CBA model and determine the impact of the different scenarios on the financial viability of the project. The CBA is considered to be the most 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.

The core function of CBA can be described as the comparison of costs and benefits over time – in the case of the HEPP the time-period is 30 years. The only factor that complicates the technique is the discounting of costs and benefits back to present values.

In practice, a CBA is performed in both financial and economic terms, i.e. a *financial CBA* and an *economic CBA*. A financial priced CBA focuses on the financial viability of a project from the investor's perspective, as in the case of the HEPP project. The crux of the matter is: Will the revenue derived from the project provide an acceptable return-on-investment? An economic CBA is undertaken from the community's perspective, where the community includes all the stakeholders that will be affected by the project, in either a positive manner (benefits) or in a negative manner (dis-benefits).

It is important to keep in mind that the volume of water for the HEPP is the excess water available after the irrigation economic activity and potable water requirements for the municipality have been met. In effect this means that the economic/financial value of the water available for HEPP is zero as this study consists of water for the economic activity of the irrigation agriculture and electricity generation in the catchment. The economic CBA in this study therefore only evaluates water for hydropower.

5.3 SCENARIO DATA

The electricity data produced under each scenario was calculated by the modelling consultants of the study and applied in the calculations. **Table 5.1** presents the estimated data to be used in the calculations in terms of electricity generated expressed in GWh per scenario.

Table 5.1 Estimated electricity generated per scenario

Scenario	Total mean electricity generated
	GWh
Scenario 2b	376.22
Scenario 2c	415.36
Scenario 54	355.78
Scenario 61	417.54
Scenario 62	353.42
Scenario 63	413.29
Scenario 65	319.17
Scenario 69	378.80

Another scenario was also developed, Scenario 70, which specifically investigates the possible impacts if an EWR flow is not released and the Tsitsa Falls and the section below the falls up to the outfall of the HEPP therefore runs dry. The mean electricity generated with this scenario is exactly the same as Scenario 69, the result being the financial and economic impact of both will be the same. However, the possible tourism impact is analysed in **Section 5.6**.

The recommended HEPP system in the Pro-Plan Consulting Engineers Report (van Wyk and de Jager, 2016) is as follows:

- Ntabelanga Dam HEPP: 4.4 MW installed capacity.
- Lalini Dam HEPP: 6.7 MW installed capacity.
- Main HEPP at Tsitsa Falls: 45.1 MW installed capacity.

The total recommended installed capacity is 56.1 MW, which is an 18% increase on the original recommendation in the 2014 Feasibility Study (DWS, 2014b).

It is accepted that the Ntabelanga HEPP electricity generated will mostly be utilised by the proposed irrigation scheme, the Lalini HEPP by rural and urban households and the surplus will enter the Eskom transmission network. The electricity generated by the Main HEPP will immediately enter the Eskom transmission network.

5.4 SOCIO-ECONOMIC MODEL AND RESULTS

The two parameters used in calculations, GDP and employment, are explained as follows:

- GDP is the monetary value of all the finished goods and services produced within a country's borders in a specific time period. The GDP is one of the primary indicators used to gauge the health of a country or a regional economy. It represents the total Rand value of all goods and services produced over a specific time period.
- Employment is the social component of the analysis, providing an indication of the social positive or negative impact of a specific scenario.

As explained the electricity generated by the HEPP system can or will contribute to economic growth in the Eastern Cape Province.

According to the 2016 Provincial Review the provincial contribution represents 7.6% of the country's GDP, this converts to R 327 400 932 000 (R327.4 billion). According to the same review, the agricultural, mining, manufacturing and construction represents 17.2% of the provincial GDP which converts to R56 312 960 304 (R56.3 billion).

The electricity supplied to the province for 2016, according to STATS SA, is 10 099.51 GWh. By dividing the R56.3 billion rand with the 10 099.51 GWh the following multiplier is obtained:

- R 5.58 / kWh.

By multiplying this value with the estimated electricity generated per scenario, the contribution to GDP per scenario is obtained.

Applying the same approach for the calculation of the estimated employment supported or created by the HEPP electricity, the following employment multiplier is obtained:

- 39.49 number/GWh.

The GDP and employment numbers created under each scenario are shown in **Table 5.2**.

Table 5.2 Estimated GDP and employment that is created/dependent on the HEPP electricity generated

Scenario	Electricity generated GWh	EC provincial electricity contribution	GDP (Rand million)	Employment numbers
Scenario 2b	376.22	3.73%	R 2 097.72	14 858
Scenario 2c	415.36	4.11%	R 2 315.99	16 404
Scenario 54	355.78	3.52%	R 1 983.76	14 051
Scenario 61	417.54	4.13%	R 2 328.13	16 490
Scenario 62	353.42	3.50%	R 1 970.59	13 958
Scenario 63	413.29	4.09%	R 2 304.44	16 322
Scenario 65	319.17	3.16%	R 1 779.64	12 605
Scenario 69	378.80	3.75%	R 2 112.13	14 960

From **Table 5.2** it appears that Scenarios 2c, 61 and 63 could be, in socio-economic terms, the most beneficial deviation from the baseline.

The results in the table only show the impact of each of the scenarios without any reference to the so-called economic baseline. In this case the economic baseline refers to the theoretical economic impact of the proposed HEPP system. The GDP of the baseline is estimated at R2 025.32 million and the employment baseline is estimated at 14 345 employment opportunities. **Table 5.3** presents the deviation from the baseline of the different scenarios.

Table 5.3 GDP and employment deviation per scenario from the economic baseline

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

Table 5.3 shows that scenarios 2b, 2c, 61, 63 and 69 provide an economic positive deviation from the economic baseline. Scenarios 54, 62 and 65 show a negative deviation from the economic baseline.

5.5 COST BENEFIT ANALYSIS MODEL AND RESULTS

The different parameters applied in a CBA model is presented are defined as follows. ***They all have a minimum value that must be met and a project will only be deemed feasible if all three parameters meet the individual minimum requirements.***

a) Net Present Value (NPV): The NPV of an investment indicates the net benefit (difference between benefits and costs) of a programme discounted to present value terms. In order for a project to be considered viable, a positive NPV is required as this indicates that the overall benefits outweigh the overall costs of the programme over time.

b) Internal Rate of Return (IRR): The IRR is the discount rate at which the present value of costs and benefits are equal. It is therefore the value of the discount rate *r*, which satisfies the appropriate criteria. Only projects with an IRR higher than the social discount rate, which forms a limit, will be considered for funding.

c) Benefit Cost Ratio (BCR): The discounted BCR is the ratio of the present value of the benefits to the present value of the costs. A project will only be considered for funding if the BCR is greater than one (1).

Discount rate: The Water Research Commission report *A Manual for Costs Benefit Analysis in South Africa with Specific Reference to Water Resource Development* states the following: In terms of the financial analysis, the discount rate used is equal to the market rate, or weighted marginal cost of capital, plus uncertainty and a risk premium. It should be noted that if the calculation is being done in constant/real prices, the discount rate used should be in real terms. For instance, if the discount rate in current prices is 10% and the prospects for inflation for the project appraisal are 5%, then the real discount rate is approximately 5%. It can be calculated as follows:

$$\left(\frac{1.10}{1.05}-1\right)\times 100=4.76\%$$

Therefore the real discount rate is not exactly 5%, but actually 4.76%. In the current South African situation it should be 4.9%.

The CBA model used in the estimation is based on constant financial prices, however it is also based on certain economic principles, which lead to the fact that it is not a pure financial analysis.

The CBA manual recommends in situations as explained, 8% should be used as the discount rate and was applied as such in the model.

5.5.1 Data and data sources

5.5.1.1 Estimated revenue per scenario

The tariff to be used in the calculation is influenced by the average Eskom tariff to its customers.

In the case of the CBA the tariff used is based on the Eskom buy-in tariff determined in 2014 at 76c/kWh. An inflation-adapted tariff is 91c/kWh while an Eskom-adjusted tariff by the National Energy Regulator of South Africa (NERSA) gives an answer of R1.05/kWh. For the purposes of this analysis 91c/kWh was used as that it is the tariff applied by Eskom when negotiating with private electricity providers. **Table 5.4** shows the estimated electricity generated per scenario, with the associated tariff income.

Table 5.4 Projected electricity produced per scenario

Scenario	Electricity generated GWh	Tariff income (Rand million)
Scenario 2b	376.22	R 395.03
Scenario 2c	415.36	R 436.13
Scenario 54	355.78	R 373.57
Scenario 61	417.54	R 438.42
Scenario 62	353.42	R 371.09
Scenario 63	413.29	R 433.96
Scenario 65	319.17	R 335.13
Scenario 69	378.80	R 397.74

5.5.1.2 Capital and operational costs

The following data is sourced from the Pro-Plan Consulting Engineers (van Wyk and de Jager 2016). The interpretation of some of the results is made by Mosaka Economists. In **Tables 5.5–5.7** the capital costs of the three HEPP turbines are presented as obtained from the relevant Pro-Plan Report and applied in the CBA model for all the scenarios except Scenario 2c where the HEPP2 is excluded from the calculations.

Table 5.5 Estimated construction costs per annum for the HEPP below the Ntabelanga Dam (4.4 MW capacity)

Year	Dam	Infrastructure	Water conveyance	Powerhouse cost	Engineering and mitigation	Total
	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.
2018	0	1.5	6.60	0.8	2.4	11.30
2019	0	3.5	11.55	1.6	2.4	19.05
2021	0	3.5	11.55	2.4	4.8	22.25
2022	0	1.5	3.30	3.2	2.4	10.40
Total	–	10.0	33.00	8.0	12.0	63.00

Table 5.5 shows that the cost of the Ntabelanga Dam is not included as the dam will not be built for hydropower generation.

Table 5.6 Estimated construction costs per annum of the HEPP above the Lalini Dam (6.7 MW capacity)

Year	Dam	Infrastructure	Water conveyance	Powerhouse cost	Engineering and mitigation	Total
	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.
2018	0	2.25	10.00	0.8	3.40	16.45
2019	0	5.25	17.50	1.6	3.40	27.75
2021	0	5.25	17.50	2.4	6.80	31.95
2022	0	2.25	5.00	3.2	3.40	13.85
Total	–	15.00	50.00	8.0	17.00	90.00

Table 5.6 shows that the cost of the Lalini Dam is excluded as the infrastructure is below Ntabelanga Dam where dam costs have already been accounted for. There is, however, provision made for additional infrastructure components for the HEPP.

Table 5.7 Estimated construction costs per annum of the main HEPP below the Lalini Dam (45 MW capacity)

Year	Dam	Infrastructure	Water conveyance	Powerhouse cost	Engineering and mitigation	Total
	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.	Rand mil.
2018	218.7	66.45	172.20	21.2	104.00	582.55
2019	218.7	155.05	301.35	42.4	104.00	821.50
2021	145.8	155.05	301.35	63.6	208.00	873.80
2022	145.8	66.45	86.10	84.8	104.00	487.15
Total	729.0	443.00	861.00	212.0	520.00	2 765.00

The cost of the Lalini Dam and the rest of the construction costs are presented in **Table 5.7**.

The operational cost, as applied in the model, is presented in **Table 5.8**.

Table 5.8 Annual operational costs as applied in the CBA

Cost component	Main HEPP cost	Dam HEPPs cost	Total Opex annual costs
	Rand mil.	Rand mil.	Rand mil.
Dam	1.755	0	**1.760**
Pipe lines and reservoirs	0	0	**0.00**
Monitoring & Evaluation cost	19.1	2.55	**21.65**
Water Treatment Works civil and buildings	0	0	**0.00**
Staff	2.08	1.04	**3.12**
Total	**22.94**	**3.59**	**26.53**

5.5.2 Cost benefit analysis results

The results of the CBA are presented in **Table 5.9**.

Table 5.9 Financial CBA results

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

Table 5.9 shows that Scenarios 2b, 2c, 61, 63 and 69 provide financial viability results, while scenarios 54, 62 and 65 indicate a negative impact on financial viability.

5.6 SCENARIO 70

5.6.1 Background

The following is a detailed explanation of Scenario 70:

- The Tsitsa Falls is located below the proposed Lalini Dam and the outfall of the water of the main HEPP is some 18 kms away. In essence, if a EWR volume is not released, this stretch of river, specifically the first stretch before the river sections that includes the Tsitsa Falls, will be dry except when the dam spills.
- This stretch has a major barrier (in both the outfall and the dam wall) and in essence, the ecological functioning of the river will only be in any reasonable state downstream of the outfall.
- In deciding whether to sacrifice this section of the river or not, it was felt that the major concern would be the impact on the Falls in terms of aesthetics; socio-cultural, tourism and recreational uses, rather than the ecology. Most scenarios (see **Chapter 2**) therefore included a D category low flow to keep the river flowing, however Scenario 70 does not include any EWR releases. It was therefore necessary to determine whether there is any recreational/tourism impact if the Tsitsa Falls dry up.

5.6.2 Scenario 70 results

The accommodation facilities in the following towns were contacted and an analysis of the number of available beds was made. These are as follows:

- Elliot – 134 beds
- Ugie – 74 beds
- Maclear – 234 beds
- Tsolo – 10 beds
- Tsitsa Falls Backpackers (upper Tsitsa Falls) – 40 beds and 20 camping sites

According to the data supplied by the facilities in the four towns, about 85% of their visitors are business people with the rest divided between holiday makers, 4x4 route drivers, mountain bikers, adventure and eco-tourists.

In the case of the Tsitsa Falls Backpackers the majority are people that go whitewater kayaking for 15 km down river, with some continuing up to the main falls and a percentage then return to the backpackers by vehicle. Others find a way down the falls and then carry on up to the point where the N2 highway crosses the river and then return by vehicle to the Backpackers. It is clear that the construction of the Ntabelanga and Lalini dams will negatively impact on the kayaking activities and the possibility of the drying up of a section of the river will add to this.

According to the data collected and the interpretation thereof, the following deductions were made:

- Elliot – about 1 365 persons visit the town annually as eco-tourists or travelling holiday makers.
- Ugie – about 3 285 persons visit the town annually as eco-tourists or travelling holiday makers.
- Maclear – about 2 790 persons visit the town annually as eco-tourists or travelling holiday makers.
- Tsolo – we could not identify any persons as eco-tourists or travelling holiday makers.

In the case of the Tsitsa Falls Backpackers over 7 000 persons annually use the facilities to go kayaking on the river, at least up to the main falls. The number that then proceeds to the N2 highway crossing is, according to our estimation, about 50%.

The following could not with be determined reasonable certainty:

- Holidaymakers staying over in the towns that actually visit the falls.
- So-called eco-tourists staying over in the towns that actually visit the falls.

One of the realities is that the following routes are available from Maclear:

- R396 via Tsolo to the N2 and the Transkei Wild Coast.
- R396 via Naude’s Pass to Rhodes, Barkley East.
- R56 to Matatiele and KwaZulu-Natal.

If it was estimated that about 40% of the tourist and holiday vehicles overnighting in the area, or approximately 7 300 persons, will head down on the R396 towards the N2 and the Transkei Wild Coast. If about 20% of this number visit the Tsitsa Falls, the number of visitors would be about 1 500.

It is therefore estimated that the total estimated number of visitors to the Tsitsa Falls (upper), kayaking and holiday makers is annually about 8 300. This number excludes any tourist travellers not staying over in Ugie and Maclear. The estimated annual turnover of the backpacker facility and the non-business people in the other facilities is estimated at about R7.3 million.

The conclusion is therefore that Scenario 70 can have a very negative impact on current activities but also on any future eco-tourism development and activities in the area, due to the drying up of Tsitsa Falls and the stretch of river below it.

5.7 RESULTS

5.7.1 Socio-economic results

Figure 5.1 presents the deviation in the GDP and Employment results from the economic baseline.

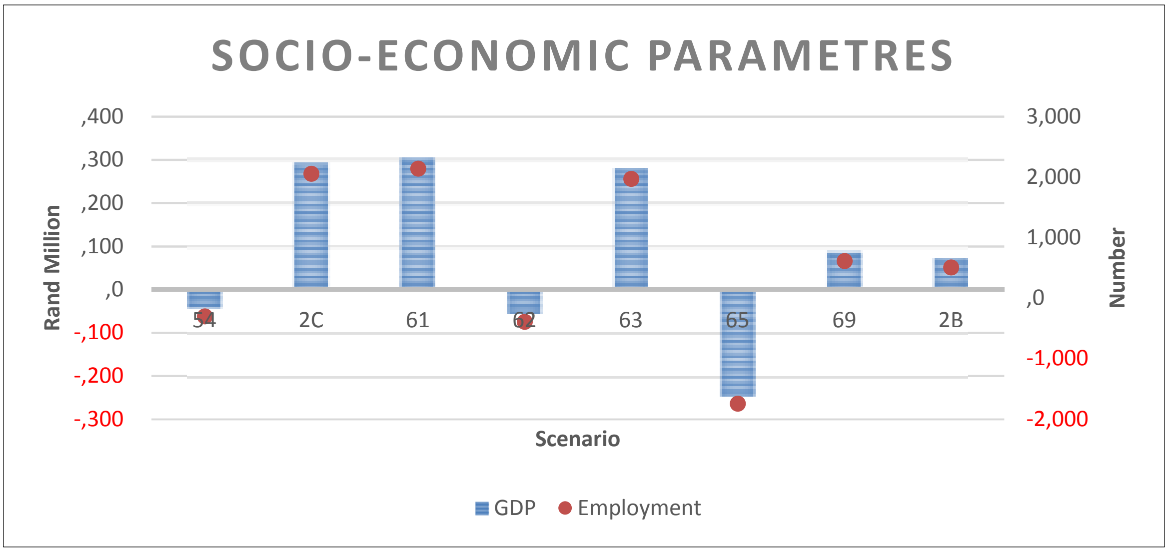


Figure 5.1 Presentation of the GDP and employment deviation from the economic baseline

The graph shows that the deviation of GDP and employment is very close for a number of the scenarios. It also shows that negative impact of Scenarios 54 and 62 are very marginal for both parameters. Scenario 65 shows a very large deviation for both parameters.

5.7.2 Cost benefit analysis results

Figure 5.2 show the NPV values of the different scenarios.

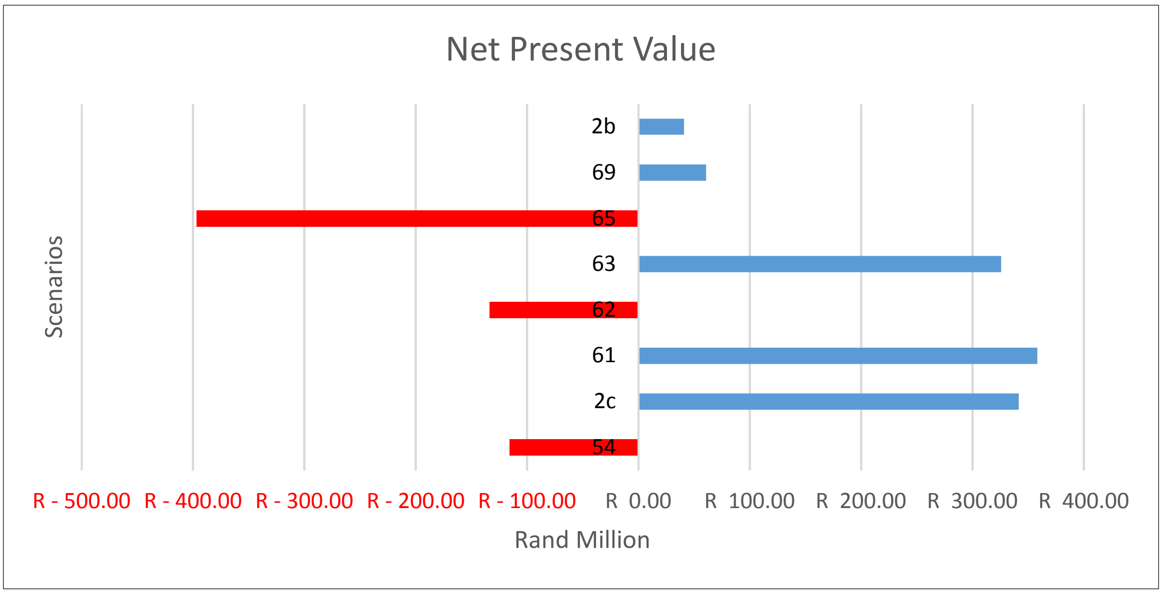


Figure 5.2 Presentation of the impact of the different scenarios on the Net Present Value

These results correspond with the GDP results of the socio-economic analysis. Scenarios 2b, 2c, 61, 63 and 69 again provide positive answers with Scenarios 54, 62 and 65 showing negative answers. Figure 5.2 also shows that the negative NPV of Scenario 65 is more than double the negative values of Scenarios 54 and 63.

5.7.3 Integration of results

The purpose of this section is to integrate the two sets of results (socio-economic and CBA).

The following is important in the final analysis of the results:

- In the interpretation of the scenarios it is important to remember that in the case of the socio-economic baseline it is a theoretical value that is used based on the multipliers calculated from the current Eastern Cape data and electricity demand in the province. It was also assumed that the electricity generated by the HEPP system will be distributed throughout the province and not only in the Transkei region.
- In the case of the CBA the tariff used is based on the Eskom buy-in tariff determined in 2014 at 76c/kWh. An inflation-adapted tariff is 80c/kWh while an Eskom-adjusted tariff by NERSA gives an answer of R1.05/kWh. For the purposes of this analysis R1.05c/kWh was used as that is the tariff applied by Eskom when negotiating with private electricity providers.
- In the case of the CBA analysis the results of the three scenarios providing a negative outcome, still show positive IRR and BCR values. It is only the NPV that provides a negative value. A very small increase in the tariff results in the NPV of Scenarios 54 and 62 turn positive. This, however, does not apply to Scenario 65.
- 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 result that the CBA results will have an important status in the final decision-making process.

Figure 5.3 compares the GDP and NPV values under the scenarios.

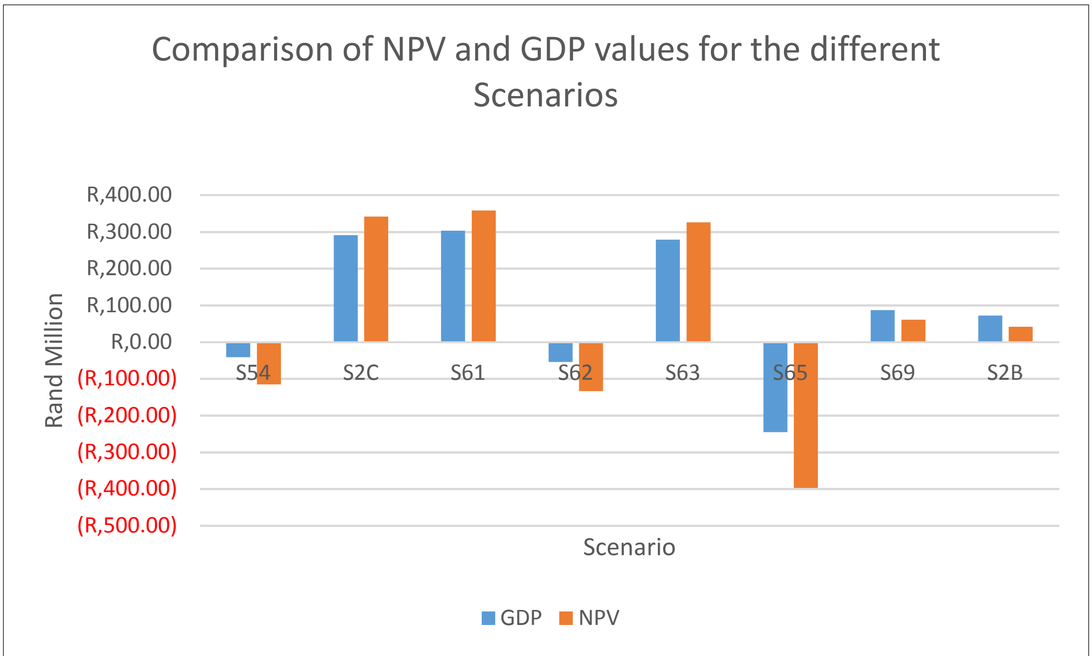


Figure 5.3 Comparison of NPV and GDP values under the different scenarios

Figure 5.3 shows that the GDP and NPV values follow the same order. In the case of Scenarios 54 and 62 the NPV negative value is marginal and in the case of an increased tariff they would become positive. However, the same does not apply to Scenario 65.

The following traffic diagrams (**Figure 5.4**) show the relationship between the GDP and NPV approaches in terms of the deviation of the two methodologies from the current economic baseline.

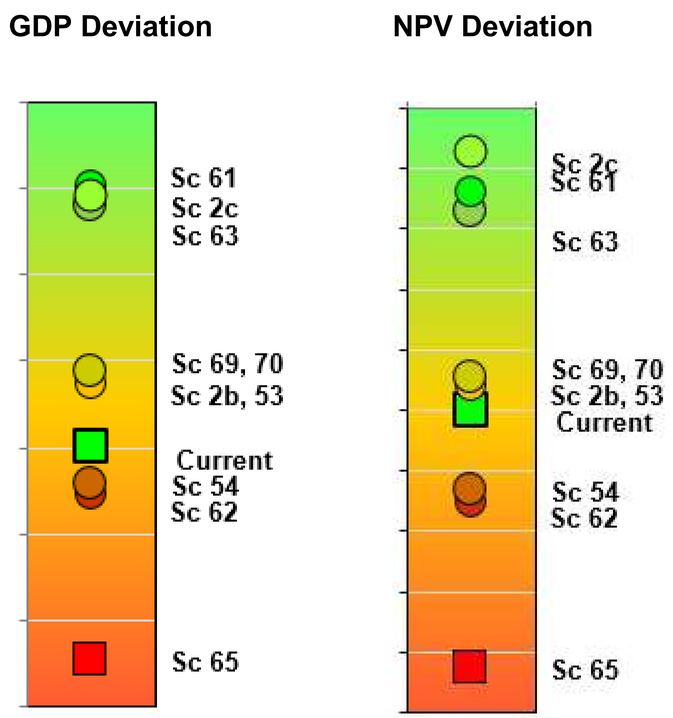


Figure 5.4 Traffic diagrams showing economic impacts under operational scenarios for the Mzimvubu catchment

5.8 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations is 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.

6 CONCLUSIONS

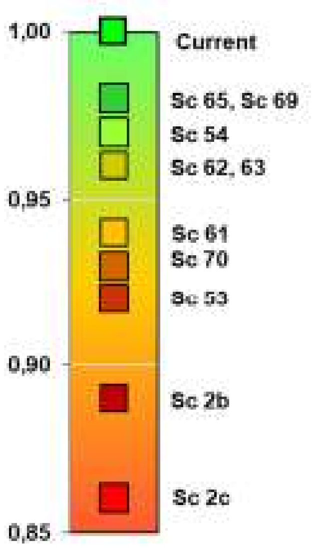
6.1 USER WATER QUALITY

No water quality pollution or protection areas were identified in the SQs potentially affected by dam building scenarios. As the EWR site, RUs and Mzimvubu Estuary potentially affected by operational scenario are all High priority RUs, ecosystem water quality requirements are the driving role player and scenario impacts were evaluated in detail and reported on in the Ecological Consequences reports for the study.

Scenario impacts on ecological water quality (i.e. the driving water quality role player) are generally negligible at the relevant sites due to the overall good state of water quality in the rivers and estuary. As most scenarios result in an improvement in water quality state, no or little negative impact is expected on user water quality under any of the operational scenarios linked to the development of Ntabelanga and Lalini dams. The only impacts are under Scenario 2b and 54 for the two Tsitsa River stretches, and Scenarios 61, 62 and 63 for the estuary. The estuary impact of Scenarios 61, 2 and 63 is due to decreases in salinity penetration, which may result in an ecological impact, but not a user water quality impact. There is a particularly negative impact on instream water quality at the two Tsitsa River sites under Scenario 2b as impacts on salts, nutrients, temperatures, oxygen levels, turbidity and toxics are significant during the dry season. More detail can be found in the Ecological Consequences Report and associated Appendix for the study, i.e. Report No. *WE/WMA7/00/CON/CLA/1117.*

6.2 ECOSYSTEM SERVICES

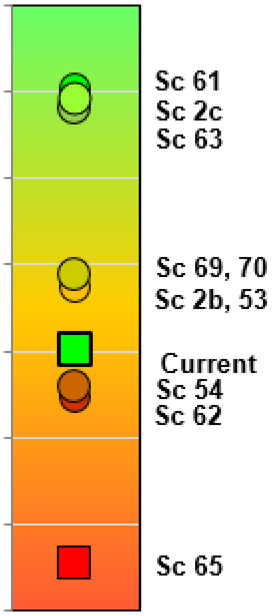
Impacts on ecosystem services were not very significant, with integrated results suggesting Sc 65 and Sc 69 showed least impact on ecosystem services, with Scenarios 54, 62 and 63 being acceptable. The integrated overall ranking of the scenarios for all three EWR sites and the Estuary is shown below.



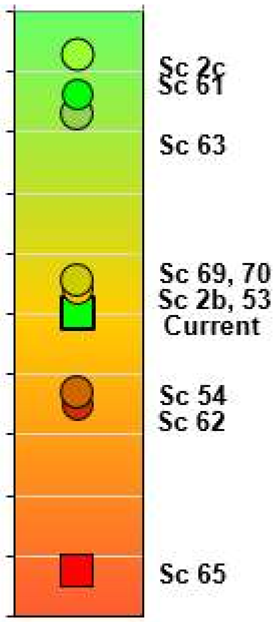
6.3 ECONOMICS

The following traffic diagrams show the relationship between the GDP and NPV approaches in terms of the deviation of the two methodologies from the current economic baseline.

GDP Deviation



NPV Deviation



The following conclusions and recommendations is 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 S65 is not viable and that S54 and S62 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 good.
- The other scenarios are acceptable from an economic viewpoint, however S70 is problematic as the possibility exists that the Tsitsa Falls can run dry.

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APPENDIX A: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment
Fiona Sephton, Joe Gqabi District Municipality – 1 March 2018				
Chapter 5; Economics	Please indicate where the cost benefit linked to the cost of water under each scenario is considered. I can see the cost of electricity generation etc. being used but no discussion on the viability of the cost of water from a particular source (of scenario). We are concerned at this stage with the development of the Nabelanga Dam, because it is so much lower than the rest of the municipal area, and DWS is indicating the municipality is to make use of this resource rather than developing other resources, that the cost of the water, coupled with the cost of pumping to high points will make it unaffordable. The area served is made up largely of indigent households and as such there is no real income generation from this water and it will serve largely as basic water. We are experiencing this concern in Sterkspruit area of Senqu where the cost of water from the DWS-owned Sterkspruit dam (Jozannashoek Dam) is the most expensive in the district but the population is mostly poor. The report is giving a perspective from the side of DWS (but I agree that your office commissioned the report) but as the Water Services Authority I would like to see the affordability of water being considered in the cost benefit scenario. I believe that as an end user the cost benefit of our ability to use the resource must be considered so that a white elephant is not created.		Yes	Note that the costs of water have been dealt with in a previous phase/study (the Feasibility Study for the MWP), which looked at the different applications of the available volume of water. The cost of water is therefore not relevant to this economic CBA, which discusses and analyses only electricity generation and the possible impact of the identified scenarios on the financial feasibility of the proposed hydro-electrical systems. Remember that the Classification study is concerned with the ecological impact of the excess water from Ntabelanga Dam. Any additional analyses around the cost of water are outside the scope of this study and directorate. A new study would have to be proposed to provide the Water Services Authority with a more suitable space in which to address their concerns. In this case the excess water actually has no value because if it is not applied in the hydro-electrical proposal it is just “stream” water.
Tovhowani Nyamande, DWS – 7 March 2018				
Sec 3.3.2; Water quality hotspots		My interest as D: SDC is water quality. As the study progreses, it will be to the advantage of the Department to include Rehabilitation or Remediation requirements for each water quality hotspots. Even if it is included on the RQOs as requirements to comply.	No	Water quality RQOs will be set for driving variables of water quality hotspots in terms of meeting the Class for the IUA in which it occurs. Compliance to these should result in a water quality improvement.

Page / Section	Report statement	Comments	Changes made?	Author comment
Sec 6.1; User water quality	No water quality pollution or protection areas were identified in the SQs potentially affected by dam building scenarios	Have you looked at the potential issue of oxygen level or saturation differences on different dam levels, which might pose as water quality issues downstream of the dam? This of course may be addressed by the way the environmental releases will be conducted.	No	The impact of dam-building on variables such as oxygen levels was evaluated for the scenarios in the Ecological Consequences Report (so for ecological water quality). Oxygen levels related to dam levels were not assessed, but rather related to water volumes and operational rules.
L Mulangaphuma, DWS Project Management Committee – 8 March 2017				
Report		Editorial comments	Yes	Addressed throughout as required.