water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WP 11004

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

SCENARIO DESCRIPTION REPORT

January 2018

Report Number: WE/WMA7/00/CON/CLA/0517

Published by

Department of Water and Sanitation
Private Bag X313
PRETORIA, 0001
Republic of South Africa

Tel: +27 (12) 336 7500
Fax: +27 (12) 323 0321

This report should be cited as:

Department of Water and Sanitation (DWS), South Africa, 2018. Determination of Water Resource Classes and Resource Quality Objectives for Water Resources in the Mzimvubu Catchment. Scenario Description Report. Authored by WRP Consulting Engineers (Pty) Ltd for Scherman Colloty and Associates cc. Report no. WE/WMA7/00/CON/CLA/0517.

Compiled by:
Scherman Colloty & Associates cc.
22 Somerset Street
Grahamstown
6139

DOCUMENT INDEX

Report name	Report number
Inception Report	WE/WMA7/00/CON/CLA/0116
Survey Report	WE/WMA7/00/CON/CLA/0216
Status Quo and (RUs and IUA) Delineation Report	WE/WMA7/00/CON/CLA/0316
River Workshop Report	WE/WMA7/00/CON/CLA/WKSP/0117
River Desktop EWR and Modelling Report: Volume 1 – Systems Modelling Volume 2 – Desktop EWR Assessment	 WE/WMA7/00/CON/CLA/0217, Volume 1 WE/WMA7/00/CON/CLA/0217, Volume 2
BHNR Report (Surface and Groundwater)	WE/WMA7/00/CON/CLA/0317
Estuary Workshop Report	WE/WMA7/00/CON/CLA/WKSP/0417
Scenario Description Report	**WE/WMA7/00/CON/CLA/0517**
River EWR Report	WE/WMA7/00/CON/CLA/0617
Estuary EWR Report	WE/WMA7/00/CON/CLA/0717
Groundwater Report	WE/WMA7/00/CON/CLA/0817
Wetland EcoClassification Report	WE/WMA7/00/CON/CLA/0917
Scenario Non-ecological Consequences Report	WE/WMA7/00/CON/CLA/1017
Ecological Consequences Report	WE/WMA7/00/CON/CLA/1117
WRC and Catchment Configuration Report	WE/WMA7/00/CON/CLA/0118
River and Estuary RQO Report	WE/WMA7/00/CON/CLA/0218
Wetlands and Groundwater RQO Report	WE/WMA7/00/CON/CLA/0317
Monitoring and Implementation Report	WE/WMA7/00/CON/CLA/0418
Water Resource Classes and RQOs Gazette Template Input	WE/WMA7/00/CON/CLA/0518
Main Report	WE/WMA7/00/CON/CLA/0618a
Close Out Report	WE/WMA7/00/CON/CLA/0618b
Issues and Response Report	WE/WMA7/00/CON/CLA/0718

Bold indicates this report

APPROVAL

TITLE:	Scenario Description Report
DATE:	January 2018
AUTHORS:	Talanda C
EDITOR:	Gowans L
REVIEWERS:	Project Management Team
LEAD CONSULTANT:	Scherman Colloty & Associates cc.
REPORT NO:	WE/WMA7/00/CON/CLA/0517
FORMAT:	MSWord and PDF
WEB ADDRESS:	http://www.dws.gov.za

Approved for Scherman Colloty & Associates cc.:

____

Dr Patsy Scherman
Study Leader

Supported by:

____

Lawrence Mulangaphuma
Project Manager

Recommended by:

____

Ms Lebogang Matlala
Director: Water Resource Classification

Approved for the Department of Water and Sanitation by:

____

Ms Ndileka Mohapi
Chief Director: Water Ecosystems

ACKNOWLEDGEMENTS

The following persons contributed to this project.

Project Management Team

Matlala, L	DWS: Water Ecosystems; Classification
Mulangaphuma, L	DWS: Water Ecosystems; Classification
Scherman, P-A	Scherman Colloty & Associates cc
Weni, E	DWS: Eastern Cape Regional Office
Botha, H	DWS: Eastern Cape Regional Office
Weston, B	DWS: Water Ecosystems; Surface Water Reserves
Neswiswi, T	DWS: Water Ecosystems; Surface Water Reserves
Kganetsi, M	DWS: Resource Protection and Waste
Molokomme, L	DWS: Water Ecosystems; Groundwater Reserves
Muthraparsad, N	DWS: Environment and Recreation
Thompson, I	DWS: Integrated Water Resource Planning
Matume, M	DWS: Stakeholder Engagement and Coordination
Cilliers, G	DWS: Resource Quality Information Services
Majola, S	DWS: Resource Quality Information Services

AUTHORS

The following persons contributed to this report:

Author	Company
Talanda, C	WRP Consulting Engineers (Pty) Ltd.

REPORT SCHEDULE

Version	Date
First draft	December 2017
Final report	January 2018

EXECUTIVE SUMMARY

BACKGROUND

This document serves to define operational scenarios and to identify scenarios for analysis, as well as the context of the scenarios and how they fit into the integrated steps of the Classification process. Possible variables that make up scenarios were identified for the Mzimvubu Catchment. These variables have been combined into different scenarios which are described in this document. The variables and scenarios are illustrated in matrices that show scenario naming and which variables are applicable to each scenario. The operational scenarios are based on flow and water quality related aspects and not on non-flow related aspects. The range of scenario and associated variables were presented and discussed with the DWS and stakeholders, and a final (representative) range selected for the purposes of modelling and scenario assessment.

SCENARIO MATRIX

Based on the information from a range of studies and various discussions with relevant authorities, operational scenarios were identified and are presented as a scenario matrix in **Chapter 2**. The matrix consists of columns which indicate the different drivers that are switched on or off for the different scenarios indicated in the rows. The descriptions of the three drivers (and their 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:** This refers 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. Note that in all cases the Recommended Ecological Category (REC) is the same as the Present Ecological State (PES). 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. 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.
- **Development options (included in all scenarios):**
    1. The Mzimvubu Water Project; comprising the following:
        - Proposed Ntabelanga Dam
        - Proposed Lalini Dam
        - Revive irrigation (T33A–T33G)
        - New municipal dams / abstractions
    2. The proposed Port St Johns 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.

- **Hydro-electric power:** Refined infrastructure design information and optimised hydropower operating rules became available from the design phase of the Mzimvubu Water Project (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.

  The hydro-electric power plants (HEPPs) are proposed 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.

CONCLUSIONS

The following conclusions are made based on the hydrological results (see **Chapter 2**) of the operational scenarios modelled and assessed:

- Scenarios 2c and 61–69 are based on the latest MWP infrastructure design information and optimised hydropower operating rules (Design phase, 2017) and are regarded as the most realistic. The operating rules are significantly different to the rules applied in the first phase of modelling of scenarios (based on the Feasibility phase information of 2014). Proposed operations are different as follows:

  - MWP (Feasibility Study, 2014): Lalini Dam is drawn down continuously and supported by Ntabelanga when the water levels reached the Dead Storage Level i.e. water is kept in Ntabelanga Dam.
  - MWP (Design Phase, 2017): Lalini Dam is operated to stay at ±75% nett storage i.e. when the dam level ≤±75% nett storage, support is provided from Ntabelanga Dam up to a minimum level to avoid failure. Lalini Dam is therefore 'kept full' for maximum head.

- An initial assessment of the scenario results showed that the large increase in baseflows in the dry winter months due to hydropower releases were unacceptable from an ecological perspective and thus needed to be reduced. Reduction scenarios were iteratively analysed until an ecologically acceptable scenario was identified. The monthly average flows identified for the two operating rule cases (Scenario 54 and Scenario 69) are very similar and the reduction in flows during the dry winter months is clearly visible when compared to their associated scenarios without the reduction i.e. Scenarios 2b and 2c respectively

It is recommended that:

- Many of the scenarios were part of an iterative process and it is thus recommended that only the following scenarios are considered during decision-making and selection of the final scenario and associated Classes (using the *Water Resource Class determination tool)*: Scenarios 2b, 2c, 54, 61, 62, 63, 65 and 69.

- The outcome of the decision analysis (recommended scenario) should be analysed and incorporated into the MWP infrastructure final design by the design team.
- The MWP catchment should be carefully monitored and controlled and upstream development should be limited as this will impact negatively on the economics of the scheme.
- The information provided in this report should be used for further assessment and decision-making, with due cognisance taken of the confidence associated with the results.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

AIP	Alien Invasive Plants
AsgiSA-EC	Accelerated and Shared Growth Initiative for South Africa-Eastern Cape
BHNR	Basic Human Needs Reserve
D/S	downstream
DWA	Department of Water Affairs (Name change applicable after April 2009)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation (Name change applicable after March 2014)
EWR(s)	Ecological Water Requirement(s)
GWh	Gigawatt hours
HEPP(s)	Hydro-electric Power Plant(s)
LM	Local Municipality
MAR	Mean Annual Runoff
MWP	Mzimvubu Water Project
OCSD	Off-channel Storage Dam
PES	Present Ecological State
RBIG	Regional Bulk Infrastructure Grant
REC	Recommended Ecological Category
RQO(s)	Resource Quality Objective(s)
Sc	Scenario
STATS SA	Statistics South Africa
ToR	Terms of Reference
U/S	upstream
WMA	Water Management Area
WRCS	Water Resource Classification System
WRYM	Water Resources Yield Model
WSS	Water Supply System
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water and Sanitation (DWS) initiated this study to determine Water Resource 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), is to undertake the following:

- Coordinate the implementation of the Water Resource Classification System (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 Resource Quality Objectives (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.

This document serves to define operational scenarios and to identify scenarios for further analysis, as well as the context of the scenarios and how they fit into the integrated steps of the WRCS process, i.e. Step 4 (**Figure 1.1**).

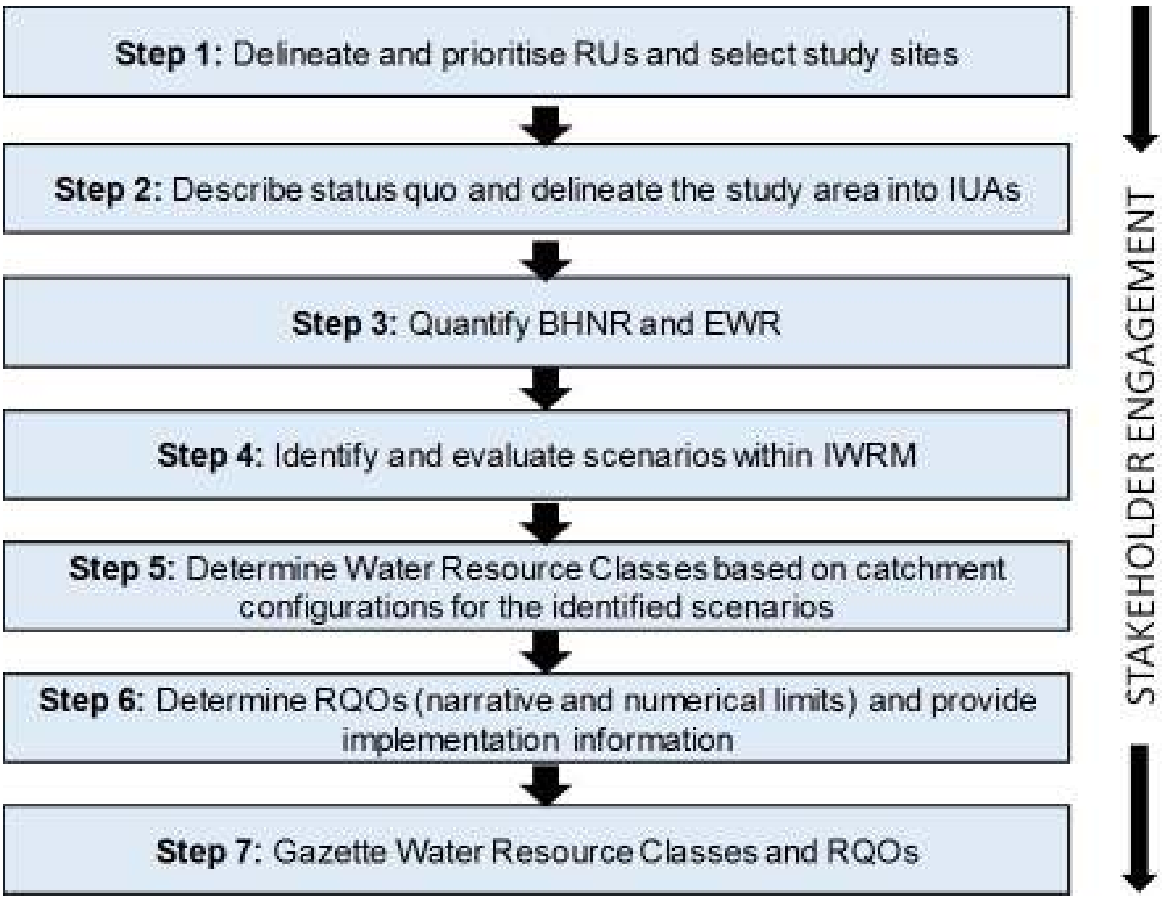

Figure 1.1 Project Plan for the Mzimvubu Classification study

1.2 STUDY AREA

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

The catchment covers more than two million hectares in the Eastern Cape and is comprised of almost 70% communal land. The Mzimvubu River system has been prioritised nationally as being one of the few remaining 'near-natural rivers' (NFEPA Assessment; Nel *et al.*, 2011), but the catchment is classified as vulnerable as a result of rapid rates of degradation in the watershed, primarily caused by erosion due to poor land management and highly erodible soils.

The WMA is relatively well endowed with water resources, with most occurring in the eastern part of the area. Of the current usage in the WMA, the most significant by far is agriculture via irrigation. The next largest use is by municipalities. No major instream dams occur along the main rivers, however the only dams of any significant size being:

- Mountain Lake Dam [Mvenyane River (T31H)],
- Crystal Springs Dam [Mzintlava River (T32C)],
- Mountain Dam [Keneka River (T33A)],
- Belfort Dam [(Mafube River (T33A)]
- Ntenetyana Dam [Ntenetyana River (T33G)],
- Ugie Dam [Wildebees River (T35F)],
- Nquadu Dam (T35K),
- Majola Dam (T36B),
- Mount Fletcher Dam (T34C),
- Maclear Dam (T35D), and
- Forest Dam (T33H).

Some remnant catchment dams exist in the Ongeluksnek valley and on the commercial farms in the margins of the Cedarville flats, but this is not a common practice in traditional farming systems (ERS/CSA, 2011). However, there are a number of instream abstraction weirs.

1.3 PURPOSE AND OUTLINE OF THIS REPORT

This document serves to define operational scenarios and to identify scenarios for analysis, as well as the context of the scenarios and how they fit into the integrated steps of the WRCS process.

A key component of the WRCS is to find the appropriate balance between protection of the ecology and using water to sustain the desired socio-economic activities that depend on the water resources. According to the WRCS guidelines this evaluation should occur in line with prevailing integrated water resource management practices that are taking place in the catchments or river systems. The approach to determine this desirable balance is therefore to identify and analyse responses to a range of different scenarios, where each scenario results in a certain level of protection and use. Generally, the higher the water use, the lower the level of protection achieved. However, these relationships are complex and opportunities to find optimal solutions are usually possible.

Scenarios, in the context of water resource management and planning are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole. The scale (resolution) of the analysis requires the aggregation of land-use effects, and therefore individual and localised small-scale developments will not significantly influence the classification of a water resource. However significant small-scale impacts on priority water resources should be managed by setting the RQOs at the specific point to protect the said water resource, especially in the case of sensitive aquatic resources.

Possible variables that make up scenarios have been identified for the Mzimvubu Catchment (**Figure 1.2**). These variables have been combined into different scenarios which are described in this document. The variables and scenarios are illustrated in matrices that show scenario naming and which variables are applicable to each scenario. The **operational scenarios** are based on **flow** and **water quality** related aspects and not on non-flow related aspects. Mitigation measures to address non-flow related aspects will be identified and will be addressed as part of the RQO identification process.

The range of scenario and associated variables were presented and discussed with the DWS and stakeholders, and a final (representative) range selected for the purposes of modelling and scenario assessment.

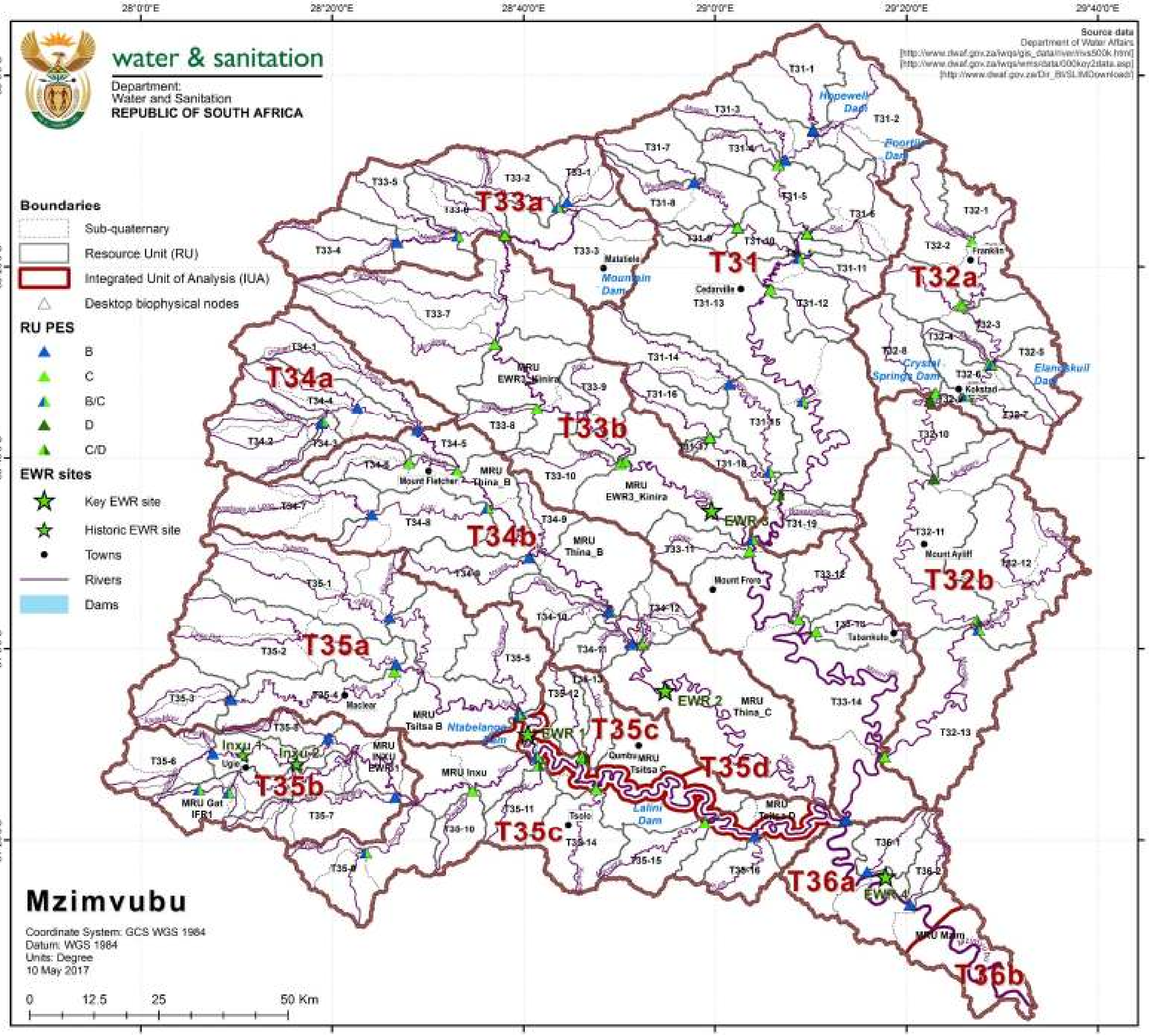

Figure 1.2 Study area; showing EWR sites, desktop nodes and proposed dams

1.4 NATURAL HYDROLOGY

The natural flow forms the baseline against which all scenarios will be assessed. The natural hydrology was sourced from the DWAF (2009) study in support of AsgiSA-EC (Accelerated and Shared Growth Initiative for South Africa-Eastern Cape), and the more recent DWS Feasibility Study for the Mzimvubu Water Project (MWP) (DWS, 2014). The selected hydrology for each of the sub-catchments is presented in **Table 1.1**.

Table 1.1 Hydrology source per catchment

Catchment	Accepted hydrology source
Mzimvubu (T31A–T31J)	(DWAF, 2009)
Mzintlava (T32A–T32H)	(DWAF, 2009)
Kinira (T33A–T33G)	(DWAF, 2009)
Tina (T34A–T34K)	(DWAF, 2009)
Tsitsa (T35A–T35M)	(DWS, 2014)
Mzimvubu (T36A–T36B)	(DWAF, 2009)

The hydrology was generally available at a quaternary level resolution and was downscaled linearly where the catchment area of the EWR study sites and biophysical nodes (defined as part of this classification study) are less than the existing catchment areas i.e., hydrological parameters scaled down in proportion to the area reduction.

The reader is referred to the *Systems Modelling Report* (Report no. WE/WMA7/00/CON/CLA/0217, Volume 1 (DWS, 2017)) for further discussion.

1.5 PRESENT DAY HYDROLOGY

The water resources models available for each of the systems was updated with the latest information available to produce the best possible estimates of present day flow. Some of the key features of the present day hydrology included updated water requirements and return flows (from the waste water treatment works (WWTW)) from the DWS's All Towns Strategies Study (DWS, 2015), municipalities or relevant previous studies.

The integrated Water Resources Yield Model (WRYM) was updated with the latest information available to produce the best possible estimates of present day flow. The WRYM was generally configured at a quaternary level, which was also downscaled where the catchment area of the EWR sites and biophysical nodes (defined as part of this classification study), was less than the quaternaries to ensure that the present day flows can be generated at these points.

The WRYM was updated with the latest catchment development or land-use information available in order to produce the best possible estimates of present day flow. The land-use components included are listed below and each of them are described in more detail in subsequent sections:

- Afforestation
- Alien invasive plants (AIP)
- Irrigation
- Urban/rural water requirements and return flows

The large dams and smaller farm dams were also included in the WRYM setup. The smaller dams were incorporated to include the effect of irrigation from farm dams, as well as the effect of multiple small dams' regulation in streamflow and loss of water by evaporation from the dam surfaces. The subsequent result is a reduction in water yield from water resource developments downstream of these dams.

The present day flows were then generated using the configured WRYM with all the catchment development information incorporated at the required resolution.

2 OPERATIONAL SCENARIOS

2.1 IDENTIFICATION OF OPERATIONAL SCENARIOS

Scenarios were identified from different sources of information and ongoing planning processes undertaken by the Department of Water and Sanitation, and municipalities. Some of the main sources of information were from discussions with DWS and municipalities as well as some of the information included but not limited to the following reports:

- DWAF (2009) Water Resource Study in support of AsgiSA-EC
- DWS (2014) Feasibility Study for the MWP
- DWS (2015) Development of Reconciliation Strategies for All Towns in the Southern Planning Region
- Ntsonyeni Ngqongweni Regional Water Supply Scheme Phase 2 and 3
- Umzimvubu and Matatiele Regional Bulk Water Supply Study
- Alfred Nzo Regional Bulk Water Supply Implementation Readiness Study
- DWS Design Phase (2017) of the MWP (van Wyk and de Jager, 2016)

Based on the information from the above studies and various discussions with relevant authorities, operational scenarios were identified and are presented as a scenario matrix (**Table 2.1**). The matrix consists of columns which indicate the different drivers that are switched on or off for the different scenarios indicated in the rows. The descriptions of the three drivers (and their 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:** This refers 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 Recommended Ecological Category (REC) is the same as the Present Ecological State (PES). 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.
- **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 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 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.
- A simplified schematic of the MWP is illustrated in **Figure 2.1**. From the figure it can be seen that hydro-electric power plants (HEPPs) are proposed 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 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 – Further reduced hydro in dry months	No	No
54	No	Yes	Low	Low	D Low	Yes – Further 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 (Increased 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

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. The economic implications of the reduction will be reported on in the Non-ecological Consequences Report.*

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

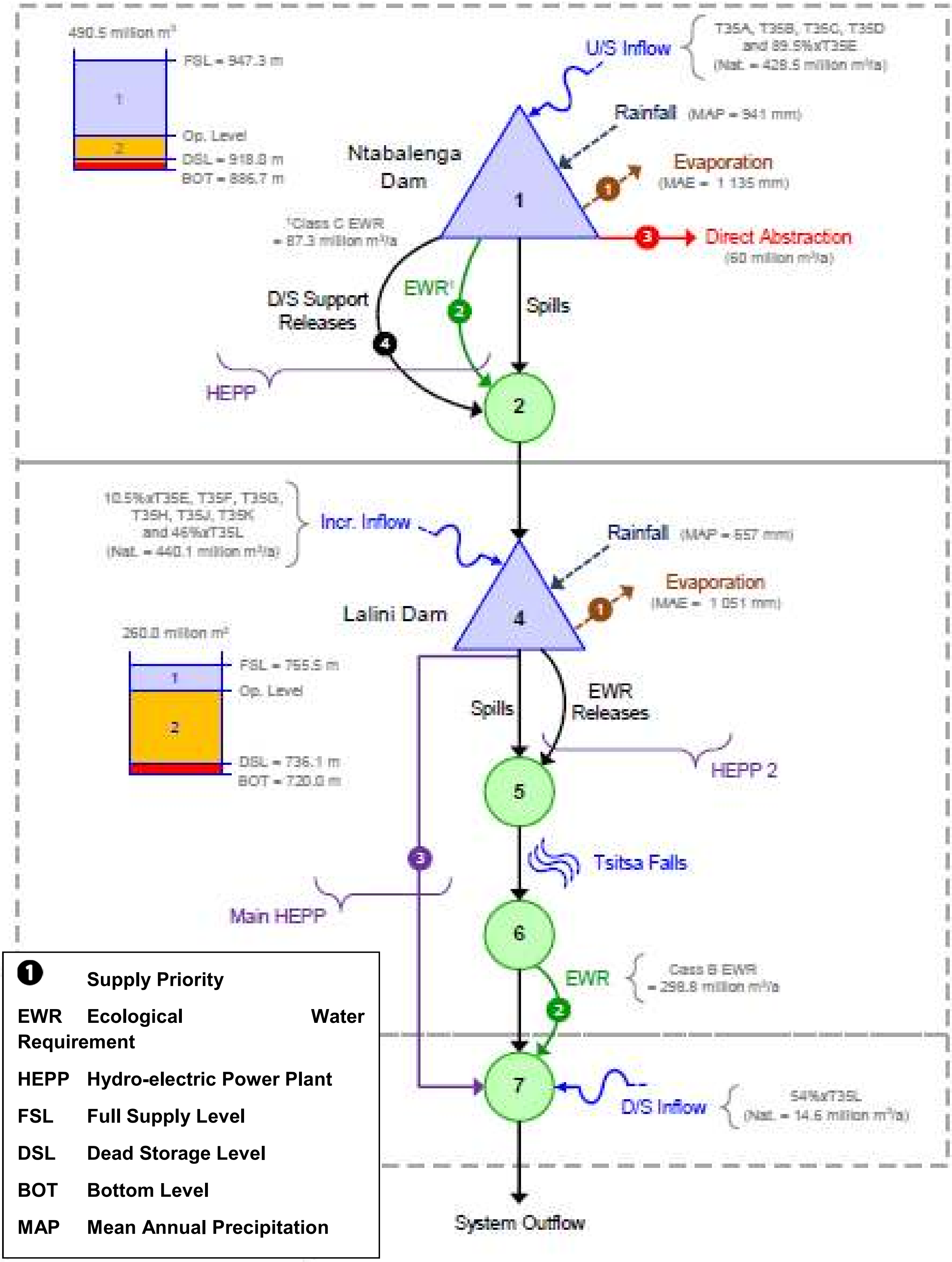

Figure 2.1 **Simplified schematic of the Mzimvubu Water Project (DWS Design Phase, 2017)**

2.2 OPERATIONAL SCENARIO DESCRIPTIONS AND RESULTS

2.2.1 Scenario 2a

Scenario 2a includes realistic estimates of increased water use and return flows for the domestic sector due to population growth and improved service delivery. Estimates for 2040 are presented in **Table 2.2**. The total domestic sector projected water use is 26.001 million m^3/a (urban: 15.276 million m^3/a; rural: 10.724 million m^3/a). The water requirement and return-flow projections were based on information sourced from the DWS All Towns study (DWS, 2015). The afforestation, alien invasive plants and irrigation water use were assumed to remain at the present day levels (presented in the *Systems Modelling Report (Volume 1)*), except for the irrigation in the T33 catchment, where it was assumed that the original irrigation that took place in the catchment (706 ha) will be revived (currently 28 ha).

Table 2.2 Projected water requirement (realistic scenario)

Quaternary	Local municipality	2040 Development level surface water use (million m^3/a)			
		Urban area	Urban	Rural	Total
T31A	Kokstad			0.002	0.002
T31B	Kokstad			0.010	0.010
T31C	Matatiele			0.136	0.136
T31D	Kokstad			0.040	0.040
T31E	Matatiele			0.133	0.133
T31F	Matatiele	Cedarville Water Supply System (WSS) (groundwater)	0	0.052	0.052
T31G	Matatiele			0.008	0.008
T31H	Matatiele Umzimvubu			0.300	0.300
T31J	Umzimvubu			0.158	0.158
Sub-total		**T31**	**0**	**0.839**	**0.839**
T32A	Kokstad			0.042	0.042
T32B	Kokstad			0.031	0.031
T32C	Kokstad	Kokstad WSS	3.783	0.069	3.852
T32D	Kokstad			0.027	0.027
T32E	Umzimvubu			0.318	0.318
T32F	Tabankulu	Mount Ayliff	2.059	0.208	2.267
T32G	Tabankulu			0.418	0.418
T32H	Tabankulu (0.5)	Flagstaff	0.451	0.346	0.797
Sub-total		**T32**	**6.293**	**1.459**	**7.752**
T33A	Matatiele	Matatiele	1.753	0.834	2.587
T33B	Matatiele			0.327	0.327
T33C	Elundini			0.150	0.150
T33D	Matatiele			0.368	0.368
T33E	Matatiele			0.148	0.148
T33F	Umzimvubu			0.218	0.218
T33G	Umzimvubu			0.276	0.276
T33H	Umzimvubu	Mount Frere and Tabankulu	2.279	0.413	2.692
T33J	Tabankulu			0.381	0.381
T33K	Mbizana			0.150	0.150
Sub-total		**T33**	**4.076**	**3.222**	**7.298**
T34A	Elundini			0.249	0.249

Quaternary	Local municipality	2040 Development level surface water use (million m^3/a)			
		Urban area	Urban	Rural	Total
T34B	Elundini			0.422	0.422
T34C	Elundini	Mount Fletcher	1.892	0.444	2.336
T34D	Elundini	Mount Fletcher	0.236	0.489	0.725
T34E	Elundini			0.000	0.000
T34F	Elundini			0.047	0.047
T34G	Elundini			0.128	0.128
T34H	Mhlontlo			0.543	0.534
T34J	Mhlontlo			0.250	0.250
T34K	Mhlontlo			0.303	0.303
Sub-total		**T34**	**2.249**	**2.745**	**4.994**
T35A	Elundini			0.087	0.087
T35B	Elundini			0.000	
T35C	Elundini	Maclear	1.057	0.000	1.057
T35D	Elundini			0.081	0.081
T35E	Elundini (0.5) Mhlontlo (0.5)			0.272	0.272
T35F	Elundini	Ugie	1.017	0.000	1.017
T35G	Elundini			0.052	0.052
T35H	Elundini (0.5) Mhlontlo (0.5)			0.286	0.286
T35J	Mhlontlo			0.177	0.177
T35K	Mhlontlo	Tsolo, Qumbu etc.	0.478	0.567	1.045
T35L	Mhlontlo (0.5)			0.318	0.318
T35M	Nyandeni (0.55) Mhlontlo (0.25)			0.190	0.190
Sub-total		**T35**	**2.634**	**1.947**	**4.582**
T36A	Nyandeni (0.45) Port St Johns (0.4) Ingquza Hill (0.15)			0.293	0.293
T36B	Port St Johns	Port St Johns	0.023	0.220	0.243
Sub-total		**T36**	**0.023**	**0.513**	**0.536**
Total			**15.276**	**10.724**	**26.001**

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

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

Raising of the Ntenetyana Dam was recommended by the RBIG Study but subsequent investigations by DWS confirmed the incremental increase in yield is minimal and the new Mkemane River Dam was recommended. It was however established that the Mkemane River

Dam supply area overlaps with the MWP supply area and was thus not included. No EWR releases were included in Scenario 2a.

The simulated average annual flows at each of the EWR sites as well as the estuary are presented in **Table 2.3.** From the results it can be seen that the average annual flows reduced as a result of the projected increase in use. There is a significant reduction in flows at the EWR1 Lalini site due to the hydropower generation through the Lalini Dam main hydropower plant, where the water used for hydropower generation is only released back into the river downstream of the Tsitsa Falls. The difference in average annual flows at MzimEWR4 and the estuary thus follow a similar reduction trend to the other EWR sites.

Table 2.3 Scenario 2a results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)		
	Natural MAR	Present day	Scenario 2a
MzimEWR1	438.043	413.164	379.860
MzimEWR2	404.512	393.224	391.020
MzimEWR3	407.086	399.297	393.186
EWR1 Lalini	887.098	830.913	314.310
MzimEWR4	2655.132	2532.213	2503.256
Mzimvubu Estuary	2737.015	2613.510	2577.341

2.2.2 Scenario 2b

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

In **Table 2.4** it can be seen that the total domestic sector projected water use is noticeably higher at 39.601million m^3/a (urban: 28.330 million m^3/a; rural: 11.271 million m^3/a).

Table 2.4 Projected water requirement (ultimate development scenario)

Quaternary	Local municipality	2040 Development level surface water use (million m^3/a)			
		Urban area	Urban	Rural	Total
T31A	Kokstad			0.003	**0.003**
T31B	Kokstad			0.017	**0.017**
T31C	Matatiele			0.162	**0.162**
T31D	Kokstad			0.067	**0.067**
T31E	Matatiele			0.158	**0.158**
T31F	Matatiele	Cedarville WSS (groundwater)	0.000	0.062	**0.062**
T31G	Matatiele			0.010	**0.010**
T31H	Matatiele Umzimvubu			0.300	**0.300**
T31J	Umzimvubu			0.158	**0.158**
Sub-total		**T31**	**0.000**	**0.937**	**0.937**
T32A	Kokstad			0.071	**0.071**
T32B	Kokstad			0.052	**0.052**

Quaternary	Local municipality	2040 Development level surface water use (million m³/a)			
		Urban area	Urban	Rural	Total
T32C	Kokstad	Kokstad WSS	7.216	0.116	**7.332**
T32D	Kokstad			0.045	**0.045**
T32E	Umzimvubu			0.318	**0.318**
T32F	Tabankulu	Mount Ayliff	3.024	0.208	**3.232**
T32G	Tabankulu			0.418	**0.418**
T32H	Tabankulu (0.5)	Flagstaff	0.451	0.346	**0.797**
Sub-total		**T32**	**10.691**	**1.575**	**12.266**
T33A	Matatiele	Matatiele + Maluti	5.089	0.843	**5.933**
T33B	Matatiele			0.331	**0.331**
T33C	Elundini			0.155	**0.155**
T33D	Matatiele			0.372	**0.372**
T33E	Matatiele			0.176	**0.176**
T33F	Umzimvubu			0.218	**0.218**
T33G	Umzimvubu	Kwa Bacha / Mount Frere	3.971	0.276	**4.247**
T33H	Umzimvubu	Mount Frere + Tabankulu	0.329	0.413	**0.742**
T33J	Tabankulu			0.381	**0.381**
T33K	Mbizana			0.244	**0.244**
Sub-total		**T33**	**9.434**	**3.366**	**12.800**
T34A	Elundini			0.256	**0.256**
T34B	Elundini			0.433	**0.433**
T34C	Elundini	Mount Fletcher	4.444	0.455	**4.899**
T34D	Elundini	Mount Fletcher	0.236	0.501	**0.738**
T34E	Elundini			0.000	**0.000**
T34F	Elundini			0.049	**0.049**
T34G	Elundini			0.133	**0.133**
T34H	Mhlontlo			0.534	**0.534**
T34J	Mhlontlo			0.250	**0.250**
T34K	Mhlontlo			0.303	**0.303**
Sub-total		**T34**	**4.801**	**2.793**	**7.594**
T35A	Elundini			0.090	**0.090**
T35B	Elundini			0.000	**0.000**
T35C	Elundini	Maclear	1.407	0.000	**1.407**
T35D	Elundini			0.084	**0.084**
T35E	Elundini (0.5) Mhlontlo (0.5)			0.272	**0.272**
T35F	Elundini	Ugie	1.413	0.000	**1.413**
T35G	Elundini			0.054	**0.054**
T35H	Elundini (0.5) Mhlontlo (0.5)			0.286	**0.286**
T35J	Mhlontlo			0.177	**0.177**
T35K	Mhlontlo	Tsolo, Qumbu etc.	0.478	0.567	**1.045**
T35L	Mhlontlo (0.5)			0.317	**0.317**
T35M	Nyandeni (0.55) Mhlontlo (0.25)			0.190	**0.190**
Sub-total		**T35**	**3.380**	**1.955**	**5.335**
T36A	Nyandeni (0.45) Port St Johns (0.4) Ingquza Hill (0.15)			0.374	**0.374**
T36B	Port St Johns	Port St Johns	0.023	0.271	**0.294**

Quaternary	Local municipality	2040 Development level surface water use (million m³/a)			
		Urban area	Urban	Rural	Total
Sub-total		**T36**	**0.023**	**0.645**	**0.668**
Total			**28.330**	**11.271**	**39.601**

The simulated average annual flows at each of the EWR sites as well as the estuary are presented in **Table 2.5**. It can be seen that the average annual flows are slightly more reduced than for Sc 2a as a result of the projected increase in use.

The difference in realistic (Scenario 2a) and ultimate development (Scenario 2b) water requirement projections does not influence any other users in the catchment apart from the Mzimvubu Water Project (hydropower projection). The MWP Feasibility Study of 2014, as well as the design phase of the project (2017), both made use of the ultimate development projection (domestic water supplied from the scheme). The realistic water projection is lower and will thus make water available for hydropower and/or the environment. Based on the above, the ultimate development scenario was applied in all the further scenarios analysed (and is consistent with the other studies).

Table 2.5 Scenario 2b results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m³/a)			
	Natural MAR	Present day MAR	Scenario 2a	Scenario 2b
MzimEWR1	438.043	413.164	379.860	353.95
MzimEWR2	404.512	393.224	391.020	391.02
MzimEWR3	407.086	399.297	393.186	387.83
EWR1 Lalini	887.098	830.913	314.310	314.98
MzimEWR4	2655.132	2532.213	2503.256	2465.30
Mzimvubu Estuary	2737.015	2613.510	2577.341	2536.76

2.2.3 Scenario 2c

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

- Scenarios 2a and 2b: Lalini Dam was drawn down continuously and supported by Ntabelanga Dam when the water levels reached the dead storage level i.e. the water is held in the upper Ntabelanga Dam. A variable release pattern was applied for generating hydropower at the Main HEPP.
- Scenario 2c: Lalini Dam operated at ±75% nett storage in order to try to maintain a constant maximum capacity flow at the Main HEPP i.e., when the dam level was at ±75% nett storage, support is provided from Ntabelanga Dam up to a minimum in Ntabelanga Dam to avoid failure, i.e. Lalini Dam is 'kept full' for maximum head.

The simulated average annual flows at each of the EWR sites as well as the estuary are presented in **Table 2.6**. MzimEWR2 (Thina River) and MzimEWR3 (Kinira River) sites are not affected by changes in the MWP hydropower operating rules and the flows at these sites thus remain unchanged. The average annual flows at MzimEWR1 are higher due to the increased support releases from Ntabelanga Dam to maintain Lalini Dam at the required operating levels. The EWR1

Lalini site flows are noticeably less as a result of larger volumes supplied through the Main HEPP. The Main HEPP water is again returned to the river downstream of the Tsitsa Falls and hence the average flows at MzimEWR4 and the estuary are similar. A comparison of the hydropower energy production results (mean, 50th (P50) and 90th percentiles (P90)) are presented in **Table 2.7** where the larger hydropower energy production at Ntabelanga HEPP 1 and Lalini Main HEPP can be seen. Note that Lalini HEPP 2 was not installed for any scenarios as all excluded EWR releases.

Table 2.6 Scenario 2c results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m³/a)				
	Natural MAR	Present day MAR	Scenario 2a	Scenario 2b	Scenario 2c
MzimEWR1	438.043	413.164	379.860	353.95	355.82
MzimEWR2	404.512	393.224	391.020	391.02	391.02
MzimEWR3	407.086	399.297	393.186	387.83	387.83
EWR1 Lalini	887.098	830.913	314.310	314.98	286.67
MzimEWR4	2655.132	2532.213	2503.256	2465.30	2465.99
Mzimvubu Estuary	2737.015	2613.510	2577.341	2536.76	2537.46

Table 2.7 Hydropower energy production results

Hydropower station	Parameter	Energy (GWh/month)	
		Scenario 2b	Scenario 2c
Ntabelanga HEPP 1	P90	12.6	16.0
	P50	19.1	25.2
	MEAN	19.3	24.4
Lalini Main HEPP	P90	342.5	390.8
	P50	360.3	393.6
	MEAN	356.9	391.0
Lalini HEPP 2 (EWR)	P90	0.0	0.0
	P50	0.0	0.0
	MEAN	0.0	0.0
Total	**P90**	**355.1**	**406.8**
Total	**P50**	**379.4**	**418.8**
Total	**MEAN**	**376.2**	**415.4**

2.2.4 Scenarios 32 and 33

These scenarios are the same as Scenario 2b but include releases for EWRs at EWR1 Lalini and MzimEWR4 as follows:

- **Sc 32:** Total EWRs
- **Sc 33:** Low flow EWRs

The scenarios did not include EWRs at MzimEWR1 (unrealistic) and was for testing purposes only. The purpose of these scenarios was to determine to what degree the total flow and low flow EWRs together with the dam spills, hydropower generation (Mzimvubu Water Project) and tributary inflows etc. would achieve the REC.

2.2.5 Scenarios 41 and 42

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

- **Sc 41:** MzimEWR1 (low) and MzimEWR4 (low) only
- **Sc 42:** MzimEWR1 (low), EWR1 Lalini (low) and MzimEWR4 (low)

The simulated average annual flows at each of the EWR sites as well as the estuary are presented in **Table 2.8**. From the results it can be seen that the flows at EWR1 Lalini are significantly higher for Scenario 42 due to the additional EWR releases. The additional EWR releases from Lalini Dam result in a reduction in hydropower through the Main HEPP but additional flows over the Tsitsa Falls. The Main HEPP water is again returned to the river downstream of the Tsitsa Falls and hence the average flows at MzimEWR4 and the estuary are similar.

Scenario analysis is an iterative process and the hydropower energy production was only calculated for the base scenarios (Scenarios 2b and 2c) and for the relevant optimised scenarios presented further in this report.

Table 2.8 Scenarios 41 and 42 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)				
	Natural MAR	Present day MAR	Scenario 2b	Scenario 41	Scenario 42
MzimEWR1	438.043	413.164	353.950	354.124	354.129
MzimEWR2	404.512	393.224	391.020	391.020	391.020
MzimEWR3	407.086	399.297	387.828	387.828	387.828
EWR1 Lalini	887.098	830.913	314.977	314.936	408.023
MzimEWR4	2655.132	2532.213	2465.296	2465.255	2465.698
Mzimvubu Estuary	2737.015	2613.510	2536.762	2536.724	2537.169

2.2.6 Scenarios 51 and 52

Scenario 51 and Scenario 52 are based on Scenario 41 and Scenario 42 respectively, but with the hydropower generation reduced in the dry winter months. The purpose of the scenario was to decrease the dry winter flows at MzimEWR4 and especially the estuary, as it could be seen that the previous modelled scenarios would provide unnaturally high and constant baseflows; impacting negatively on the ecology. The hydropower generation was increased by a similar amount in the wet summer months.

From the simulated average annual flows at each of the EWR sites and estuary in **Table 2.9**, it can be seen that the average flows at MzimEWR4 and the estuary are very similar to the equivalent Series 4 scenario, but the seasonal distribution varied. The slightly reduced flows at EWR1 Lalini are due to the reduced spills from Lalini Dam in the wet summer months as a result of the increased hydropower generation.

Table 2.9 Scenarios 51 and 52 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)					
	Present day MAR	Scenario 2b	Scenario 41	Scenario 42	Scenario 51	Scenario 52
MzimEWR1	413.164	353.950	354.124	354.129	354.125	354.134
MzimEWR2	393.224	391.020	391.020	391.020	391.020	391.020
MzimEWR3	399.297	387.828	387.828	387.828	387.828	387.828
EWR1 Lalini	830.913	314.977	314.936	408.023	312.975	402.091
MzimEWR4	2532.213	2465.296	2465.255	2465.698	2465.181	2465.504
Mzimvubu Estuary	2613.510	2536.762	2536.724	2537.169	2536.649	2536.976

2.2.7 Scenarios 53 and 54

Scenario 53 and Scenario 54 are based on Scenario 51 and Scenario 52 respectively, but with the hydropower generation further reduced in the dry winter months. Initial analysis of Scenarios 51 and 52 showed that the increase in baseflows due to hydropower releases are still unacceptable from an ecological perspective and thus needed to be reduced further.

The simulated average annual flows at each of the EWR sites as well as the estuary are presented **in Table 2.10**. Initial investigations showed that Scenario 53 is likely to achieve the ecological objectives. However, it included no flows for the reach immediately downstream of the proposed Lalini Dam and as the Tsitsa Falls may dry frequently, resulting in a social and environmental flaw. To test the economic implications, a D category low flow EWR was released from Lalini Dam. This would ensure flow over the falls at all times, but would drop the Ecological Category in the reach and may have additional (to Scenario 53) economic impacts. The flow to be provided in the reach downstream of Lalini Dam could be further adjusted, but further optimisation will depend on the outcome of the economic analysis.

Table 2.10 Scenarios 53 and 54 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)						
	Present day MAR	Scenario 41	Scenario 42	Scenario 51	Scenario 52	Scenario 53	Scenario 54
MzimEWR1	413.164	354.124	354.129	354.125	354.134	354.161	354.157
MzimEWR2	393.224	391.020	391.020	391.020	391.020	391.020	391.020
MzimEWR3	399.297	387.828	387.828	387.828	387.828	387.828	387.828
EWR1 Lalini	830.913	314.936	408.023	312.975	402.091	294.626	354.892
MzimEWR4	2532.213	2465.255	2465.698	2465.181	2465.504	2464.631	2465.108
Mzimvubu Estuary	2613.510	2536.724	2537.169	2536.649	2536.976	2536.099	2536.576

2.2.8 Scenario 61

Scenario 61 includes the latest MWP infrastructure design information and optimised hydropower operating rules from the 2017 design phase of the project, as received from the design team (see **Section 2.1**). The hydropower operating rules are significantly different to the rules applied in the previous scenarios, which influences the flows at the EWR sites (**Section 2.2.3**).

The simulated average annual flows at each of the EWR sites as well as the estuary are presented **in Table 2.11**. MzimEWR2 and MzimEWR3 sites are not affected by changes in the MWP hydropower operating rules and the flows at these sites thus remain unchanged. The average annual flows at MzimEWR1 are slightly higher than Scenario 54 due to the increased support releases from Ntabelanga Dam to maintain Lalini Dam at the required operating levels. The flows at the EWR1 Lalini site are noticeably less as a result of larger volumes supplied through the Main HEPP. The Main HEPP water is again returned to the river downstream of the Tsitsa Falls and hence the average flows at MzimEWR4 and the estuary are similar (slightly higher). A comparison of the hydropower energy production results (mean, 50th and 90th percentiles) are presented in **Table 2.12**. The larger hydropower energy production at Ntabelanga HEPP 1 and Lalini Main HEPP is as a result of the optimised hydropower scheme and operating rules. Note that Lalini HEPP 2 hydropower production is also slightly higher than under Scenario 54, despite the lower flows through Lalini HEPP 2 (EWR1 Lalini). This is due to the change in operating rules resulting in greater storage levels/head in Lalini Dam, which is operated at a minimum of ±75% for maximum head.

Table 2.11 Scenario 61 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)				
	Present day MAR	Scenario 2b	Scenario 2c	Scenario 54	Scenario 61
MzimEWR1	413.164	353.95	355.82	354.157	357.208
MzimEWR2	393.224	391.02	391.02	391.020	391.020
MzimEWR3	399.297	387.83	387.83	387.828	387.828
EWR1 Lalini	830.913	314.98	286.67	354.892	296.531
MzimEWR4	2532.213	2465.30	2465.99	2465.108	2467.668
Mzimvubu Estuary	2613.510	2536.76	2537.46	2536.576	2539.136

Table 2.12 Hydropower energy production results

Hydropower station	Energy (GWh/month)				
	Parameter	Scenario 2b	Scenario 2c	Scenario 54	Scenario 61
Ntabelanga HEPP 1	P90	12.582	16.041	13.225	17.075
	P50	19.096	25.199	19.485	26.919
	MEAN	19.343	24.355	19.477	25.572
Lalini Main HEPP	P90	342.545	390.755	314.475	384.202
	P50	360.334	393.636	330.942	392.543
	MEAN	356.876	391.009	327.425	382.638
Lalini HEPP 2	P90	0.000	0.000	1.846	1.872
	P50	0.000	0.000	8.446	9.463
	MEAN	0.000	0.000	8.879	9.332
Total	**P90**	**355.127**	**406.796**	**329.545**	**403.149**
Total	**P50**	**379.430**	**418.835**	**358.873**	**428.925**
Total	**MEAN**	**376.219**	**415.364**	**355.780**	**417.542**

2.2.9 Scenarios 62 and 65

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

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 unacceptable from an ecological perspective and were thus reduced further.

The simulated average annual flows at each of the EWR sites as well as the estuary are presented **in Table 2.13**Table 2.11. The average annual flows at MzimEWR1, MzimEWR4 and the estuary for Scenarios 62 and 65 are slightly lower than Scenario 61 as a result of the reduced flows in the dry winter months, while the summer month flows were maintained at the infrastructure design capacities. The reduced dry winter flows also resulted in a reduced overall hydropower energy production (**Table 2.14).**

Table 2.13 Scenarios 62 and 65 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)						
	Present day MAR	Scenario 2b	Scenario 2c	Scenario 54	Scenario 61	Scenario 62	Scenario 65
MzimEWR1	413.164	353.95	355.82	354.157	357.208	354.820	354.274
MzimEWR2	393.224	391.02	391.02	391.020	391.020	391.020	391.020
MzimEWR3	399.297	387.83	387.83	387.828	387.828	387.828	387.828
EWR1 Lalini	830.913	314.98	286.67	354.892	296.531	378.331	418.378
MzimEWR4	2532.213	2465.30	2465.99	2465.108	2467.668	2464.873	2464.059
Mzimvubu Estuary	2613.510	2536.76	2537.46	2536.576	2539.136	2536.332	2535.526

Table 2.14 Hydropower energy production results

Hydropower station	Energy (GWh/month)						
	Parameter	Scenario 2b	Scenario 2c	Scenario 54	Scenario 61	Scenario 62	Scenario 65
Ntabelanga HEPP 1	P90	12.582	16.041	13.225	17.075	18.590	15.984
	P50	19.096	25.199	19.485	26.919	23.804	21.727
	MEAN	19.343	24.355	19.477	25.572	23.913	21.751
Lalini Main HEPP	P90	342.545	390.755	314.475	384.202	317.562	285.175
	P50	360.334	393.636	330.942	392.543	320.226	287.905
	MEAN	356.876	391.009	327.425	382.638	319.845	287.646
Lalini HEPP 2	P90	0.000	0.000	1.846	1.872	2.247	2.308
	P50	0.000	0.000	8.446	9.463	9.704	9.946
	MEAN	0.000	0.000	8.879	9.332	9.659	9.774
Total	**P90**	**355.127**	**406.796**	**329.545**	**403.149**	**338.399**	**303.468**

Hydropower station	Energy (GWh/month)						
	Parameter	**Scenario 2b**	**Scenario 2c**	**Scenario 54**	**Scenario 61**	**Scenario 62**	**Scenario 65**
Total	**P50**	**379.430**	**418.835**	**358.873**	**428.925**	**353.734**	**319.578**
Total	**MEAN**	**376.219**	**415.364**	**355.780**	**417.542**	**353.417**	**319.171**

2.2.10 Scenarios 63 and 69

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

The Scenarios 63 and 69 simulated average annual flows at each of the EWR sites as well as the estuary, are presented in **Table 2.15**Table 2.11. The average annual flows at MzimEWR1, MzimEWR4 and the estuary are slightly higher than the respective Scenarios 62 and 65 as a result of the increased hydropower generation design capacity with the associated increased hydropower releases in the wet summer months. This also resulted in an increased overall hydropower energy production (**Table 2.16).**

Table 2.15 Scenarios 63 and 69 results

Site	Average annual flow for indicated operational scenarios: 1920–2004 (million m^3/a)						
	Present day MAR	**Scenario 54**	**Scenario 61**	**Scenario 62**	**Scenario 65**	**Scenario 63**	**Scenario 69**
MzimEWR1	413.164	354.157	357.208	354.820	354.274	355.697	354.723
MzimEWR2	393.224	391.020	391.020	391.020	391.020	391.020	391.020
MzimEWR3	399.297	387.828	387.828	387.828	387.828	387.828	387.828
EWR1 Lalini	830.913	354.892	296.531	378.331	418.378	292.766	333.259
MzimEWR4	2532.213	2465.108	2467.668	2464.873	2464.059	2466.054	2464.869
Mzimvubu Estuary	2613.510	2536.576	2539.136	2536.332	2535.526	2537.512	2536.336

Table 2.16 Hydropower energy production results

Hydropower station	Parameter	Energy (GWh/month)							
		Scenario 2b	Scenario 2c	Scenario 54	Scenario 61	Scenario 62	Scenario 65	Scenario 63	Scenario 69
Ntabelanga HEPP 1	P90	12.582	16.041	13.225	17.075	18.590	15.984	18.038	16.582
	P50	19.096	25.199	19.485	26.919	23.804	21.727	25.399	23.448
	MEAN	19.343	24.355	19.477	25.572	23.913	21.751	24.522	22.625
Lalini Main HEPP	P90	342.545	390.755	314.475	384.202	317.562	285.175	382.029	345.620
	P50	360.334	393.636	330.942	392.543	320.226	287.905	386.610	348.839
	MEAN	356.876	391.009	327.425	382.638	319.845	287.646	379.450	346.676
Lalini HEPP 2	P90	0.000	0.000	1.846	1.872	2.247	2.308	2.023	2.201
	P50	0.000	0.000	8.446	9.463	9.704	9.946	9.412	9.402
	MEAN	0.000	0.000	8.879	9.332	9.659	9.774	9.320	9.503
Total	**P90**	**355.127**	**406.796**	**329.545**	**403.149**	**338.399**	**303.468**	**402.090**	**364.403**
Total	**P50**	**379.430**	**418.835**	**358.873**	**428.925**	**353.734**	**319.578**	**421.421**	**381.689**
Total	**MEAN**	**376.219**	**415.364**	**355.780**	**417.542**	**353.417**	**319.171**	**413.292**	**378.803**

2.2.11 Estuary team only: Proposed Port St Johns WWTW

Due to the uncertainties linked to the development and location of the proposed new Port St Johns WWTW, a simple approach was followed for this scenario assessment by the estuary team. The Environmental Impact Assessment for the WWTW was undertaken during 2017, with one of the four possible sites potentially impacting on the estuary by entering the estuary via a small tributary outside the Estuary Functional Zone. The estuary team therefore followed a simple approach and assessed the impact of additional flows from the WWTW entering the estuary on top of present day flows. The capacity of the WWTW will be 3.5 ML/day. Over the next 30 years this would increase to 4.5 ML/day. Discharge will be treated to DWS General Standards. Scenarios are therefore referred to as PresW1, i.e. Present river inflow, including 3.5ML per day WWTW inflow, and PresW2, Present river inflow, including 4.5ML per day WWTW inflow. Results are reported on in the EWR Estuary (*Report No. WE/WMA7/00/CON/CLA/0717*) and Ecological Consequences (*Report No. WE/WMA7/00/CON/CLA/1117*) reports for the study.

3 SUMMARY AND CONCLUSIONS

A summary of the simulated average annual flows at each of the EWR sites for each of the scenarios is presented in **Table 3.1**. (Refer to **Table A.1** in **Appendix A** for the simulated average annual flows at all the biophysical nodes and EWR sites).

The hydropower generation results for each of the scenarios are summarised in **Table 3.2** and the seasonal variations are illustrated in **Figure 3.1** (the monthly hydropower generation results are presented in **Table A.2** in **Appendix A**). It must be noted that the hydropower generation was calculated at a level of accuracy suitable for scenario comparison purposes within the Classification process and should be treated as such.

The following conclusions are made based on the results of the operational scenarios presented above and discussed in more detail in **Chapter 2**:

- Scenarios 2c and 61–69 are based on the latest MWP infrastructure design information and optimised hydropower operating rules and are regarded as the most realistic. The operating rules are significantly different to the rules applied in the prior scenarios.
- An initial assessment of the scenario results showed that the large increase in baseflows in the dry winter months due to hydropower releases were unacceptable from an ecological perspective and thus needed to be reduced. Reduction scenarios were iteratively analysed until an ecologically acceptable scenario was identified. The monthly average flows identified for the two operating rule cases (Scenario 54 and Scenario 69) are very similar (**Figure 3.1**) and the reduction in flows during the dry winter months is clearly visible when compared to their associated scenarios without the reduction i.e. Scenarios 2b and 2c respectively

It is recommended that:

- Many of the scenarios were part of an iterative process and it is thus recommended that only the following scenarios are considered during decision-making and selection of the final scenario and associated Classes (using the *Water Resource Class determination tool)*: Scenarios 2b, 2c, 54, 61, 62, 63, 65 and 69.
- The outcome of the decision analysis (recommended scenario) should be analysed and incorporated into the MWP infrastructure final design by the design team.
- The MWP catchment should be carefully monitored and controlled and upstream development should be limited as this will impact negatively on the economics of the scheme.
- The information provided in this report should be used for further assessment and decision-making, with due cognisance taken of the confidence associated with the results.

Table 3.1 Scenario analysis results

Mean Annual Flows (million m^3/a)																		
Site	Natural	Present day	Sc 2a	Sc 2b	Sc 2c	Sc 32	Sc 33	Sc 41	Sc 42	Sc 51	Sc 52	Sc 53	Sc 54	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
MzimEWR1	438	413	380	354	356	354	354	354	354	354	354	354	354	357	355	356	354	355
MzimEWR2	405	393	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391	391
MzimEWR3	407	399	393	388	388	388	388	388	388	388	388	388	388	388	388	388	388	388
EWR1 Lalini	887	831	314	315	287	426	408	315	408	313	402	295	355	297	378	293	418	333
MzimEWR4	2655	2532	2503	2465	2466	2466	2466	2465	2466	2465	2466	2465	2465	2468	2465	2466	2464	2465
Mzimvubu Estuary	2737	2614	2577	2537	2537	2537	2537	2537	2537	2537	2537	2536	2537	2539	2536	2538	2536	2536

Table 3.2 Hydropower analysis results

Hydropower station	Energy (GWh/month)								
	Parameter	Sc 2b	Sc 2c	Sc 54	Sc 61	Sc 62	Sc 65	Sc 63	Sc 69
Ntabelanga HEPP 1	P90	12.582	16.041	13.225	17.075	18.590	15.984	18.038	16.582
	P50	19.096	25.199	19.485	26.919	23.804	21.727	25.399	23.448
	MEAN	19.343	24.355	19.477	25.572	23.913	21.751	24.522	22.625
Lalini Main HEPP	P90	342.545	390.755	314.475	384.202	317.562	285.175	382.029	345.620
	P50	360.334	393.636	330.942	392.543	320.226	287.905	386.610	348.839
	MEAN	356.876	391.009	327.425	382.638	319.845	287.646	379.450	346.676
Lalini HEPP 2	P90	0.000	0.000	1.846	1.872	2.247	2.308	2.023	2.201
	P50	0.000	0.000	8.446	9.463	9.704	9.946	9.412	9.402
	MEAN	0.000	0.000	8.879	9.332	9.659	9.774	9.320	9.503
Total	**P90**	**355.127**	**406.796**	**329.545**	**403.149**	**338.399**	**303.468**	**402.090**	**364.403**
Total	**P50**	**379.430**	**418.835**	**358.873**	**428.925**	**353.734**	**319.578**	**421.421**	**381.689**
Total	**MEAN**	**376.219**	**415.364**	**355.780**	**417.542**	**353.417**	**319.171**	**413.292**	**378.803**

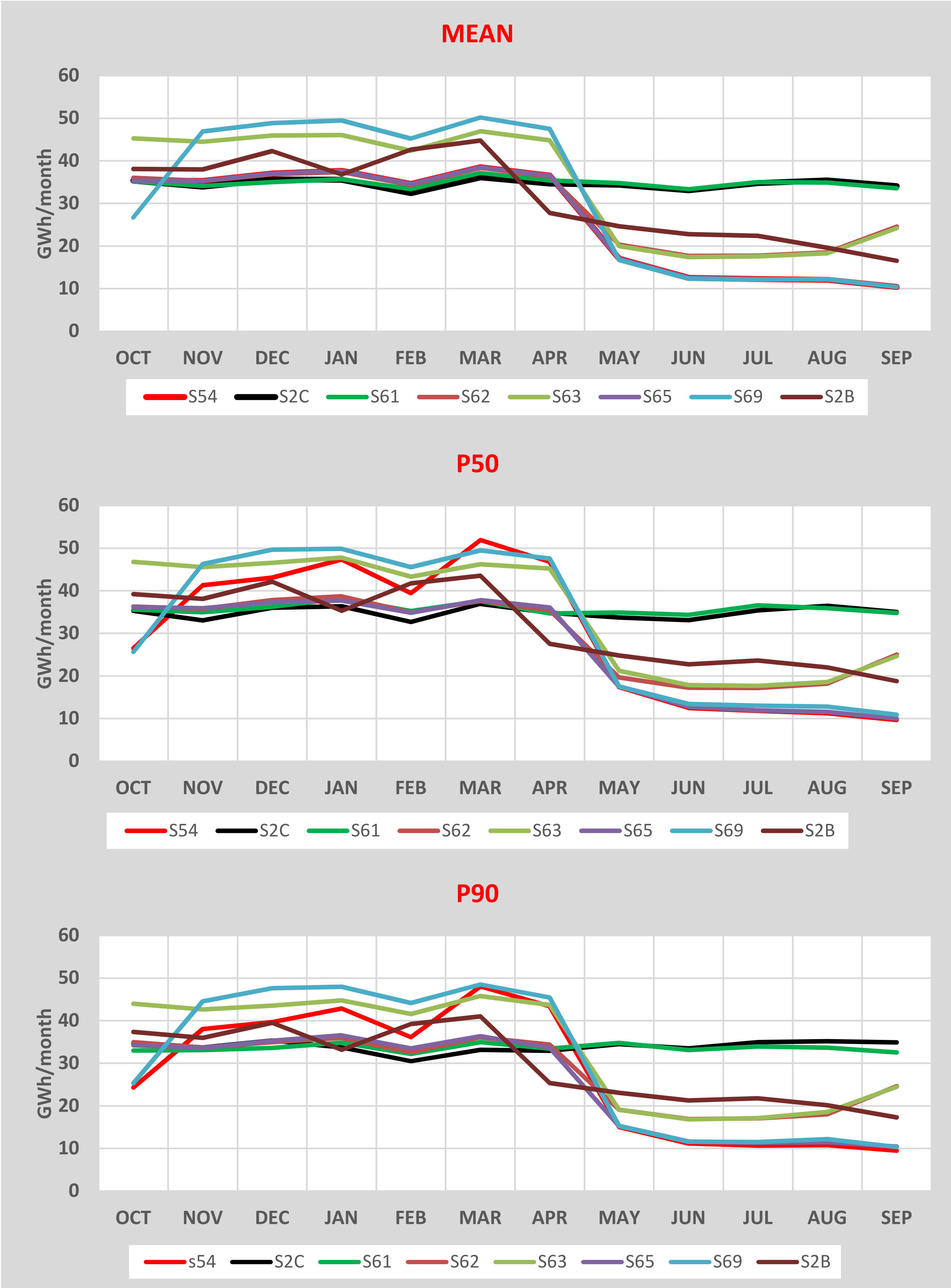

Figure 3.1 Hydropower analysis results

4 REFERENCES

Department of Water Affairs and Forestry (DWAF), South Africa. 2009. DWAF Water Resource Study in Support of the ASGISA EC Mzimvubu Development Project. Prepared by BKS (Pty) Ltd. For: DWS Directorate: National Water Resources Planning. Report No: P WMA 12/000/00/3609, Pretoria, South Africa.

Statistics South Africa (STATS SA), 2012. Census. 2011. Published by Statistics South Africa, Pretoria, 2012.

Department of Water and Sanitation (DWS), South Africa. 2014. Feasibility Study for the Mzimvubu Water Project: Water Resources. Prepared by Jeffares & Green (Pty) Ltd. For: DWS Directorate: Options Analysis. Report No: P WMA 12/T30/00/5212/5, Pretoria, South Africa.

Department of Water and Sanitation (DWS), South Africa. 2015. Development of Reconciliation Strategies for All Towns in the Southern Planning Region. Prepared by Umvoto. For: DWS Directorate: National Water Resources Planning, Pretoria, South Africa.

Department of Water and Sanitation (DWS), South Africa, 2017. Determination of Water Resource Classes and Resource Quality Objectives for Water Resources in the Mzimvubu Catchment. River Desktop EWR and Modelling Report: Volume 1 – Systems Modelling. Compiled by WRP Consulting Engineers (Pty) Ltd for Scherman Colloty and Associates cc. Report no. WE/WMA7/00/CON/CLA/0217, Volume 1

Environmental and Rural Solutions – Conservation South Africa (ERS/CSA). 2011. Umzimvubu overview. December 2011, Draft 2.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L., and Nienaber, S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas Project. WRC Report No. 1801/2/11.

Van Wyk, R.S.J., and de Jager, F.G.B. 2016. Mzimvubu Water Project Hydropower Energy Optimization Report. Draft Report No. 60494564-1 prepared by AECOM for Pro-Plan Consulting Engineers.

APPENDIX A: ANALYSIS RESULTS

Table A.1 Scenario analysis results (Simulated average annual flows at EWR sites and biophysical nodes)

	Mean Annual Flows (million m^3/a)																	
Site	**Natural**	**Present day MAR**	**Sc 2a**	**Sc 2b**	**Sc 2c**	**Sc 32**	**Sc 33**	**Sc 41**	**Sc 42**	**Sc 51**	**Sc 52**	**Sc 53**	**Sc 54**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
MzimEWR1	438.043	413.164	379.860	353.95	355.82	353.99	353.96	354.12	354.13	354.125	354.134	354.161	354.157	357.208	354.820	355.697	354.274	354.723
MzimEWR2	404.512	393.224	391.020	391.02	391.02	391.02	391.02	391.02	391.02	391.020	391.020	391.020	391.020	391.020	391.020	391.020	391.020	391.020
MzimEWR3	407.086	399.297	393.186	387.83	387.83	387.83	387.83	387.83	387.83	387.828	387.828	387.828	387.828	387.828	387.828	387.828	387.828	387.828
EWR1 Lalini	887.098	830.913	314.310	314.98	286.67	426.11	407.97	314.94	408.02	312.975	402.091	294.626	354.892	296.531	378.331	292.766	418.378	333.259
MzimEWR4	2655.132	2532.213	2503.256	2465.30	2465.99	2465.88	2465.75	2465.26	2465.70	2465.181	2465.504	2464.631	2465.108	2467.668	2464.873	2466.054	2464.059	2464.869
T31_1	32.730	31.253	31.253	31.25	31.25	31.25	31.25	31.25	31.25	31.253	31.253	31.253	31.253	31.253	31.253	31.253	31.253	31.253
T31_2	31.326	29.946	29.914	29.91	29.91	29.91	29.91	29.91	29.91	29.914	29.914	29.914	29.914	29.914	29.914	29.914	29.914	29.914
T31_3	87.007	83.510	83.543	83.54	83.54	83.54	83.54	83.54	83.54	83.543	83.543	83.543	83.543	83.543	83.543	83.543	83.543	83.543
T31_4	8.925	8.830	8.925	8.93	8.93	8.93	8.93	8.93	8.93	8.925	8.925	8.925	8.925	8.925	8.925	8.925	8.925	8.925
T31_5	104.920	100.320	100.414	100.41	100.41	100.41	100.41	100.41	100.41	100.414	100.414	100.414	100.414	100.414	100.414	100.414	100.414	100.414
T31_6	13.980	11.927	11.927	11.93	11.93	11.93	11.93	11.93	11.93	11.927	11.927	11.927	11.927	11.927	11.927	11.927	11.927	11.927
T31_7	12.776	12.712	12.776	12.78	12.78	12.78	12.78	12.78	12.78	12.776	12.776	12.776	12.776	12.776	12.776	12.776	12.776	12.776
T31_8	29.543	27.727	27.853	27.85	27.85	27.85	27.85	27.85	27.85	27.853	27.853	27.853	27.853	27.853	27.853	27.853	27.853	27.853
T31_9	3.992	3.969	3.969	3.97	3.97	3.97	3.97	3.97	3.97	3.969	3.969	3.969	3.969	3.969	3.969	3.969	3.969	3.969
T31_11	3.704	3.422	3.422	3.42	3.42	3.42	3.42	3.42	3.42	3.422	3.422	3.422	3.422	3.422	3.422	3.422	3.422	3.422
T31_12	190.452	178.256	178.539	178.54	178.54	178.54	178.54	178.54	178.54	178.539	178.539	178.539	178.539	178.539	178.539	178.539	178.539	178.539
T31_13	217.808	204.879	205.161	205.16	205.16	205.16	205.16	205.16	205.16	205.161	205.161	205.161	205.161	205.161	205.161	205.161	205.161	205.161
T31_14	23.979	21.436	21.451	21.45	21.45	21.45	21.45	21.45	21.45	21.451	21.451	21.451	21.451	21.451	21.451	21.451	21.451	21.451
T31_15	40.830	37.948	37.962	37.96	37.96	37.96	37.96	37.96	37.96	37.962	37.962	37.962	37.962	37.962	37.962	37.962	37.962	37.962
T31_16	13.610	13.484	13.610	13.61	13.61	13.61	13.61	13.61	13.61	13.610	13.610	13.610	13.610	13.610	13.610	13.610	13.610	13.610
T31_17	1.296	1.296	1.296	1.30	1.30	1.30	1.30	1.30	1.30	1.296	1.296	1.296	1.296	1.296	1.296	1.296	1.296	1.296
T31_18	64.809	61.800	61.942	61.94	61.94	61.94	61.94	61.94	61.94	61.942	61.942	61.942	61.942	61.942	61.942	61.942	61.942	61.942
T31_19	335.658	316.544	316.968	316.97	316.97	316.97	316.97	316.97	316.97	316.968	316.968	316.968	316.968	316.968	316.968	316.968	316.968	316.968
T32_1	9.461	8.774	8.775	8.78	8.78	8.78	8.78	8.78	8.78	8.775	8.775	8.775	8.775	8.775	8.775	8.775	8.775	8.775
T32_2	37.596	31.926	31.926	31.93	31.93	31.93	31.93	31.93	31.93	31.926	31.926	31.926	31.926	31.926	31.926	31.926	31.926	31.926
T32_3	11.078	10.743	10.743	10.74	10.74	10.74	10.74	10.74	10.74	10.743	10.743	10.743	10.743	10.743	10.743	10.743	10.743	10.743
T32_4	4.264	4.118	4.118	4.12	4.12	4.12	4.12	4.12	4.12	4.118	4.118	4.118	4.118	4.118	4.118	4.118	4.118	4.118
T32_5	13.857	13.144	13.145	13.14	13.14	13.14	13.14	13.14	13.14	13.145	13.145	13.145	13.145	13.145	13.145	13.145	13.145	13.145
T32_6	86.162	75.383	71.525	71.52	71.52	71.52	71.52	71.52	71.52	71.525	71.525	71.525	71.525	71.525	71.525	71.525	71.525	71.525
T32_7	8.528	8.175	8.175	8.17	8.17	8.17	8.17	8.17	8.17	8.175	8.175	8.175	8.175	8.175	8.175	8.175	8.175	8.175
T32_8	18.430	16.633	16.632	16.63	16.63	16.63	16.63	16.63	16.63	16.632	16.632	16.632	16.632	16.632	16.632	16.632	16.632	16.632
T32_9	98.138	88.082	85.600	85.60	85.60	85.60	85.60	85.60	85.60	85.600	85.600	85.600	85.600	85.600	85.600	85.600	85.600	85.600
T32_10	134.489	120.438	117.945	117.94	117.94	117.94	117.94	117.94	117.94	117.945	117.945	117.945	117.945	117.945	117.945	117.945	117.945	117.945
T32_11	223.242	205.324	201.326	200.94	200.94	200.94	200.94	200.94	200.94	200.937	200.937	200.937	200.937	200.937	200.937	200.937	200.937	200.937
T32_12	57.164	55.404	55.404	55.40	55.40	55.40	55.40	55.40	55.40	55.404	55.404	55.404	55.404	55.404	55.404	55.404	55.404	55.404
T32_13	348.860	326.941	322.943	322.55	322.55	322.55	322.55	322.55	322.55	322.554	322.554	322.554	322.554	322.554	322.554	322.554	322.554	322.554
T33_1	20.448	19.599	19.662	19.66	19.66	19.66	19.66	19.66	19.66	19.662	19.662	19.662	19.662	19.662	19.662	19.662	19.662	19.662
T33_2	26.290	26.158	20.077	14.72	14.72	14.72	14.72	14.72	14.72	14.719	14.719	14.719	14.719	14.719	14.719	14.719	14.719	14.719
T33_3	97.371	94.751	89.474	84.12	84.12	84.12	84.12	84.12	84.12	84.116	84.116	84.116	84.116	84.116	84.116	84.116	84.116	84.116

Mean Annual Flows (million m³/a)																		
Site	**Natural**	**Present day MAR**	**Sc 2a**	**Sc 2b**	**Sc 2c**	**Sc 32**	**Sc 33**	**Sc 41**	**Sc 42**	**Sc 51**	**Sc 52**	**Sc 53**	**Sc 54**	**Sc 61**	**Sc 62**	**Sc 63**	**Sc 65**	**Sc 69**
T33_4	33.938	33.875	33.938	33.94	33.94	33.94	33.94	33.94	33.94	33.938	33.938	33.938	33.938	33.938	33.938	33.938	33.938	33.938
T33_5	69.761	69.374	69.469	69.47	69.47	69.47	69.47	69.47	69.47	69.469	69.469	69.469	69.469	69.469	69.469	69.469	69.469	69.469
T33_6	94.272	93.663	93.431	93.43	93.43	93.43	93.43	93.43	93.43	93.431	93.431	93.431	93.431	93.431	93.431	93.431	93.431	93.431
T33_7	302.962	296.359	290.826	285.47	285.47	285.47	285.47	285.47	285.47	285.468	285.468	285.468	285.468	285.468	285.468	285.468	285.468	285.468
T33_8	6.163	6.131	6.163	6.16	6.16	6.16	6.16	6.16	6.16	6.163	6.163	6.163	6.163	6.163	6.163	6.163	6.163	6.163
T33_9	368.318	360.768	354.532	349.17	349.17	349.17	349.17	349.17	349.17	349.174	349.174	349.174	349.174	349.174	349.174	349.174	349.174	349.174
T33_10	15.569	15.148	15.148	15.15	15.15	15.15	15.15	15.15	15.15	15.148	15.148	15.148	15.148	15.148	15.148	15.148	15.148	15.148
T33_11	14.014	12.063	12.039	12.04	12.04	12.04	12.04	12.04	12.04	12.039	12.039	12.039	12.039	12.039	12.039	12.039	12.039	12.039
T33_12	17.052	16.894	17.052	17.05	17.05	17.05	17.05	17.05	17.05	17.052	17.052	17.052	17.052	17.052	17.052	17.052	17.052	17.052
T33_13	9.217	8.625	9.018	9.02	9.02	9.02	9.02	9.02	9.02	9.018	9.018	9.018	9.018	9.018	9.018	9.018	9.018	9.018
T34_1	33.579	33.478	33.478	33.48	33.48	33.48	33.48	33.48	33.48	33.478	33.478	33.478	33.478	33.478	33.478	33.478	33.478	33.478
T34_2	32.909	32.643	32.643	32.64	32.64	32.64	32.64	32.64	32.64	32.643	32.643	32.643	32.643	32.643	32.643	32.643	32.643	32.643
T34_3	41.136	40.887	40.887	40.89	40.89	40.89	40.89	40.89	40.89	40.887	40.887	40.887	40.887	40.887	40.887	40.887	40.887	40.887
T34_4	68.062	67.393	67.393	67.39	67.39	67.39	67.39	67.39	67.39	67.393	67.393	67.393	67.393	67.393	67.393	67.393	67.393	67.393
T34_5	123.477	120.058	117.474	117.47	117.47	117.47	117.47	117.47	117.47	117.474	117.474	117.474	117.474	117.474	117.474	117.474	117.474	117.474
T34_6	20.347	20.204	20.204	20.20	20.20	20.20	20.20	20.20	20.20	20.204	20.204	20.204	20.204	20.204	20.204	20.204	20.204	20.204
T34_7	45.203	44.381	44.382	44.38	44.38	44.38	44.38	44.38	44.38	44.382	44.382	44.382	44.382	44.382	44.382	44.382	44.382	44.382
T34_8	84.700	83.316	83.316	83.32	83.32	83.32	83.32	83.32	83.32	83.316	83.316	83.316	83.316	83.316	83.316	83.316	83.316	83.316
T34_9	27.127	22.545	22.545	22.54	22.54	22.54	22.54	22.54	22.54	22.545	22.545	22.545	22.545	22.545	22.545	22.545	22.545	22.545
T34_10	20.074	18.961	18.962	18.96	18.96	18.96	18.96	18.96	18.96	18.962	18.962	18.962	18.962	18.962	18.962	18.962	18.962	18.962
T34_11	11.862	11.296	11.423	11.42	11.42	11.42	11.42	11.42	11.42	11.423	11.423	11.423	11.423	11.423	11.423	11.423	11.423	11.423
T34_12	18.249	17.132	17.132	17.13	17.13	17.13	17.13	17.13	17.13	17.132	17.132	17.132	17.132	17.132	17.132	17.132	17.132	17.132
T35_1	101.144	97.599	97.599	97.60	97.60	97.60	97.60	97.60	97.60	97.599	97.599	97.599	97.599	97.599	97.599	97.599	97.599	97.599
T35_2	79.710	78.364	78.460	78.46	78.46	78.46	78.46	78.46	78.46	78.460	78.460	78.460	78.460	78.460	78.460	78.460	78.460	78.460
T35_3	63.686	61.519	61.520	61.52	61.52	61.52	61.52	61.52	61.52	61.520	61.520	61.520	61.520	61.520	61.520	61.520	61.520	61.520
T35_4	127.569	111.923	111.923	111.92	111.92	111.92	111.92	111.92	111.92	111.923	111.923	111.923	111.923	111.923	111.923	111.923	111.923	111.923
T35_5	46.087	43.895	43.990	43.99	43.99	43.99	43.99	43.99	43.99	43.990	43.990	43.990	43.990	43.990	43.990	43.990	43.990	43.990
T35_6	37.608	33.709	33.709	33.71	33.71	33.71	33.71	33.71	33.71	33.709	33.709	33.709	33.709	33.709	33.709	33.709	33.709	33.709
T35_7	26.147	24.018	24.017	24.02	24.02	24.02	24.02	24.02	24.02	24.017	24.017	24.017	24.017	24.017	24.017	24.017	24.017	24.017
T35_8	14.291	9.674	9.674	9.67	9.67	9.67	9.67	9.67	9.67	9.674	9.674	9.674	9.674	9.674	9.674	9.674	9.674	9.674
Inxu1	44.377	39.415	42.377	36.18	36.18	36.18	36.18	36.18	36.18	36.185	36.185	36.185	36.185	36.185	36.185	36.185	36.185	36.185
Inxu2	57.164	49.712	52.736	46.54	46.54	46.54	46.54	46.54	46.54	46.544	46.544	46.544	46.544	46.544	46.544	46.544	46.544	46.544
GAT1	2.905	1.509	1.509	1.51	1.51	1.51	1.51	1.51	1.51	1.509	1.509	1.509	1.509	1.509	1.509	1.509	1.509	1.509
GAT2	10.895	8.148	8.148	8.15	8.15	8.15	8.15	8.15	8.15	8.148	8.148	8.148	8.148	8.148	8.148	8.148	8.148	8.148
T35_9	35.059	34.431	34.431	34.43	34.43	34.43	34.43	34.43	34.43	34.431	34.431	34.431	34.431	34.431	34.431	34.431	34.431	34.431
T35_10	19.867	19.725	19.725	19.72	19.72	19.72	19.72	19.72	19.72	19.725	19.725	19.725	19.725	19.725	19.725	19.725	19.725	19.725
T35_11	29.757	29.182	31.141	31.14	31.14	31.14	31.14	31.14	31.14	31.141	31.141	31.141	31.141	31.141	31.141	31.141	31.141	31.141
T35_12	18.120	17.572	17.635	17.63	17.63	17.63	17.63	17.63	17.63	17.635	17.635	17.635	17.635	17.635	17.635	17.635	17.635	17.635
T35_13	14.722	14.253	14.317	14.32	14.32	14.32	14.32	14.32	14.32	14.317	14.317	14.317	14.317	14.317	14.317	14.317	14.317	14.317
T35_14	36.240	33.383	54.312	54.31	54.31	54.31	54.31	54.31	54.31	54.312	54.312	54.312	54.312	54.312	54.312	54.312	54.312	54.312
T35_15	10.193	10.066	10.192	10.19	10.19	10.19	10.19	10.19	10.19	10.192	10.192	10.192	10.192	10.192	10.192	10.192	10.192	10.192
T35_16	13.520	13.520	13.520	13.52	13.52	13.52	13.52	13.52	13.52	13.520	13.520	13.520	13.520	13.520	13.520	13.520	13.520	13.520
T36_1	14.343	14.246	14.246	14.25	14.25	14.25	14.25	14.25	14.25	14.246	14.246	14.246	14.246	14.246	14.246	14.246	14.246	14.246

Mean Annual Flows (million m³/a)																		
Site	Natural	Present day MAR	Sc 2a	Sc 2b	Sc 2c	Sc 32	Sc 33	Sc 41	Sc 42	Sc 51	Sc 52	Sc 53	Sc 54	Sc 61	Sc 62	Sc 63	Sc 65	Sc 69
T36_2	9.779	9.716	9.716	9.72	9.GW72	9.72	9.72	9.72	9.72	9.716	9.716	9.716	9.716	9.716	9.716	9.716	9.716	9.716
Mzimvubu Estuary	2737.015	2613.510	2577.341	2536.76	2537.46	2537.35	2537.22	2536.72	2537.17	2536.649	2536.976	2536.099	2536.576	2539.136	2536.332	2537.512	2535.526	2536.336

Table A.2 Hydropower analysis results

SCENARIO 2B														
Hydropower station	Energy (GWh/month)													Energy (GWh/a)
	Parameter	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Ntabalenga HEPP 1	P90	1.279	1.184	1.205	0.494	0.728	0.893	1.263	0.700	0.300	1.070	1.846	1.620	12.582
	P50	1.941	1.797	1.829	0.749	1.105	1.356	1.917	1.062	0.455	1.624	2.802	2.459	19.096
	MEAN	0.897	1.750	2.371	2.799	2.592	3.097	2.477	1.137	0.655	0.588	0.489	0.491	19.343
Lalini Main HEPP	P90	36.110	34.806	38.271	32.671	38.504	40.111	24.092	22.348	21.002	20.684	18.285	15.661	342.545
	P50	37.273	36.288	40.295	34.528	40.605	42.166	25.628	23.732	22.302	21.979	19.217	16.322	360.334
	MEAN	37.198	36.208	39.909	34.014	40.016	41.662	25.304	23.499	22.118	21.811	19.098	16.038	356.876
Lalini HEPP 2	P90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	P50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MEAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	**P90**	**37.389**	**35.990**	**39.476**	**33.164**	**39.232**	**41.004**	**25.355**	**23.048**	**21.301**	**21.754**	**20.132**	**17.281**	**355.127**
Total	**P50**	**39.215**	**38.084**	**42.124**	**35.278**	**41.710**	**43.522**	**27.545**	**24.794**	**22.757**	**23.602**	**22.019**	**18.781**	**379.430**
Total	**MEAN**	**38.095**	**37.958**	**42.280**	**36.813**	**42.609**	**44.759**	**27.780**	**24.636**	**22.773**	**22.399**	**19.588**	**16.528**	**376.219**

SCENARIO 54														
Hydropower station	Energy (GWh/month)													Energy (GWh/a)
	Parameter	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Ntabalenga HEPP 1	P90	0.633	0.222	0.970	1.473	3.170	3.254	2.178	0.756	0.357	0.112	0.000	0.099	13.225
	P50	1.468	1.780	2.473	3.145	2.663	3.120	2.956	1.225	0.286	0.282	0.087	0.000	19.485
	MEAN	0.879	1.664	2.344	2.756	2.635	3.197	2.529	1.153	0.684	0.617	0.500	0.518	19.477
Lalini Main HEPP	P90	23.516	37.467	38.716	41.147	32.636	44.792	41.064	14.106	10.722	10.566	10.648	9.094	314.475
	P50	24.636	39.151	40.340	43.249	34.447	47.715	43.559	14.852	11.276	11.095	11.150	9.474	330.942
	MEAN	24.397	38.833	40.144	42.700	33.886	47.039	43.071	14.718	11.172	10.994	11.064	9.408	327.425
Lalini HEPP 2	P90	0.144	0.348	0.000	0.227	0.298	0.000	0.139	0.184	0.088	0.000	0.139	0.278	1.846
	P50	0.430	0.363	0.251	0.969	2.309	1.054	0.268	1.273	0.918	0.402	0.000	0.208	8.446
	MEAN	0.311	0.578	0.692	1.076	1.272	1.675	1.325	0.755	0.430	0.329	0.211	0.227	8.879
Total	**P90**	**24.293**	**38.037**	**39.686**	**42.848**	**36.103**	**48.046**	**43.381**	**15.046**	**11.167**	**10.678**	**10.788**	**9.471**	**329.545**
Total	**P50**	**26.534**	**41.293**	**43.064**	**47.363**	**39.420**	**51.889**	**46.782**	**17.350**	**12.480**	**11.779**	**11.237**	**9.682**	**358.873**
Total	**MEAN**	**25.587**	**41.075**	**43.180**	**46.532**	**37.793**	**51.911**	**46.924**	**16.625**	**12.287**	**11.940**	**11.775**	**10.152**	**355.780**

SCENARIO 2C														
Hydropower station	Energy (GWh/month)													Energy (GWh/a)
	Parameter	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Ntabalenga HEPP 1	P90	1.354	1.606	2.170	0.536	0.279	0.000	0.833	1.327	1.391	1.770	1.988	2.787	16.041
	P50	2.093	0.940	2.799	2.855	1.885	3.112	2.142	0.155	0.871	2.198	3.286	2.864	25.199
	MEAN	2.147	1.777	2.261	2.339	1.986	2.484	2.145	1.109	1.117	2.096	2.570	2.324	24.355
Lalini Main HEPP	P90	33.165	32.095	33.165	33.165	30.223	33.165	32.095	33.165	32.095	33.165	33.165	32.095	390.755
	P50	33.203	32.132	33.203	33.486	30.790	33.816	32.725	33.538	32.206	33.203	33.203	32.132	393.636
	MEAN	33.187	32.192	33.345	33.237	30.453	33.622	32.508	33.260	31.985	32.661	32.813	31.747	391.009
Lalini HEPP 2	P90	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	P50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MEAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	**P90**	**34.519**	**33.700**	**35.335**	**33.701**	**30.501**	**33.165**	**32.928**	**34.492**	**33.486**	**34.934**	**35.153**	**34.882**	**406.796**
Total	**P50**	**35.296**	**33.072**	**36.002**	**36.341**	**32.675**	**36.928**	**34.867**	**33.693**	**33.077**	**35.401**	**36.489**	**34.996**	**418.835**
Total	**MEAN**	**35.334**	**33.969**	**35.606**	**35.576**	**32.439**	**36.106**	**34.653**	**34.368**	**33.102**	**34.757**	**35.382**	**34.071**	**415.364**

SCENARIO 61														
Hydropower station	Energy (GWh/month)													Energy (GWh/a)
	Parameter	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Ntabalenga HEPP 1	P90	0.843	1.734	1.469	2.150	1.959	1.972	1.345	1.360	1.156	1.146	0.998	0.942	17.075
	P50	1.895	2.007	1.949	2.807	2.795	2.906	1.838	1.023	1.761	3.040	2.532	2.366	26.919
	MEAN	2.242	1.991	2.093	2.364	2.151	2.508	2.138	1.477	1.749	2.466	2.385	2.007	25.572
Lalini Main HEPP	P90	32.049	31.175	32.154	32.471	29.988	32.990	31.926	32.989	31.925	32.815	32.507	31.214	384.202
	P50	33.204	32.133	33.204	33.204	30.504	33.761	32.509	33.352	32.133	33.204	33.204	32.133	392.543
	MEAN	32.595	31.532	32.224	32.142	29.888	32.890	31.850	32.480	31.175	32.223	32.318	31.323	382.638
Lalini HEPP 2	P90	0.119	0.186	0.000	0.197	0.244	0.000	0.194	0.433	0.000	0.000	0.135	0.364	1.872
	P50	0.464	0.792	1.063	2.165	1.929	0.923	0.321	0.545	0.443	0.355	0.165	0.298	9.463
	MEAN	0.326	0.605	0.720	1.150	1.339	1.777	1.410	0.804	0.437	0.332	0.201	0.231	9.332
Total	**P90**	**33.011**	**33.094**	**33.623**	**34.818**	**32.190**	**34.962**	**33.466**	**34.783**	**33.081**	**33.962**	**33.640**	**32.521**	**403.149**
Total	**P50**	**35.563**	**34.932**	**36.216**	**38.176**	**35.228**	**37.590**	**34.667**	**34.920**	**34.336**	**36.599**	**35.900**	**34.796**	**428.925**
Total	**MEAN**	**35.162**	**34.128**	**35.037**	**35.656**	**33.378**	**37.176**	**35.398**	**34.761**	**33.360**	**35.021**	**34.903**	**33.562**	**417.542**

SCENARIO 62														
Hydropower station		**Energy (GWh/month)**												**Energy (GWh/a)**
	Parameter	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	
Ntabalenga HEPP 1	P90	1.592	1.209	1.793	2.604	2.101	2.915	2.105	0.755	0.452	0.640	0.772	1.652	18.590
	P50	2.633	2.597	3.142	3.151	2.421	3.198	2.439	0.622	0.293	0.401	0.840	2.066	23.804
	MEAN	2.453	2.407	2.736	2.759	2.434	2.929	2.395	1.213	0.805	0.901	1.173	1.709	23.913
Lalini Main HEPP	P90	33.167	32.097	33.167	33.167	30.225	33.168	32.098	18.085	16.308	16.426	17.064	22.591	317.562
	P50	33.217	32.145	33.217	33.389	30.709	33.823	32.648	18.321	16.469	16.546	17.117	22.625	320.226
	MEAN	33.227	32.228	33.378	33.434	30.547	33.622	32.487	18.259	16.428	16.510	17.125	22.599	319.845
Lalini HEPP 2	P90	0.194	0.398	0.000	0.196	0.260	0.000	0.190	0.232	0.161	0.000	0.197	0.419	2.247
	P50	0.425	0.975	1.476	2.157	1.795	0.599	0.294	0.678	0.493	0.244	0.219	0.349	9.704
	MEAN	0.352	0.630	0.748	1.185	1.365	1.806	1.435	0.839	0.472	0.353	0.220	0.254	9.659
Total	**P90**	**34.953**	**33.704**	**34.960**	**35.968**	**32.586**	**36.083**	**34.393**	**19.071**	**16.922**	**17.065**	**18.033**	**24.661**	**338.399**
Total	**P50**	**36.275**	**35.717**	**37.835**	**38.697**	**34.925**	**37.620**	**35.381**	**19.622**	**17.255**	**17.191**	**18.176**	**25.040**	**353.734**
Total	**MEAN**	**36.031**	**35.265**	**36.862**	**37.378**	**34.347**	**38.357**	**36.317**	**20.310**	**17.706**	**17.764**	**18.517**	**24.562**	**353.417**

SCENARIO 63														
Hydropower station		**Energy (GWh/month)**												**Energy (GWh/a)**
	Parameter	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	
Ntabalenga HEPP 1	P90	1.326	1.581	1.408	2.358	2.168	2.423	1.695	0.825	0.490	0.700	1.362	1.704	18.038
	P50	3.156	2.968	3.105	3.138	2.743	2.319	2.719	1.568	0.351	0.622	1.072	1.638	25.399
	MEAN	2.346	2.418	2.575	2.746	2.370	2.672	2.404	1.434	1.153	1.315	1.383	1.707	24.522
Lalini Main HEPP	P90	42.531	40.929	42.128	42.243	39.017	43.072	41.648	18.108	16.330	16.447	17.087	22.489	382.029
	P50	43.073	41.702	43.092	43.094	39.447	43.592	41.924	18.163	16.342	16.455	17.095	22.632	386.610
	MEAN	42.577	41.461	42.664	42.187	38.645	42.509	41.010	17.758	15.812	15.907	16.706	22.214	379.450
Lalini HEPP 2	P90	0.123	0.140	0.000	0.152	0.359	0.289	0.357	0.183	0.000	0.000	0.120	0.300	2.023
	P50	0.581	0.856	0.376	1.552	1.120	0.329	0.573	1.501	1.157	0.595	0.405	0.367	9.412
	MEAN	0.339	0.606	0.715	1.139	1.321	1.756	1.383	0.808	0.447	0.344	0.214	0.250	9.320
Total	**P90**	**43.980**	**42.650**	**43.535**	**44.753**	**41.544**	**45.784**	**43.700**	**19.116**	**16.819**	**17.148**	**18.569**	**24.493**	**402.090**
Total	**P50**	**46.810**	**45.525**	**46.573**	**47.783**	**43.310**	**46.240**	**45.217**	**21.232**	**17.850**	**17.672**	**18.572**	**24.637**	**421.421**
Total	**MEAN**	**45.261**	**44.484**	**45.955**	**46.072**	**42.335**	**46.936**	**44.797**	**19.999**	**17.411**	**17.567**	**18.303**	**24.171**	**413.292**

SCENARIO 65														
Hydropower station	**Energy (GWh/month)**													**Energy (GWh/a)**
	Parameter	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	
Ntabalenga HEPP 1	P90	0.862	1.374	2.121	3.213	2.895	2.874	1.181	0.302	0.219	0.215	0.097	0.632	15.984
	P50	2.305	2.709	2.686	2.717	2.962	3.258	2.752	1.435	0.568	0.204	0.073	0.055	21.727
	MEAN	1.650	2.357	2.884	2.955	2.625	3.056	2.566	1.176	0.700	0.656	0.563	0.564	21.751
Lalini Main HEPP	P90	33.194	32.124	33.195	33.195	30.250	33.195	32.124	14.815	11.259	11.117	11.203	9.504	285.175
	P50	33.240	32.148	33.336	33.462	30.747	33.797	32.668	15.024	11.394	11.228	11.290	9.572	287.905
	MEAN	33.318	32.280	33.416	33.479	30.590	33.646	32.525	14.972	11.365	11.208	11.281	9.569	287.646
Lalini HEPP 2	P90	0.146	0.136	0.000	0.155	0.374	0.310	0.367	0.174	0.151	0.000	0.165	0.331	2.308
	P50	0.663	1.029	1.288	1.512	1.141	0.742	0.655	1.060	0.800	0.479	0.220	0.358	9.946
	MEAN	0.368	0.642	0.756	1.193	1.374	1.811	1.445	0.849	0.483	0.363	0.226	0.265	9.774
Total	**P90**	**34.202**	**33.634**	**35.316**	**36.562**	**33.519**	**36.379**	**33.672**	**15.290**	**11.629**	**11.332**	**11.465**	**10.467**	**303.468**
Total	**P50**	**36.207**	**35.887**	**37.310**	**37.690**	**34.850**	**37.798**	**36.075**	**17.519**	**12.763**	**11.911**	**11.583**	**9.986**	**319.578**
Total	**MEAN**	**35.336**	**35.278**	**37.055**	**37.626**	**34.588**	**38.514**	**36.536**	**16.996**	**12.548**	**12.226**	**12.070**	**10.398**	**319.171**
SCENARIO 69														
Hydropower station	**Energy (GWh/month)**													**Energy (GWh/a)**
	Parameter	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	
Ntabalenga HEPP 1	P90	0.439	0.837	2.736	2.956	2.728	3.066	1.450	0.290	0.277	0.424	0.863	0.517	16.582
	P50	0.333	1.816	3.164	3.098	2.840	2.744	2.847	1.714	1.318	1.232	1.342	1.001	23.448
	MEAN	1.527	2.481	2.834	2.957	2.605	2.893	2.566	1.371	0.862	0.868	0.926	0.734	22.625
Lalini Main HEPP	P90	24.715	43.555	44.871	44.843	41.056	45.124	43.611	14.801	11.249	11.107	11.193	9.496	345.620
	P50	24.824	43.785	45.245	45.245	41.549	45.878	44.130	14.905	11.325	11.163	11.230	9.560	348.839
	MEAN	24.813	43.812	45.304	45.343	41.291	45.496	43.541	14.558	11.057	10.909	11.117	9.435	346.676
Lalini HEPP 2	P90	0.156	0.145	0.000	0.154	0.374	0.291	0.362	0.186	0.076	0.000	0.132	0.326	2.201
	P50	0.489	0.670	1.236	1.507	1.186	0.863	0.610	0.879	0.759	0.632	0.219	0.352	9.402
	MEAN	0.362	0.620	0.736	1.167	1.339	1.770	1.394	0.820	0.462	0.351	0.222	0.260	9.503
Total	**P90**	**25.310**	**44.536**	**47.607**	**47.953**	**44.157**	**48.481**	**45.422**	**15.277**	**11.602**	**11.531**	**12.188**	**10.338**	**364.403**
Total	**P50**	**25.645**	**46.272**	**49.645**	**49.850**	**45.575**	**49.484**	**47.587**	**17.498**	**13.402**	**13.026**	**12.791**	**10.914**	**381.689**
Total	**MEAN**	**26.703**	**46.912**	**48.875**	**49.466**	**45.235**	**50.159**	**47.501**	**16.749**	**12.381**	**12.129**	**12.265**	**10.430**	**378.803**

APPENDIX B: COMMENTS REGISTER

Page / Section	Report statement	Comments	Changes made?	Author comment
DWS Project Management Committee, Ms T Nyamande – 19 January 2018				
Pg vi: Conclusions	The operating rules are significantly different to the rules applied in the prior scenarios	Indicate the implications of the "significant difference" OR how are the two different rules aligned.	Yes	Text has been added to explain the differences in operating rules followed in Phase 1 and 2 of modelling.
Pg 2-4	Section on Scenario naming	Is that scenario comparison tool standard? Is it approved by the Department to an extent that it can be used for other areas as well? My concern is that the DWS did a study on "Standardisation of Guidelines", of which from now onwards we should be able to standardise.	No	This tool has been used to prepare scenarios for comparison by river ecologists throughout a number of Reserve and Classification studies. It was also listed and assessed in the reports related to the following DWS study (reports finalised in 2017): *Development of Procedures to Operationalise Resource Directed Measures.*
Fig 2.1		Legends and labels not clear.	Yes	The figure is not available in any other format, but the label has been redone to improve clarity.
Page 2-5, Page 2-17 – Paragraph 2.2.11	Discharge into the estuary will be treated to DWS General Standards	Is the scenario going to be revised after the RQOs are determined and Gazetted, for in case it contradicts with the General Standards? Currently, is there a RWQOs determined for that estuary? My suggestion is to consider RWQOs first before reaching the RQOs stage. When consolidating the RQOs Implementation Plan, it gets complicated when the RWQOs are different from the gazette RQOs.	No	General Standards are end-of-pipe standards and RQOs are instream objectives which are guided by different sets of legislation. RWQOs are planning guidelines set for rivers (not estuaries) which are superceded by gazetted RQOs. The estuary team will set two sets of RQOs during that phase of the study, i.e. the river inflow to the estuary and in the estuary itself. Note that the PSJ WWTW scenario could not be assessed at a higher level of confidence without modelling and without more detailed information on the location etc. of the plant, which were not available from the EIA process.