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WP 11004

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

River Desktop EWR and Modelling Report:

VOLUME 1 – SYSTEMS MODELLING

May 2017

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Bold indicates this report

APPROVAL

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EXECUTIVE SUMMARY

INTRODUCTION

The purpose of this Systems Modelling Report is to present the information used and the methodology applied to determine the natural and present day monthly river flow time-series data at the relevant Ecological Water Requirement (EWR) sites and the identified desktop biophysical nodes in the study area. This data is required for the ecological assessments.

The study area was delineated into Resource Units (RUs) during Step 1 of the study, with each RU represented by a biophysical node. These nodes are either survey or EWR sites, or hypothetical points known as desktop biophysical nodes. The determination of ecological water requirements for both survey sites (i.e. EWR sites) and desktop biophysical nodes, are undertaken during Step 3 and will be reported in the next series of reports for the study.

The following EWR sites were surveyed during the study:

- MzimEWR1 on the Tsitsa River in T35E
- MzimEWR2 on the Thina River in T34J
- MzimEWR3 on the Kinira River in T33G
- MzimEWR4 on the lower Mzimvubu River in T36A

The Mzimvubu catchment 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.

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 Water Management Area (WMA) 7, i.e. the Mzimvubu to Tsitsikamma WMA.

No major instream dams occur along the main rivers, although there are approximately 10 dams used to supply municipal water requirements. 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.

METHODOLOGY

Natural hydrology

A review of the various past and current studies in the study area was undertaken as part of the status quo assessments to confirm the availability and status of both the hydrology and water resource models available.

The natural flow forms the baseline against which all scenarios will be assessed. The hydrology for the baseline was derived 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 (DWS, 2014), which updated the hydrology of the Kinira and Tsitsa rivers, which were expected to be at higher confidence levels.

A comparison assessment of the available hydrology was undertaken and the results confirmed that the updated hydrology from the DWS Feasibility Study for the Mzimvubu Water Project for the Kinira River System was unacceptable (**Section 2.2**), and thus only the Tsitsa hydrology was utilised from the study (as shown in **Table 1** below).

The hydrology was generally available at a quaternary level resolution and was downscaled linearly where the catchment area of the EWRs and biophysical nodes (**Figure 2.3**) was less than the existing catchment areas, i.e. hydrological parameters scaled down in proportion to the area reduction.

Table 1 Hydrology source per catchment

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

Present day hydrology

The integrated Water Resources Yield Model (WRYM) was generally configured at a quaternary level, which was also downscaled where the catchment area of the EWRs and biophysical nodes (defined as part of this Classification study) was less than the quaternaries, to ensure that the present day flows could 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 the so-called 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 of 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.

RESULTS

A summary of the natural and present day flows at EWR sites and Resource Units (RUs) where EWR estimates are required, are presented in **Table 2** as Mean Annual Runoff (MAR). The results confirm the Mzimvubu catchment's relatively undeveloped or "near-natural" status.

Table 2 Summary of natural and present day flows

EWR Site / Resource Unit	Natural MAR (million m^3/a)	Present Day MAR (million m^3/a)	% Present Day MAR of Natural MAR
MzimEWR1	438.0	413.2	94.3%
MzimEWR2	404.5	393.2	97.2%
MzimEWR3	407.1	399.3	98.1%
MzimEWR4	2655.1	2532.2	95.4%
T31-1	32.7	31.3	95.5%
T31-2	31.3	29.9	95.6%
T31-3	87.0	83.5	96.0%
T31-4	8.9	8.8	98.9%
T31-5	104.9	100.3	95.6%
T31-6	14.0	11.9	85.3%
T31-7	12.8	12.7	99.5%
T31-8	29.5	27.7	93.9%
T31-9	4.0	4.0	99.4%
T31-11	3.7	3.4	92.4%
T31-12	190.5	178.3	93.6%
T31-13	217.8	204.9	94.1%
T31-14	24.0	21.4	89.4%
T31-15	40.8	37.9	92.9%
T31-16	13.6	13.5	99.1%
T31-17	1.3	1.3	100.0%
T31-18	64.8	61.8	95.4%
T31-19	335.7	316.5	94.3%
T32-1	9.5	8.8	92.7%
T32-2	37.6	31.9	84.9%
T32-3	11.08	10.743	97.0%
T32-4	4.3	4.1	96.6%
T32-5	13.9	13.1	94.9%
T32-6	86.2	75.4	87.5%
T32-7	8.5	8.2	95.9%
T32-8	18.4	16.6	90.2%
T32-9	98.1	88.1	89.8%
T32-10	134.5	120.4	89.6%
T32-11	223.2	205.3	92.0%
T32-12	57.2	55.4	96.9%
T32-13	348.9	326.9	93.7%
T33-1	20.4	19.6	95.8%
T33-2	26.3	26.2	99.5%
T33-3	97.4	94.8	97.3%
T33-4	33.9	33.9	99.8%
T33-5	69.8	69.4	99.4%
T33-6	94.3	93.7	99.4%

EWR Site / Resource Unit	Natural MAR (million m^3/a)	Present Day MAR (million m^3/a)	% Present Day MAR of Natural MAR
T33-7	303.0	296.4	97.8%
T33-8	6.2	6.1	99.5%
T33-9	368.3	360.8	98.0%
T33-10	15.6	15.1	97.3%
T33-11	14.0	12.1	86.1%
T33-12	17.1	16.9	99.1%
T33-13	9.2	8.6	93.6%
T33-14	No estimate required as extrapolated from MzimEWR4 using the WRYM		
T34-1	33.6	33.5	99.7%
T34-2	32.9	32.6	99.2%
T34-3	41.1	40.9	99.4%
T34-4	68.1	67.4	99.0%
T34-5	123.5	120.1	97.2%
T34-6	20.3	20.2	99.3%
T34-7	45.2	44.4	98.2%
T34-8	84.7	83.3	98.4%
T34-9	27.1	22.5	83.1%
T34-10	20.1	19.0	94.5%
T34-11	11.9	11.3	95.2%
T34-12	18.2	17.1	93.9%
T35-1	101.1	97.6	96.5%
T35-2	79.7	78.4	98.3%
T35-3	63.7	61.5	96.6%
T35-4	127.6	111.9	87.7%
T35-5	46.1	43.9	95.2%
T35-6	37.6	33.7	89.6%
T35-7	26.1	24.0	91.9%
T35-8	14.3	9.7	67.7%
EWR Inxu1	44.4	39.4	88.8%
EWR Inxu2	57.2	49.7	87.0%
EWR GAT1	2.9	1.5	51.9%
EWR GAT2	10.9	8.1	74.8%
T35-9	35.1	34.4	98.2%
T35-10	19.87	19.72	99.3%
T35-11	29.76	29.18	98.1%
T35-12	18.1	17.6	97.0%
T35-13	14.7	14.3	96.8%
T35-14	36.2	33.4	92.1%
T35-15	10.2	10.1	98.8%
T35-16	13.5	13.5	100.0%
T36-1	14.3	14.2	99.3%
T36-2	9.8	9.7	99.4%

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LIST OF ACRONYMS

AIP	Alien Invasive Plants
AsgiSA-EC	Accelerated and Shared Growth Initiative for South Africa-Eastern Cape
BHNR	Basic Human Needs Reserve
CMA	Catchment Management Agency
DWA	Department of Water Affairs (name change from DWAF after April 2009)
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation (name change from DWA after May 2014)
EWR	Ecological Water Requirements
FS	Feasibility Study
GIS	Global Information System
MAR	Mean Annual Runoff
NFEPA	National Freshwater Ecosystem Priority Areas project
PD	Present Day
RQOs	Resource Quality Objectives
RUs	Resource Units
STATS SA	Statistics South Africa
ToR	Terms of Reference
WMA	Water Management Area
WR2005	Water Resources of South Africa 2005
WR2012	Water Resources of South Africa 2012
WRCS	Water Resource Classification System
WRSM2000	Water Resources Simulation Model 2000
WRYM	Water Resources Yield Model
WTW	Water Treatment Works
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 report described the information used and the methodology applied to determine the natural and present day monthly river flow time-series data for the relevant EWR sites and the identified desktop biophysical nodes in the study area. Although setting up the systems model is not the outcome of a particular step of the Project Plan, it underlines Steps 3 and 4 of the process (**Figure 1.1**).

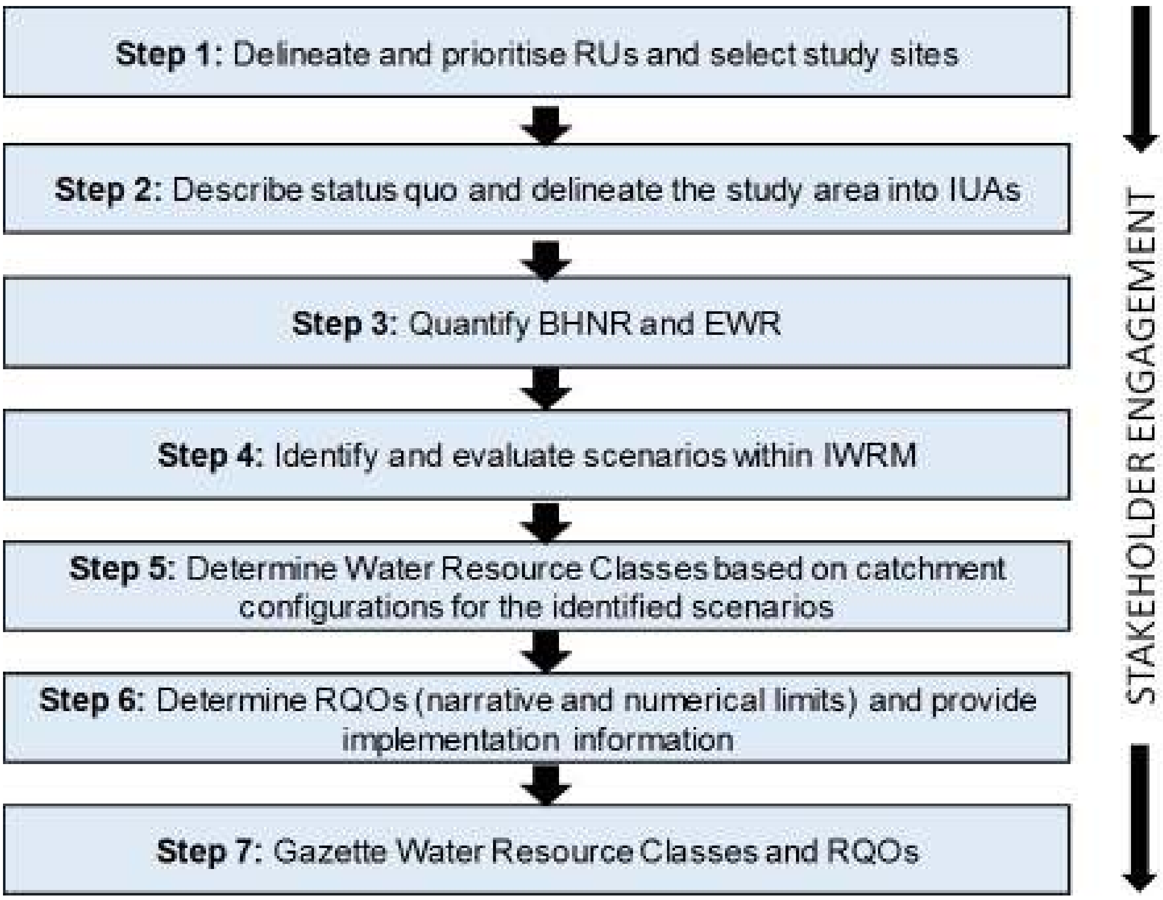

Figure 1.1 Project Plan for the Mzimvubu Classification study

1.2 STUDY AREA

The study area is represented by the Mzimvubu catchment which consists of the main Mzimvubu River, with the Tsitsa (**Figure 1.2**), 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

The purpose of the Systems Modelling Report is to present the information used and the methodology applied to determine the natural and present day monthly river flow time-series data for the relevant EWR sites and the identified desktop biophysical nodes in the study area (**Figure 2.3**). This information is required for the ecological assessments to be undertaken by the study.

The report outline is as follows:

- **Section 2** describes the methodology applied to determine the natural and present day flows.
- A summary of the natural and present day flow results are presented in **Section 3**.
- References are listed in **Section 4**.

Figure 1.2 represents the study area.

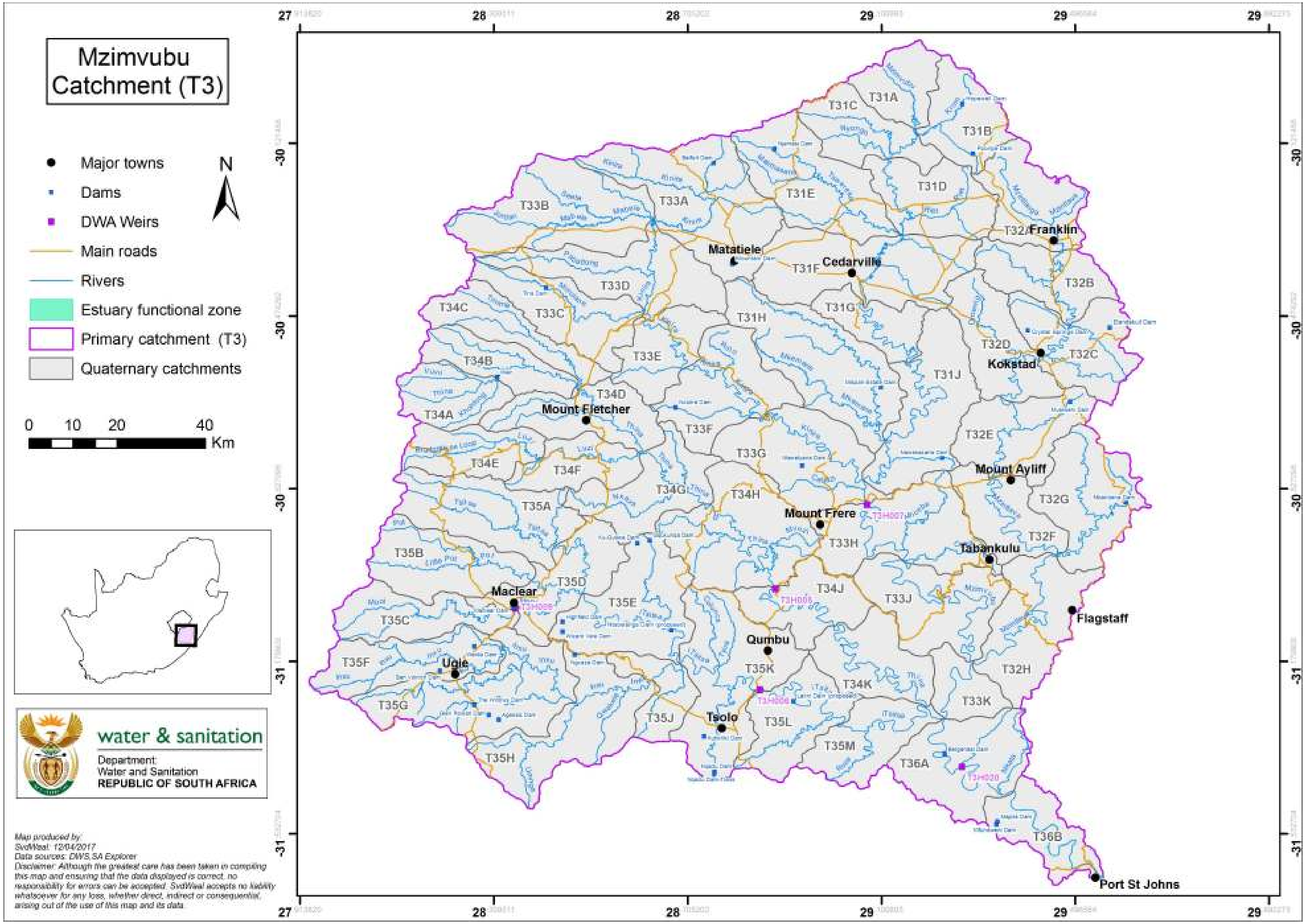

Figure 1.2 Study area

2 METHODOLOGY

2.1 EXISTING HYDROLOGY AND DECISION SUPPORT SYSTEMS

A review of the various past and current studies in the study area was undertaken as part of the status quo assessment to confirm the availability and status of both the hydrology and water resource models available.

The DWS Water Resources Yield Model (WRYM) was configured for the entire Mzimvubu catchment by the DWAF (2009) study in support of the AsgiSA-EC Mzimvubu Development Project, which was conducted prior to the feasibility study for Ntabelanga Dam. The study made use of the WR2005 hydrology.

The WRYM model and hydrological data was updated in the recent DWS Feasibility Study for the Mzimvubu Water Project (DWS, 2014), where it was expected that the confidence of the WRYM and hydrological data was improved through a detailed hydrological assessment including rainfall analysis, rainfall-runoff modelling and stochastic streamflow analysis of both the Kinira and Tsitsa rivers.

The hydrology common to both projects was compared to understand the difference, and the latest checked and accepted hydrology was integrated with the Mzimvubu Development Project WRYM configuration (WR2005 hydrology) for the remaining portion of the Mzimvubu catchment.

The WR2012 study data also recently became available (in 2016), which is an update of the WR2005 data. At the time of this study the WR2012 had not created the irrigation, afforestation and streamflow reduction water use files that are required to determine the present day developed flows. As a result the WR2012 hydrology was not used for this study.

2.2 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's Mzimvubu Development Project study and the more recent DWS Feasibility Study for the Mzimvubu Water Project (DWS, 2014).

A comparison of the updated natural hydrology for the Kinira and Tsitsa River systems against the WR2005 and WR2012 data (for reference purposes) was undertaken to gain an understanding of the differences and the related reasons for the differences.

The comparison results for the Kinira River System (T33A–T33G) are presented in **Figure 2.1**. From the results it can be seen that the total WR2005 and WR2012 MARs are very similar (total difference of 3%) while the DWS Feasibility Study is substantially higher (47% higher than the WR2005).

The major differences appear in T33E, T33F and T33G and further investigation showed that the catchment rainfall was noticeably higher in these quaternaries, especially in T33E (79 vs 20 Mm^3) and T33F (146 vs 52 Mm^3).

The hydrology was calibrated at gauging station T3H002 (T33A, T33B, T33C and T33D outflow) with a record period of 45 years, and T3H007 (T33G outflow) with a shorter record period of 16 years. The MAR comparison of the three information sources seem tolerable for T33A, T33B, T33C and T33D (unit mm runoff were also compared), but the DWS Feasibility Study MAR is noticeably higher for the quaternaries between T3H002 and T3H007, i.e. T33E, T33F and T33G. The calibration at T3H007 was undertaken for a very short record period of 17 years, which also coincided with the wettest period of the rainfall record, and these calibration factors were then applied to the entire 89-year record period (1920–2009).

The findings presented above contributed to the excessively high DWS Feasibility MAR for T33E, T33F and T33G quaternaries. As a result, the DWS Feasibility Study hydrology for the Kinira River System was regarded as unacceptable.

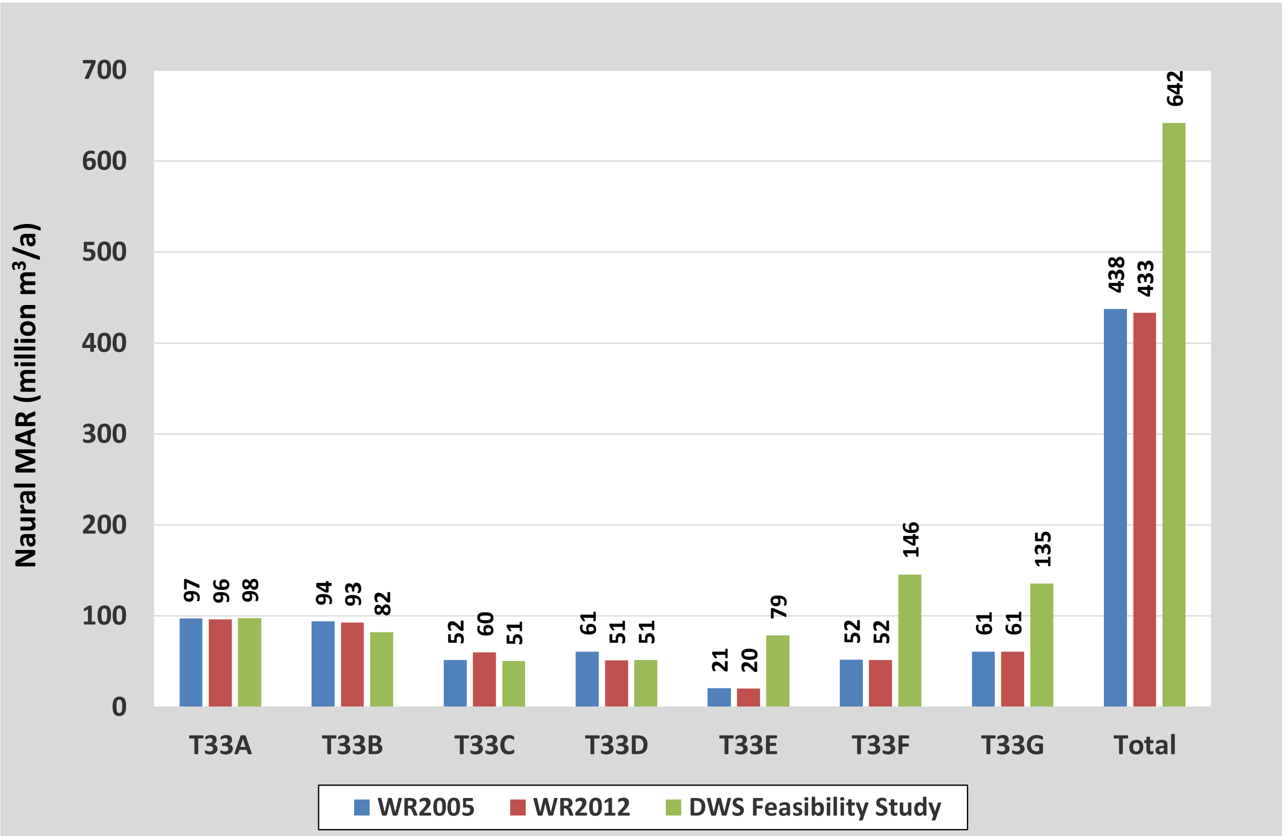

Figure 2.1 Kinira River System (T33A–T33G) natural MAR comparison

The comparison results for the Tsitsa River System (T33A–T33G) are presented in **Figure 2.2**. From the results it can be seen that the total WR2012 MAR is slightly higher than WR2005 MARs (5%) while the DWS Feasibility Study (FS) MAR is about 9% higher than the WR2012 MAR.

The catchment rainfall, calibrations and unit runoffs (mm runoff) were checked and based on the findings, the DWS Feasibility Study hydrology was accepted for the Tsitsa River system.

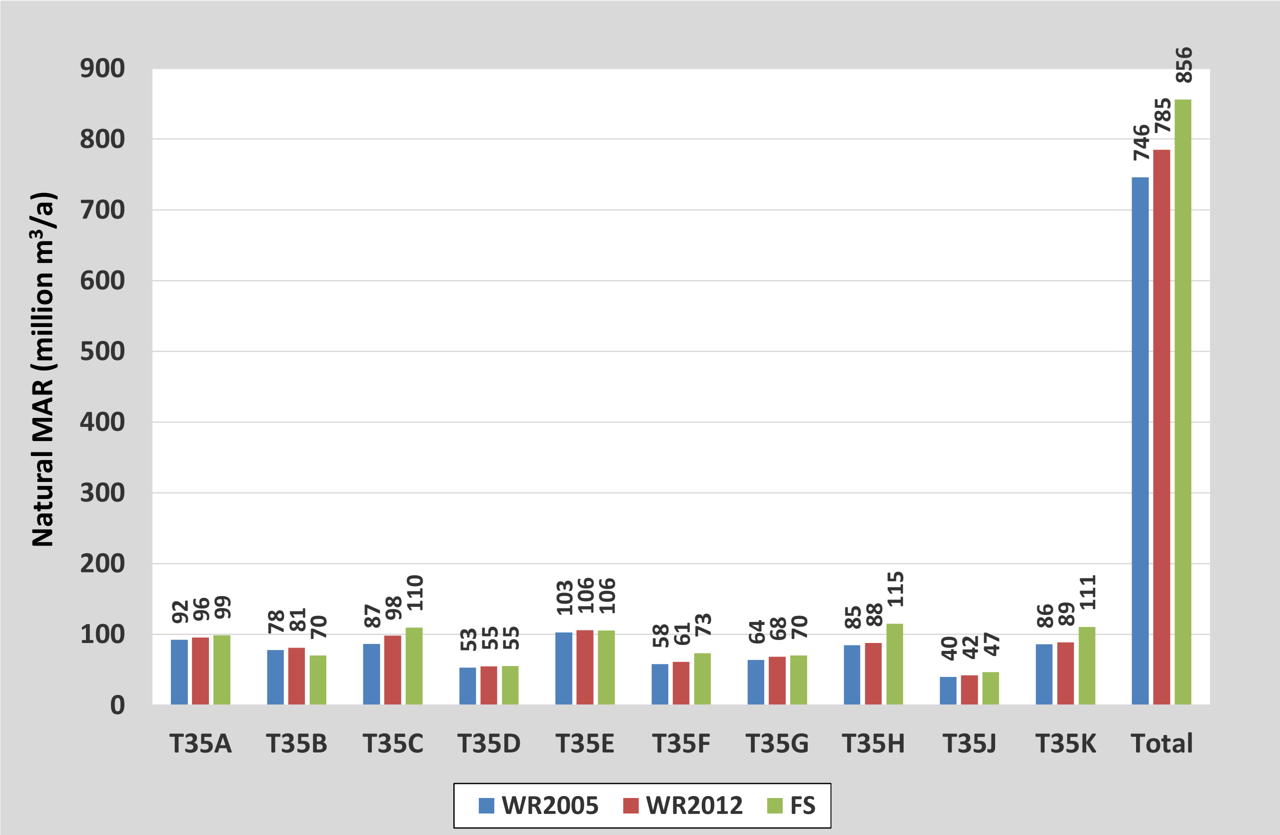

Figure 2.2 Tsitsa River System (T35A–T35K) natural MAR comparison

A summary of the accepted natural hydrology for each of the catchments is presented in **Table 2.1.** The Thina hydrology and associated WRYM network configuration was integrated with the SA-EC Mzimvubu Development Project WRYM configuration.

Table 2.1 Hydrology source per catchment

Catchment	Accepted hydrology source
Mzimvubu (T31A–T31J)	DWAF, 2009
Mzintlava (T32A–T32H)	DWAF, 2009
Kinira (T33A–T33G)	DWAF, 2009
Thina (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 EWRs 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 location of the EWR sites and biophysical nodes are illustrated in **Figure 2.3**.

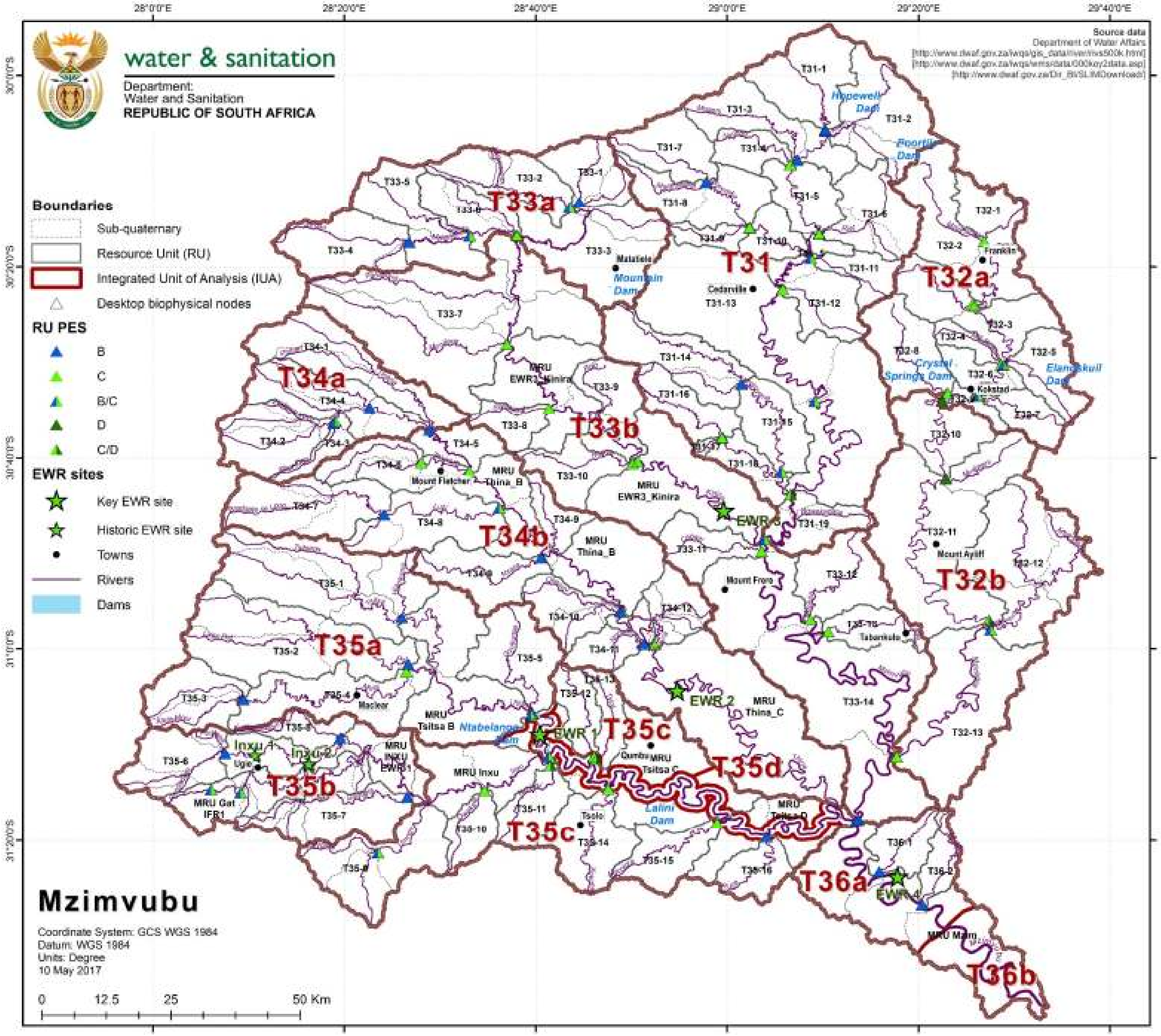

Figure 2.3 Location of EWR sites and biophysical nodes

2.3 PRESENT DAY HYDROLOGY

The integrated WRYM was generally configured at a quaternary level, which was also downscaled where the catchment area of the EWRs 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 the so-called 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. This information was sourced from the DWAF (2009) AsgiSA-EC Mzimvubu Development Project for the entire study area, with the exception of the Tsitsa catchment, which was sourced from the DWS Feasibility Study (DWS, 2014).

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

2.3.1 Afforestation

Commercial forestry has been declared a streamflow reduction activity and reduces baseflow in rivers. Existing forestry water use therefore needed to be considered in determining the present day flows.

The afforestation information was adopted from DWS Feasibility Study (DWS, 2014) for the Tsitsa catchments and from the DWAF (2009) AsgiSA-EC Mzimvubu Development Project WRYM for the remainder of the study area. A summary of the afforestation areas is presented in **Table 2.2**. The total afforestation in the study area equates to 505.37 km^2 and is predominantly concentrated in the middle to upper portion of the Tsitsa River catchment.

The GIS afforestation shapefiles were sourced and utilised where catchment areas were downscaled to accommodate the EWRs and biophysical nodes.

2.3.2 Alien invasive plants

Alien invasive plants (AIPs), particularly those in the riparian zones, also cause a reduction of baseflow in rivers. The areas of invasive alien vegetation were obtained from the DWS Feasibility Study (DWS, 2014) for the Tsitsa catchments and from the DWAF (2009) AsgiSA-EC Mzimvubu Development Project WRYM for the remainder of the Mzimvubu catchment and the effects of the alien vegetation on water resources were included in this study's present day estimates.

A summary of the AIP areas is presented in **Table 2.2**. The total AIP area in the Mzimvubu catchment equates to 301.6 km^2.

Table 2.2 Afforestation and AIP areas

Quaternary	Afforestation areas (km^2)		AIP areas (km^2)		Source
T31A	9	10.6	1.6	65.5	DWAF, 2009
T31B	1.1		2		
T31C	0		5.8		
T31D	0		1.1		
T31E	0.5		13.8		
T31F	0		5		
T31G	0		4.5		
T31H	0		28.9		
T31J	0		2.8		
T32A	0.9	25	7	74.4	DWAF, 2009
T32B	0		12.6		
T32C	5.4		12.1		
T32D	0		10		
T32E	0		13.9		
T32F	4.8		2.1		
T32G	8		8.4		
T32H	5.9		8.3		
T33A	0	10.4	17.3	50.9	DWAF, 2009
T33B	0		1		
T33C	0		0.6		
T33D	0		22.7		
T33E	0		0		
T33F	4.9		2.3		
T33G	1.5		0.5		
T33H	2.5		2.9		
T33J	1.5		3.6		
T33K	0		0		
T34A	0	76.1	0	27.3	DWAF, 2009
T34B	0.9		1		
T34C	0		0		
T34D	1.1		1.3		
T34E	5.6		6.7		
T34F	0		9.4		
T34G	7.3		0.6		
T34H	58.9		8.3		
T34J	2.3		0		
T34K	0		0		
T35A	62.5	382.37	5.8	82	DWS, 2014
T35B	30.2		1.2		
T35C	72.16		0.6		
T35D	21.39		12.5		
T35E	3.2		10		
T35F	100.5		0.5		
T35G	55.7		3		
T35H	0.39		3.6		
T35J	10.49		1.6		
T35K	23.74		2.2		
T35L	2.1		41		
T35M	0		0		
T36A	0.9	0.9	0	1.5	DWAF, 2009
T36B	0		1.5		
TOTAL	**505.4**		**301.6**		

2.3.3 Irrigation

Irrigation water requirements are strongly linked to land tenure systems present in the catchment. The catchment can be roughly divided into two land tenure sectors, namely sector one, which is the old Natal and Eastern Cape regions of the catchment outside of the former Transkei borders, and sector two is the former Transkei region of the catchment.

Sector one is characterised by commercial agricultural and irrigation operations, while sector two is characterised by state-owned land mostly administered through the tribal land tenure system, and subsistence agriculture.

Irrigation expansions have been prominent in the Mzimvubu (T31A–T31J) and Mzintlava (T32A–T32H) catchments, which prompted further investigations as part of this study. Information on the irrigation areas and crop mixes here adopted from the following studies:

- This study: Mzimvubu (T31A–T31J), Mzintlava (T32A–T32H) and Mzimvubu (T36A–T36B)
- DWS Feasibility Study (DWS, 2014): Kinira (T33A–T33G) and Tsitsa (T35A–T35M)
- DWAF (2009) AsgiSA-EC Mzimvubu Development Project: Thina (T34A–T34K)

A summary of the irrigation areas is presented in **Table 2 3**. The total irrigation in the study area equates to 139.49 km^2 and is predominantly concentrated in sector one, i.e. portions of the Mzimvubu, Mzintlava and Tsitsa catchments. Satellite imagery was used to split up the irrigation areas in the catchment areas that were downscaled to accommodate the EWRs and biophysical nodes.

Table 2.3 Irrigation areas

Quaternary	Irrigation area (km^2)		Source
T31A	5.98	62.28	This study
T31B	1.36		
T31C	-		
T31D	11.05		
T31E	7.70		
T31F	21.48		
T31G	3.34		
T31H	–		
T31J	11.37		
T32A	17.38	49.35	This study
T32B	9.49		
T32C	4.64		
T32D	16.30		
T32E	0.82		
T32F	–		
T32G	0.28		
T32H	0.44		
T33A	0.26	0.43	DWS, 2014
T33B	–		
T33C	–		
T33D	0.02		
T33E	–		
T33F	–		
T33G	–		
T33H	0.06		
T33J	0.06		
T33K	0.03		

Quaternary	Irrigation area (km^2)		Source
T34A	0.06	0.72	DWAF, 2009
T34B	0.06		
T34C	0.09		
T34D	0.09		
T34E	0.06		
T34F	0.06		
T34G	0.09		
T34H	0.12		
T34J	0.03		
T34K	0.06		
T35A	0.4	20.23	DWS, 2014
T35B	2.03		
T35C	–		
T35D	1.02		
T35E	–		
T35F	0.09		
T35G	16.56		
T35H	0.1		
T35J	–		
T35K	–		
T35L	–		
T35M	0.03		
T36A	5.00	6.48	This study
T36B	1.48		
TOTAL	**139.49**		

2.3.4 Urban and rural water requirements and return flows

Information on urban and rural water use within the catchment was obtained from the following sources.

- DWAF (2009) study supporting the AsgiSA-EC Mzimvubu Development Project
- Development of Reconciliation Strategies for All Towns (DWS, 2015)
- Census 2011 (STATS SA, 2012)
- DWA Blue Drop (DWA, 2012a)
- DWA Green Drop (DWA, 2012b)

The DWAF (2009) AsgiSA-EC Mzimvubu Development Project investigated rural water and urban water use throughout the study area, which was incorporated into the WRYM configuration. The DWS feasibility study did not include any urban or rural water use.

The approach followed was to use the DWAF (2009) urban and rural water use as the base source of information, which was then updated with information from the DWS Development of Reconciliation Strategies for All Towns study (DWS, 2015) where available (all urban areas and some rural areas were updated). Information from the DWS Blue Drop report (DWA, 2012a) was also used to confirm the production volumes of the Water Treatment Works (WTW). The water use information from the different sources was for different dates or time stamps, which were then projected to a common present day date (2014) by using the Census 2011 municipal 2001–2011 population growth rates (STATS SA, 2012). Where water requirement projections for the specific demand centre were unavailable, water use was assumed to remain constant for the demand centres located in municipalities where the Census 2001–2011 population growth was negative (conservative approach).

Information for Waste Water Treatment Works (WWTW) return flows was sourced from the DWS Development of Reconciliation Strategies for All Towns study (DWS, 2015) as well as the DWS Green Drop Report (DWA, 2012b). Where necessary, the return flows were projected to the 2014 development level by assuming a constant return flow factor. The present day urban and rural water requirements and return flows are presented in **Table 2.4**.

Table 2.4 Urban/rural water requirements and return flows

Quaternary	2014 water use (million m3/a)				2014 WWTW return flows (million m^3/a)
	Description	Urban	Rural	Total	
T31A			0.002	0.002	
T31B			0.011	0.011	
T31C			0.142	0.142	
T31D			0.046	0.046	
T31E			0.139	0.139	
T31F			0.054	0.054	
T31G			0.008	0.008	
T31H			0.300	0.300	
T31J			0.158	0.158	
T31 Sub-total		**0.000**	**0.862**	**0.862**	**0.000**
T32A			0.048	0.048	
T32B			0.035	0.035	
T32C	Kokstad	3.783	0.079	3.862	1.592
T32D			0.031	0.031	
T32E			0.318	0.318	
T32F	Mt Ayliff	2.059	0.208	2.267	0.457
T32G			0.418	0.418	
T32H	Flagstaff	0.451	0.346	0.797	
T32 Sub-total		**6.293**	**1.483**	**7.777**	**2.049**
T33A	Matatiele & Maluti	1.753	0.834	2.587	0.256
T33B			0.327	0.327	
T33C			0.151	0.151	
T33D			0.368	0.368	
T33E			0.155	0.155	
T33F			0.218	0.218	
T33G	Kwa Bacha / Mr Frere	2.085	0.276	2.361	
T33H	Mt Frere & Tabankulu	0.329	0.413	0.742	0.558
T33J			0.381	0.381	
T33K			0.170	0.170	
T33 Sub-total		**4.168**	**3.294**	**7.461**	**0.814**
T34A			0.249	0.249	
T34B			0.422	0.422	
T34C	Mount Fletcher	1.892	0.444	2.336	0.073
T34D			0.725	0.725	
T34E			0.000	0.000	
T34F			0.047	0.047	
T34G			0.129	0.129	
T34H			0.534	0.534	
T34J			0.250	0.250	
T34K			0.303	0.303	

Quaternary	2014 water use (million m3/a)				2014 WWTW return flows (million m^3/a)
	Description	**Urban**	**Rural**	**Total**	
T34 Sub-total		**1.892**	**3.104**	**4.996**	**0.073**
T35A			0.088	0.088	
T35B			0.000	0.000	
T35C	Maclear	1.057	0.000	1.057	0.311
T35D			0.082	0.082	
T35E			0.272	0.272	
T35F	Ugie	1.017	0.000	1.017	0.215
T35G			0.052	0.052	
T35H			0.286	0.286	
T35J			0.177	0.177	
T35K	Tsolo, Qumbo etc.	0.478	0.567	1.045	
T35L			0.317	0.317	
T35M			0.190	0.190	
T35 Sub-total		**2.552**	**2.031**	**4.583**	**0.526**
T36A			0.312	0.312	
T36B	Port St. Johns	0.023	0.232	0.255	
T36 Sub-total		**0.023**	**0.544**	**0.567**	**0.000**
Total		**14.928**	**11.317**	**26.246**	**3.462**

3 RESULTS

A summary of the natural and present day flows derived by applying the methodologies presented in **Section 2.2** and **Section 2.3**, and at EWR sites and Resource Units where EWR estimates are required, are presented in **Table 3.1**. The results confirm the Mzimvubu River system's relatively undeveloped or 'near-natural' status. The most significant land use contributing to the lower present day flows is agriculture via irrigation, followed by the urban and rural or municipal water use, afforestation and AIPs. No major instream dams occur along the main rivers, with the only dams (approximately 10) of any significant size being used to support municipal requirements.

The hydrology, natural and present day time-series files for each of the sites and the Mzimvubu WRYM setup are available in electronic format on the study database.

Table 3.1 Summary of natural and present day flows

EWR Site / Resource Unit	Natural MAR (million m^3/a)	Present Day MAR (million m^3/a)	% Present Day MAR of Natural MAR
MzimEWR1	438.0	413.2	94.3%
MzimEWR2	404.5	393.2	97.2%
MzimEWR3	407.1	399.3	98.1%
MzimEWR4	2655.1	2532.2	95.4%
T31-1	32.7	31.3	95.5%
T31-2	31.3	29.9	95.6%
T31-3	87.0	83.5	96.0%
T31-4	8.9	8.8	98.9%
T31-5	104.9	100.3	95.6%
T31-6	14.0	11.9	85.3%
T31-7	12.8	12.7	99.5%
T31-8	29.5	27.7	93.9%
T31-9	4.0	4.0	99.4%
T31-11	3.7	3.4	92.4%
T31-12	190.5	178.3	93.6%
T31-13	217.8	204.9	94.1%
T31-14	24.0	21.4	89.4%
T31-15	40.8	37.9	92.9%
T31-16	13.6	13.5	99.1%
T31-17	1.3	1.3	100.0%
T31-18	64.8	61.8	95.4%
T31-19	335.7	316.5	94.3%
T32-1	9.5	8.8	92.7%
T32-2	37.6	31.9	84.9%
T32-3	11.08	10.743	97.0%
T32-4	4.3	4.1	96.6%
T32-5	13.9	13.1	94.9%
T32-6	86.2	75.4	87.5%
T32-7	8.5	8.2	95.9%
T32-8	18.4	16.6	90.2%
T32-9	98.1	88.1	89.8%
T32-10	134.5	120.4	89.6%

EWR Site / Resource Unit	Natural MAR (million m^3/a)	Present Day MAR (million m^3/a)	% Present Day MAR of Natural MAR
T32-11	223.2	205.3	92.0%
T32-12	57.2	55.4	96.9%
T32-13	348.9	326.9	93.7%
T33-1	20.4	19.6	95.8%
T33-2	26.3	26.2	99.5%
T33-3	97.4	94.8	97.3%
T33-4	33.9	33.9	99.8%
T33-5	69.8	69.4	99.4%
T33-6	94.3	93.7	99.4%
T33-7	303.0	296.4	97.8%
T33-8	6.2	6.1	99.5%
T33-9	368.3	360.8	98.0%
T33-10	15.6	15.1	97.3%
T33-11	14.0	12.1	86.1%
T33-12	17.1	16.9	99.1%
T33-13	9.2	8.6	93.6%
T33-14	No estimate required as extrapolated from MzimEWR4 using the WRYM		
T34-1	33.6	33.5	99.7%
T34-2	32.9	32.6	99.2%
T34-3	41.1	40.9	99.4%
T34-4	68.1	67.4	99.0%
T34-5	123.5	120.1	97.2%
T34-6	20.3	20.2	99.3%
T34-7	45.2	44.4	98.2%
T34-8	84.7	83.3	98.4%
T34-9	27.1	22.5	83.1%
T34-10	20.1	19.0	94.5%
T34-11	11.9	11.3	95.2%
T34-12	18.2	17.1	93.9%
T35-1	101.1	97.6	96.5%
T35-2	79.7	78.4	98.3%
T35-3	63.7	61.5	96.6%
T35-4	127.6	111.9	87.7%
T35-5	46.1	43.9	95.2%
T35-6	37.6	33.7	89.6%
T35-7	26.1	24.0	91.9%
T35-8	14.3	9.7	67.7%
EWR Inxu1	44.4	39.4	88.8%
EWR Inxu2	57.2	49.7	87.0%
EWR GAT1	2.9	1.5	51.9%
EWR GAT2	10.9	8.1	74.8%
T35-9	35.1	34.4	98.2%
T35-10	19.87	19.72	99.3%
T35-11	29.76	29.18	98.1%
T35-12	18.1	17.6	97.0%
T35-13	14.7	14.3	96.8%
T35-14	36.2	33.4	92.1%
T35-15	10.2	10.1	98.8%

EWR Site / Resource Unit	Natural MAR (million m^3/a)	Present Day MAR (million m^3/a)	% Present Day MAR of Natural MAR
T35-16	13.5	13.5	100.0%
T36-1	14.3	14.2	99.3%
T36-2	9.8	9.7	99.4%

In conclusion, this report is a summary of the information used to set up the systems model which will support subsequent ecological assessment steps of the study. The purpose is to present the information used and the methodology applied to determine the natural and present day monthly river flow time-series data at the relevant Ecological Water Requirement (EWR) sites and the identified desktop biophysical nodes in the study area. All Mzimvubu WRYM setups are available in electronic format on the study database.

4 REFERENCES

Department of Water Affairs (DWA). South Africa 2012a. Blue Drop Report. Prepared by DWA, Pretoria, South Africa.

Department of Water Affairs (DWA). South Africa 2012b. Green Drop Report. Prepared by DWA, Pretoria, South Africa.

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.

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.

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.

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

APPENDIX A: COMMENTS REPORT

Page / Section	Report statement	Comments	Changes made?	Author comment
DWS Project Management Committee – 7 April 2017				
Report		Editorial comments	Yes	Addressed throughout.
Page iv, Exec Summary		Add: • Information about the number of EWRs and RUs so that when you discuss them under results one has already been introduced to the subject. • Briefly explain the relationship between the nodes and EWR sites. • Explain the next step which will guide readers of what is likely going to happen.	Yes	Text added as required.
Section 1.1: General		Change Section name to "Background"	Yes	
Pg 1-1		It would help to add a little bit of information pertaining to which step we are at; what that step entails and what is the expected outcome.	Yes	
Pg 2-1	"As a result the WR2012 hydrology was not considered for the study."	The discussion of WR2012 is confusing because you mentioned that this was not considered but the information discussed here indicates that you used it somehow. Why say you did not consider it then come down and say something contrary?	Yes	The text has been changed to clarify that the WR2012 information that became available in 2016 was considered, but not used.
Chapter 3		Vol 1 of the Water Resource classification system guideline, part 7.1.2.1.1 (page 21) outlines what a river node table should look like. I don't get it in this report? I expected to get that information under results.	No	The guideline documents present an outline of what information should be contained in a river node table. It is not prescriptive as to exactly what such a table should look like.
Page 3-3		Add a Conclusion	Yes	

Page / Section	Report statement	Comments	Changes made?	Author comment
Isa Thompson – 20 April 2017				
Report	Example: "..was configured for the entire Mzimvubu catchment by the ASGISA-EC Mzimvubu Development Project".	Please correct the reference to this study throughout all reports and presentations. It was a DWAF (2009) study, in support of the AsgiSA-EC study.	Yes	Reference to the study changed throughout the document.