DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems Management

DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE THUKELA CATCHMENT

MAIN REPORT
WP 11255

Study Report No.

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ACRONYMNS

BAS	Best Attainable State
BWSS	Bulk water supply scheme
CD: WEM	Chief Directorate: Water Ecosystems Management
DRM	Desktop Reserve Method
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EI /ES	Ecological importance / Ecological Sensitivity
ESBC	Ecologically Sustainable Base Configuration
EWR	Ecological Water Requirements
FEPAs	Freshwater Ecosystem Priority Areas
GMU	Groundwater Management Unit
GVRS	Greater Vaal River System
GVA	Gross Value Added
IEM	Integrated Economic Model
IUA	Integrated Unit of Analysis
IUAs	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
L/s	Litres per second
MIRAI	Macroinvertebrate Response Assessment Index
m^3	Cubic metres
MAP	Mean Annual Precipitation
MEA	Millennium Ecosystem Assessment
ML/d	Megalitres per day
NLC	National land cover
NMAR	Natural Mean Annual Runoff
NWA	National Water Act
PES	Present Ecological State
QSAM	Quasi-Social Accounting Matrix ()
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RUs	Resource Units

SEZ	Socio-economic Zones
SPI	Specific Pollution sensitivity Index
TEC	Target Ecological Category
TEEB	The Economics of Ecosystems and Biodiversity
UNESCO	United Nations Educational, Scientific and Cultural Organization
WRCS	Water Resource Classification System
WTP	Water Treatment Plant
WWTWs	Wastewater Treatment Works

EXECUTIVE SUMMARY

Water Resource Classification, the Reserve and Resource Quality Objectives (RQOs) are protection-based measures that make up Resource Directed Measures (RDM), the protection principles contained in Chapter 3 of the National Water Act (Act No. 36 of 1998). These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other.

In September 2019, the Chief Directorate: Water Ecosystems Management of the Department of Water and Sanitation (DWS) initiated the determination of water resource classes and RQOs for the Thukela catchments.

The main objectives of the study were to determine appropriate water resource classes and Resource Quality Objectives (RQOs) for all significant water resources in the Thukela River catchment area that would facilitate sustainable use of the water resources while maintaining ecological integrity, specifically maintain or improving the present ecological state of the water resources. The project approach and methodology applied was based on the 7-step process of the Water Resource Classification System (WRCS) as outlined in Regulation 810, the DWS manual *Procedures to Develop and Implement RQOs* (DWA, 2011), and the integrated process detailed in the report: *Development of Procedures to operationalise Resource Directed Measures* (DWS, 2017).

The study area was the Thukela River catchment which is the only river system making up the V hydrological drainage region comprising of the secondary drainage regions V1 to V7, including the Upper Thukela, Mooi/ Sundays, Buffalo and Lower Thukela sub-catchments.

The status quo assessment considered strategic water source areas, climate change, water resources and systems analysis, socio-economic and ecosystem services, rivers, groundwater, wetlands, and the Thukela estuary.

The quantification of the relationships that link socio-economic and ecological value and condition of water resources, the selection of those linkages that were considered priority, and determination of the scoring system to be used to evaluate the catchment scenarios in later steps of the process, was undertaken to inform the evaluation of scenarios within the integrated water resources management process. The scenario configuration and evaluation was an iterative process that assessed the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible for the catchment being classified, in this case the Thukela catchments, to support the recommended water resource management class options. The scenarios assessed were the current scenario (2025) including the key current infrastructure developments in the Thukela catchment, and future development scenarios of a medium-term scenario (2030), and a long term scenario (2040 - 2045).

The project produced water resource classes for 15 Integrated Units of Analysis in the Thukela Catchment: 12 IUAs as Class III rivers, 2 IUAs as Class II rivers and only 1 IUA as Class 1 (predominantly within the strategic water source areas).

Seventy five (75) resource units (RU) within the IUAs were delineated of which fifty four (54) were prioritised for RQOs setting for rivers. These included dams (6), groundwater RUs (7), wetlands (12), and the estuary.

This report summarises the overall outputs of the study per IUA highlighting the water resources class, quaternary catchments, resource units with main rivers and dams, wetlands, and groundwater prioritised areas, EWR sites, Target Ecological Category, and the components for which RQOs have been set.

In conclusion it is noted that the water resource classes determined and RQOs that have been set provide a set of objectives based on available data, information, previous studies, the Water Resource Classification component and inputs from external specialists and stakeholders.

These proposed RQOs and associated numerical limits were taken through various stakeholder consultation processes and were based on guidance received and best available information sources at the time of development.

The team feels confident that implementation of the RQOs will maintain or improve the water resources (rivers, dams, groundwater, wetlands, and the estuary) in the Thukela catchment.

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1. INTRODUCTION

Resource Directed Measures (RDM) is enabled through Chapter 3 of the National Water Act, 1998 (Act No.36 of 1998) (NWA) which provides for the protection of water resources through the Classification of water resources, determination of Resource Quality Objectives (RQOs) and determination of the Reserve. These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other.

1.1 Background

In September 2019, the Chief Directorate: Water Ecosystems Management of the Department of Water and Sanitation (DWS) initiated the determination of water resource classes and RQOs for the Thukela catchments.

The main objectives of the study were to determine appropriate water resource classes and Resource Quality Objectives (RQOs) for all significant water resources in the Thukela River catchment area that would facilitate sustainable use of the water resources while maintaining ecological integrity, specifically maintain or improving the present ecological state of the water resources.

Classification of water resources aims to ensure that a balance is reached between the need to protect and sustain water resources on one hand and the need to develop and use them on the other. The goal of the classification process is the implementation of the water resource classification system which has as its final product the selection of one of three water resource classes.

- **Class I**, a water resource that is minimally used, and the overall condition of that water resource is minimally altered from its pre-development condition, with an ecological category of A-B
- **Class II,** a water resource that is moderately used, and the overall condition of that water resource is moderately altered from its pre-development condition, with an ecological category of C
- **Class III,** a water resource that is heavily used, and the overall condition of that water resource is significantly altered from its pre-development condition, with an ecological category of D.

The purpose of the water resource class is to establish clear goals relating to the quantity and quality of the relevant water resource, and conversely, the degree to which it can be utilised by considering the economic, social, and ecological goals from an integrated water resource management perspective.

Resource Quality Objectives have to be determined for a significant water resource as the means to ensure a desired level of protection. The purpose of RQOs is to provide limits or boundaries for biological, physical, and chemical attributes which should be met in the receiving water resource in order to ensure protection.

In determining RQOs it is important to recognise that different water resources will require different levels of protection. In addition to achieving the Water Resource Class, the RQOs determined will ensure that the needs of all users and competing interests who rely on the water resources are considered.

1.2 Study Area

The study area was the Thukela River catchments which is the only river system making up the V hydrological drainage region comprising of the secondary drainage regions V1 to V7 briefly described in Table 1 and illustrated in Figure 1 .

Table 1: Summary description of the study area

Sub-catchment	**Description**	**Tertiary drainage regions**	**Catchment area(1) (km^2)**
Upper Thukela	The catchment of the Thukela River to just upstream of the confluence with the Bushmans River.	V11, V12, V13 and V14	7645
Mooi/ Sundays	The catchment of the Mooi, Bushmans and Sundays River as well as of smaller tributaries, down to the confluence of the Buffalo River with the Thukela River.	V20, V60, V70	8496
Buffalo	The catchment of the Buffalo River.	V31, V32 and V33	9803
Lower Thukela	The catchment of the Thukela River between the confluence of the Buffalo River and the Indian ocean.	V40 and V50	3102

[1]WR2012

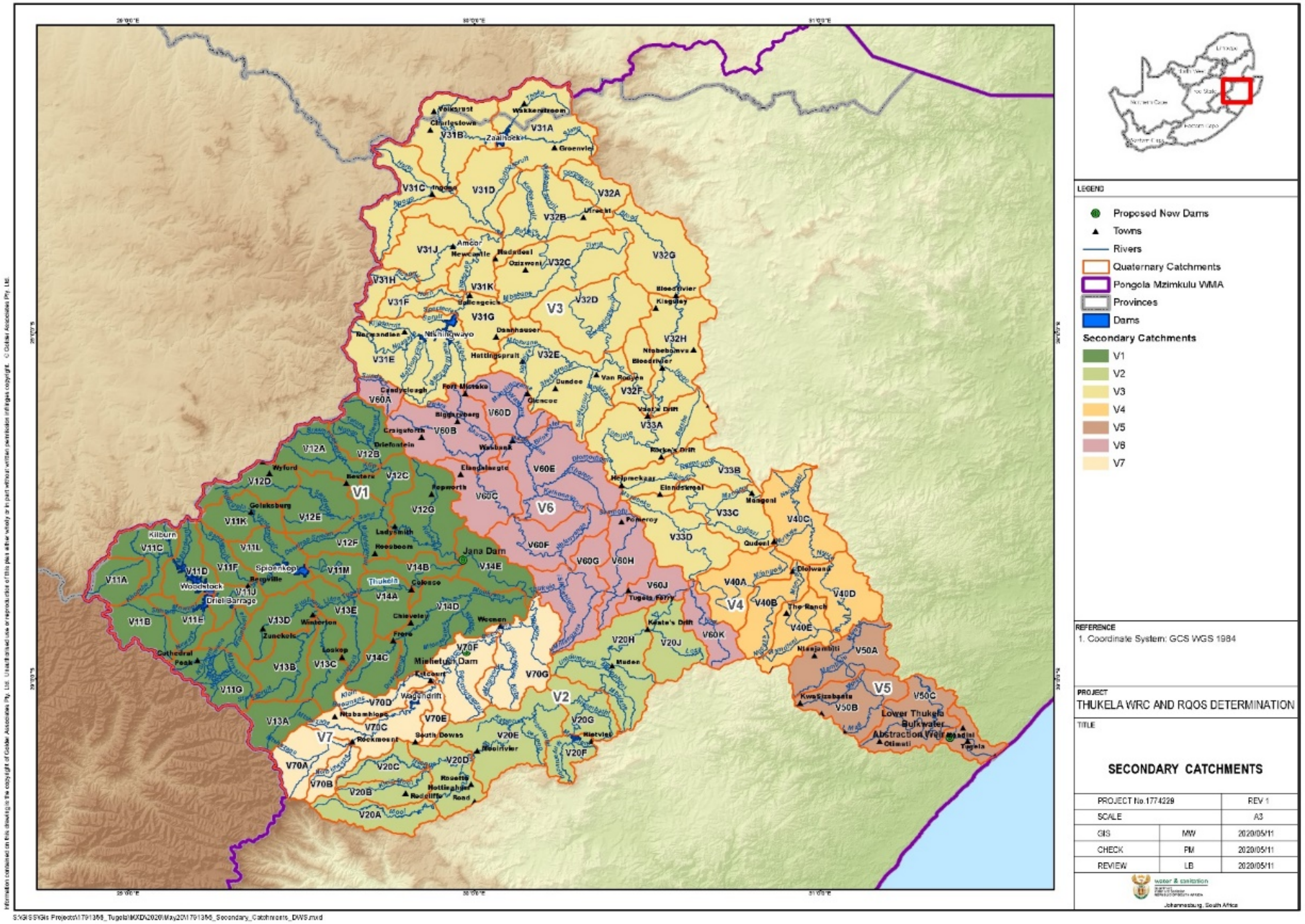

Figure 1: Study Area showing the tertiary drainage regions and quaternary catchments

1.3 Study Overview

The main objectives of the study were to determine appropriate water resource classes and Resource Quality Objectives (RQOs) for all significant water resources in the Thukela catchments that will enable sustainable use of the water resources while maintaining or improving ecological integrity of the water resources.

The key aims of this study were to co-ordinate the implementation of the Water Resource Classification System (WRCS) published as Regulation 810 in September 2010 for determination of water resource classes and associated RQOs in the Thukela catchment.

The water resource classes and associated RQOs will assist the Department in ensuring that water resources within Thukela catchment are protected to achieve equitable share in a sustainable manner. In determining classes and associated RQOs, socio-economic factors and ecological goals were considered by evaluating the magnitude of impacts in the present as well as proposed future developments. The water resource classes and associated RQOs will need to be considered by the Department during authorisation of future water uses, operation and management of the river system and the evaluation of the magnitude of the impacts of the present and proposed developments, as well as assist in attaining economic, social, and ecological goals.

At the start of the project, it was recognised that the successful determination of the water resource classes and RQOs would be dependent on the integration of a number of disciplines in respect of water resources with the water uses and the needs of the water users present in the catchment area, through consultative processes. Specialist technical assessment and stakeholder engagement were therefore key components of the process.

1.4 Purpose of this Report

The objective of this report is to summarise the technical outcomes of the various components of the study.

It is important that this report is read in conjunction with the following reports to understand context and get the detail.

- RDM/WMA04/00/CON/CLA/0120: Water Resources Information and Gap Analysis Report
- RDM/WMA04/00/CON/CLA/0320: Status Quo and Integrated Unit of Analysis and Resource Units Report
- RDM/WMA04/00/CON/CLA/0420: Report on Linking the Socio-Economic and Ecological Value and Condition of the Water Resources
- RDM/WMA04/00/CON/CLA/0520: Preliminary Resource Units Selection and Prioritisation Report
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- RDM/WMA04/00/CON/CLA/0620: Sub-components prioritization and indicators selection Report

- RDM/WMA04/00/CON/CLA/0121: Scenarios Evaluation and Proposed Water Resource Classes Report
- RDM/WMA04/00/CON/CLA/0221: Draft RQOs and Numerical Limits Report

1.5 Study Approach

The project approach and methodology applied was based on the 7-step process of the Water Resource Classification System (WRCS) as outlined in Regulation 810, the DWS manual *Procedures to Develop and Implement RQOs* (DWA, 2011), and the integrated process detailed in the report: *Development of Procedures to operationalise Resource Directed Measures* (DWS, 2017).

As the preliminary Reserve determination has been undertaken, integration considered the preliminary Reserves. Where the preliminary Reserve was available and relevant, it was adopted and where needed and possible within the study mandate, gaps were filled according to standard methodologies for Reserve determinations.

Figure 1 outlines the integrated approach that was followed in undertaking the project to determine water resource classes and RQOs for the Thukela catchments. The chapters to follow will highlight the outcomes for each of the key steps.

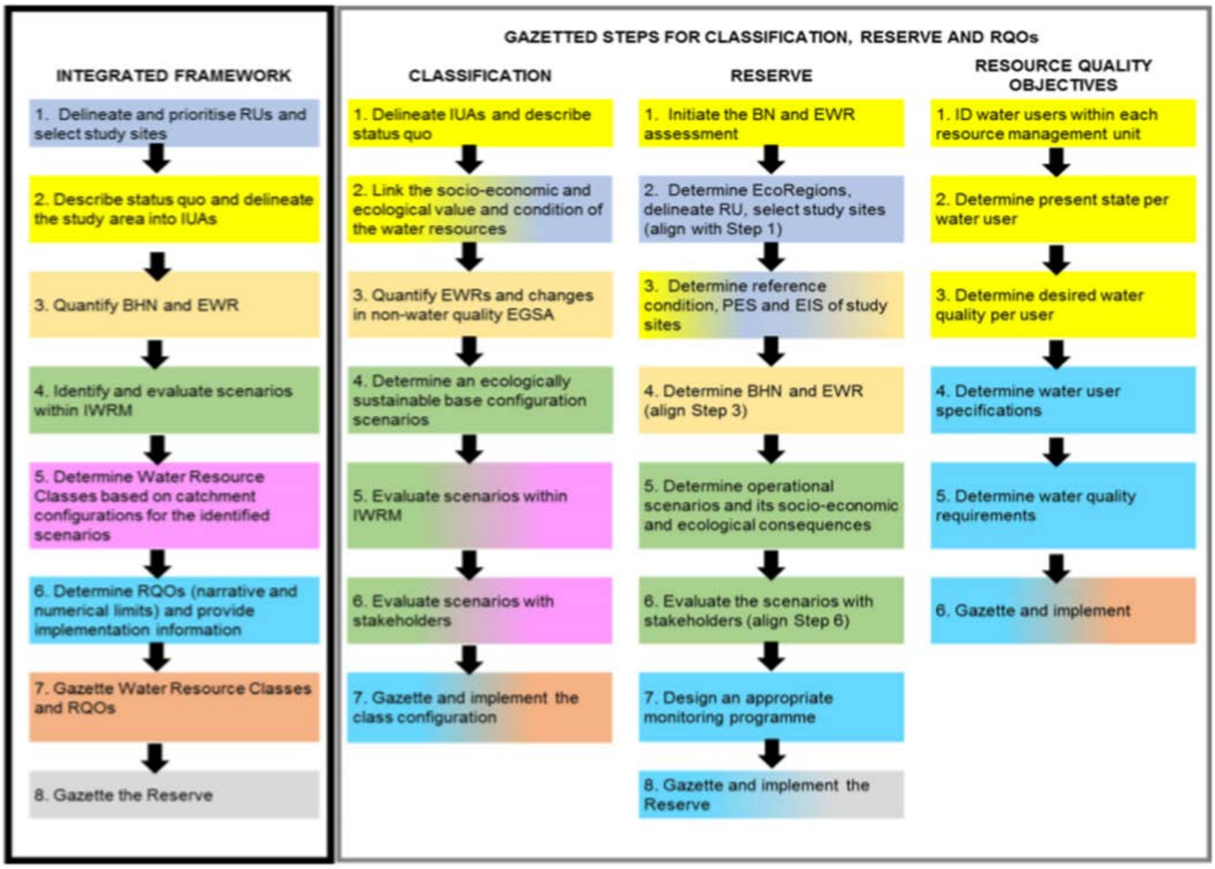

Figure 2: Integrated Framework of the Gazetted steps for Classification, Reserve and RQO Determination (DWS, 2017)

2. WATER RESOURCE INFORMATION AND GAP ANALYSIS

The first step of the integrated approach was to assess the existing data to indicate gaps and propose mitigation to fill as many of the gaps as possible. The outcomes of the assessment noted that there were very few recent studies (within the last 10 years) that had been undertaken in the Thukela catchment, and not always to the extent needed to support all aspects of the classification and RQO setting process. Table 1 sets out the key gaps identified, and interventions undertaken to fill the gaps. Details of the information sources used, and gap analysis are included in Report number: RDM/WMA04/00/CON/CLA/0120.

Table 2: Gaps identified with interventions undertaken

Aspect	**Gap Identified**	**Potential Consequence to outputs**	**Interventions undertaken**
Hydraulics	Unavailability of data and modelling results from previous 2003 Reserve Study.	Inaccuracy in EWR quantification and scenario modelling. Additional Budget requirement for 2 weeks in field and additional modelling to re-survey the existing sites.	Selection of only key EWR sites based on priorities in terms of IUA and hydronode selection to reduce the number of sites required for re-survey.
BHN	Outdated population figures	Inaccurate BHN provision in scenario assessment, influence the setting of water resource class	Updated population in terms of the 2011 census.
EWRs for the system	No EWR sites and preliminary Reserve for sub-catchments within the Thukela Catchment i.e., Upper Buffalo, upper Mooi River,	Gap in the scenario modelling for these catchments in terms of IWRM context.	Rapid assessments were undertaken at additional sites to address potential EWR gaps: 1. Upper Buffalo: V31D - Zaaihoek Dam upstream on the Slang River (tributary of Buffalo) with no EWR determined to be released from the dam. Existing EWR site on Buffalo are after the Ngagane confluence 2. Mooi: V20J - New site on bottom end of the Mooi just before the confluence with Thukela. EWR 11 too high on Mooi river to account for downstream reach and impacts of Craigie Burns Dam. 3. Klip River: V12C or V12G - To provide information on the possible impact of reduced floods on the Thukela River at the proposed Jana Dam (at confluence of Klip and Thukela Rivers) 4. Little Mooi: V20B or V20D - Water resource developments planned (farm dams and increased irrigation) to determine the impact of water

Aspect	Gap Identified	Potential Consequence to outputs	Interventions undertaken
			availability in the lower Mooi, and 5. Nzuse: V40D - Only a few significant tributaries in the lower Thukela with little/ no biological information available.
PES	Validity of PES as preliminary Reserve was undertaken in 2003 (16 years ago). Confirmation of PES at EWR sites required.	Inaccurate configuration and EWR quantification. Inaccuracy in RQO determination	Biological surveys undertaken at key existing EWR sites to provide current information for the confirmation of the present state of the water resources.
Riparian vegetation	Approach used in 2003 been revised totally	Inaccurate data for the determination of the EWRs	Rapid IHI assessment were used as surrogate.
Rule and tab tables	Changes to the reference hydrology	Inaccurate results of EWR quantification and scenario analysis	Comparisons between reference hydrology used during 2003 and that chosen for this study was undertaken and tables adjusted accordingly.
Catchment scenarios	Not available for entire Thukela catchment as no reconciliation strategy was undertaken	Possible gaps in the scenario modelling for some planned water resource developments in the catchment.	Discussions with water resource and municipal managers and other role players to ensure all possible water resource developments are identified and included in the scenarios, were undertaken, as possible.
Water Quality	Limited or lack of baseline monitoring data on some rivers. Water quality impacts at local scale are not understood.	Impacted areas/hotspots maybe be missed, or adequate protection measures maybe not be identified if is not available to indicate status.	Some further data sources were investigated to obtain additional water quality monitoring data such as those of the local municipalities and mines in the WMA, or other programmes.
Modelling			
Wate Resources Planning Model	Currently available complete WRPM or WRYM configurations are dated, or not focused on the whole catchment.		Certain sub-catchments were well studied with updated hydrology and models. An updated model was designed to combine the existing models and can now be used as a base by the department for the future reconciliation study.
Water Resource Yield Model			
Planning scenarios	Various planning scenarios for different parts of the catchment linked to different strategies	Multiple scenarios may not talk to each other, or require lots of different scenarios – unnecessary complexity	Long term planning options/ scenarios were generated to determine possible changes in water resources supply and demands.
Water supply volumes	Water supply volumes (in particular) water transfers, not explicitly documented and	Water transfer volumes (biggest water use in the	Meetings with the DWS planning team to discuss the appropriate source for this data were held.

Aspect	Gap Identified	Potential Consequence to outputs	Interventions undertaken
(current future)	embedded in past model simulation results.	catchment) need to be fixed for the future.	
Recon-ciliation strategy	No strategy has been developed for the Thukela catchment.	Status of catchment water balance and supply /allocations- continued water supply over the medium to long term not correctly quantified.	Planning scenarios and water supply into the future were addressed as described above.
Municipal Urban Water requirements	No current and agreed upon water requirements and projects for the municipal areas within the catchment.	Inaccurate water requirement projections in the scenario analysis will influence the water balance.	The All Towns Study strategies and the Thukela Water Project was a source of some of this data. In addition, available current projections from the District Municipalities were sought.
Hydrology			
Record period and longest overlapping period	Data in models currently only extends to 1994.	The last 25 years hydrology not included in hydrological records.	A comparison with other more recent national studies to evaluate differences as described in above section was undertaken.
Land use modelling	Older hydrology makes use of older modelling methods for land uses, e.g., stream flow reduction activities.	Limited as the model will be run in historic mode and the newer methods are more relevant to stochastic analysis	No intervention was required.
Wetlands			
Mapping of Priority wetlands	Integrated GIS layer	Inaccurate delineation of priority wetlands	Was developed as part of the study.
Delineation and typing of Priority Wetlands	Delineation and typing mostly available at a desktop level only	Will require updating for all the Priority Wetlands	Updated desktop mapping of the Priority Wetlands was undertaken as part of study where appropriate.
Ecological categorisation of the Priority Wetlands	Present Ecological State (PES) and Importance and Sensitivity (IS) information is not available for most wetland systems.	Information available for determining the REC or BAS is limited or not available in most cases	Surrogate databases and information sources were used where appropriate to derive general state and importance and sensitivity indicators where possible. This was used to derive the REC and TEC where appropriate/ possible.
Estuary			

Aspect	**Gap Identified**	**Potential Consequence to outputs**	**Interventions undertaken**
Hydrology	Based on topographical data collected by DWAF in 1996; includes beach and estuary cross sections. Data could be outdated.	Error that has developed over time related to EWR.	Hydrological information was updated by conducting a geomorphological assessment of the estuary (to the extent possible within scope of study).
Closed mouth conditions	No available information related to berm height, salinity profiles, water quality, and all biotic components during mouth closure.	Low confidence in EWR (DWAF, 2004) leading to possible exaggerated environmental response.	An assessment of abiotic drivers and biotic responses during a closed mouth event was conducted.
Delineation	The upper boundary of the estuary is ~6 km from mouth (DWAF, 2004). Estuary is now included in an MPA that stretches to ~8.5 km from mouth.	Management strategy of the estuary needs to be amended to include additional 2.5 km.	Delineation of the estuary was amended to include MPA boundaries.
Present Ecological State (PES)	PES was set as Ecological Category C (estuarine health score = 70) (DWAF, 2004). Estuary now falls within boundaries of a Marine Protected Area (MPA)*; i.e.,* is classified as protected and should be restored to and maintained in either an A category or the Best Attainable State (BAS).	Management strategy of the estuary needs to be amended to include rules associated with the MPA unless it is decided that the estuary can only be managed at BAS.	The highest level that the estuary can be managed at was determined.
Limited abiotic and biotic information	EWR was based on limited salinity, nutrient, dissolved oxygen, TSS/turbidity, pH, trace metals, microalgae, and zooplankton profiles.	Lower accuracy, based on low-confidence information, of EWR.	One assessment of abiotic drivers and biotic responses was conducted.

3 STATUS QUO AND DELINEATION OF INTEGRATED UNITS OF ANALYSIS AND RESOURCE UNITS

Details of the status quo assessment and delineation of Integrated Units of Analysis (IUA) are set out in Report: RDM/WMA04/00/CON/CLA/0120.

3.1 *Status Quo* Assessment

The purpose of the *status quo* assessment was to describe the current status of the water resources in the Thukela catchment in terms of the water resource systems, the ecological characteristics, the socio-economic conditions, and the community well-being. Water resource description and characterisation based on water resource operation and management, location of significant water resource infrastructure (including proposed infrastructure), water resource characteristics and condition, groundwater resources, water quality and distinctive functions of the catchments in context of the larger system were assessed and the findings documented. The socio-economic analysis of the catchment was also undertaken, and a perspective presented in the report. The following chapters highlight the key outcomes for each of the components assessed.

3.1.1 Strategic Water Source Areas

The status quo assessment indicated that parts of the catchment of the Thukela have been identified and delineated as strategic water source areas (SWSA) in South Africa (WRC, 2018). Strategic water source areas are critical because they produce large volumes of water that sustain people locally and regionally and, in the case of groundwater, are often the only sustainable and reliable water source.

Within the Thukela catchment, much of the escarpment areas of the Northern and Southern Drakensberg where the Thukela River and some of its major tributaries rise, as well as the Lower Thukela (Zululand Coast) have been delineated as surface water SWSAs (Figure 3). A very small portion of catchments V50B and V50C are part of the KwaDukuza groundwater SWSA zone, which falls predominantly in the Mvoti Catchment. The surface water SWSAs are of major significance and are nationally important in terms of the water security within the Thukela, and more importantly for recipient catchments including the Vaal, Mgeni and Mhlatuze.

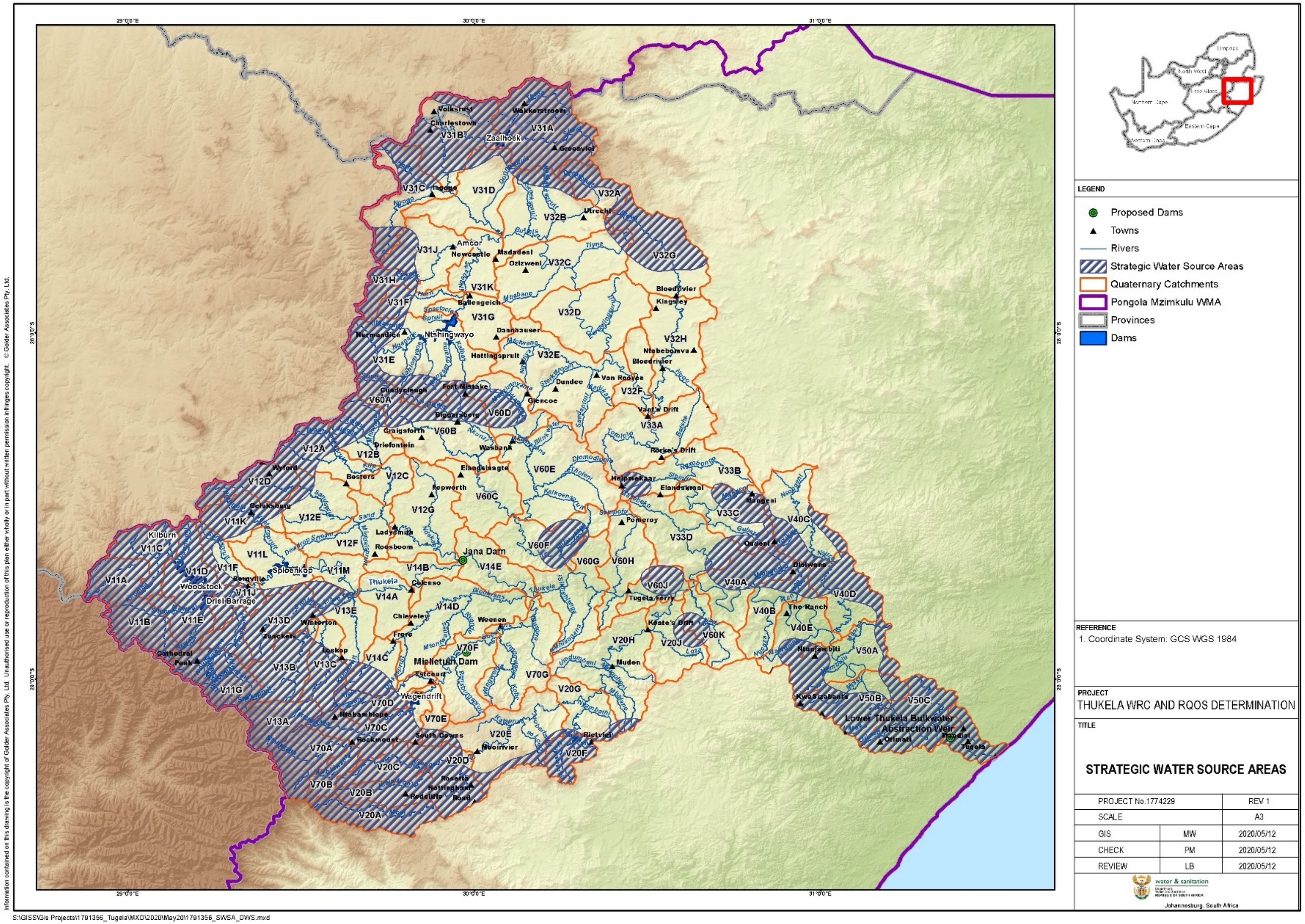

Figure 3: Strategic Water Source Areas delineated within the Thukela catchment

3.1.2 Climate change

The climate change related impacts in respect of rainfall for the Thukela catchment were based on the DWS National Integrated Water Information System (NIWIS) which used data for the period 2016 to 2045. It was noted that Thukela catchment is a key catchment in South Africa, with the highest runoff in KwaZulu-Natal (KZN), estimated at 3 799 million m^3/a (DWAF 2002). Rainfall is however erratic and years of prolonged drought in the central and lower catchment alternate with very wet periods.

The outcomes of the analysis summarised in bullet form highlights the severe impact that climate change is likely to have on the water resources of the Thukela catchment.

- Rainfall change is expected to range between a decrease of 5% rainfall to an increase of just over 3%. The biggest decreases (4% – 5%) are expected to be seen in the north western catchment areas, specifically Upper Buffalo River, Ngagane River, Middle Buffalo River and Sundays River.
- Changes in streamflow are expected to show decreases between 28% to 35% in the Ngagane River, Middle Buffalo River, Sunday River and Middle Thukela River catchments. Limited increase in streamflow (>1%) may be expected in V32F, V32H, V20H and V20J.
- Percentage change in evapotranspiration is expected to increase by 8% – 11%, with the highest increase expected in the north western catchments, and
- an independent study undertaken by the Wakkerstroom Natural Heritage Association (WNHA), the Slang River in the Buffalo catchment has shown at 60% decrease in streamflow based on a 70 year flow record analysis, and a 10% decrease in rainfall (*personal communication*, Rupert Lawlor, WNHA).

3.1.3 Water Resources and System Analysis

A number of large dams have been constructed associated with both water supply within the catchment, and water transfer to neighbouring catchments. The key dams are listed in Table 3. There are also many smaller dams with a total surface area of 99.9 km^2 and a total capacity of 319.1 Mm^3 (million cubic meters).

Table 3: Key dams in the Thukela catchment

Dam name	Sub - catchment	Rivers	Purpose	Capacity (million m^3)
Woodstock	Upper Thukela	Thukela	Water transfer	373.3
Spioenkop	Upper Thukela	Thukela	Water supply and irrigation	270.6
Qedusizi	Upper Thukela	Klip	Flood Control (operated empty)	±200
Zaaihoek	Buffalo	Slang	Water transfer	184.6
Ntshingwayo	Buffalo	Ngagane	Water supply and irrigation	194.6
Spring Grove	Mooi	Mooi	Water Transfer and Irrigation	139.5
Mearns Weir	Mooi	Mooi	Water Transfer and Irrigation	5.1

Dam name	Sub - catchment	Rivers	Purpose	Capacity (million m^3)
Craigieburn	Mooi	Myamvubu	Water supply and irrigation	22.5
Wagendrift	Boesmans	Bushmans	Water supply and irrigation	55.9

The following major transfer schemes with a total capacity of 2 415 ML/d were described:

- Thukela Vaal Scheme: To fill Sterkfontein Dam and support Vaal System (1 700ML/d)
- Buffalo Vaal Scheme: To supply Majuba Power station and support Grootdraai Dam (186 ML/d)
- Mooi Mgeni Transfer Scheme (MMTS) (phase 1 and 2): To keep Midmar Full and support Mgeni (388 ML/d))
- Thukela to Mhlathuze scheme (also known as the Middeldrift Transfer): Support Mhlathuze by pumping until Goedetrouw Dam > 60% (86 ML/d)
- Lower Thukela Bulk Water Supply Scheme (LTBWSS) (phase 1): To supply users along North coast (KwaDukuza)(55ML/d)

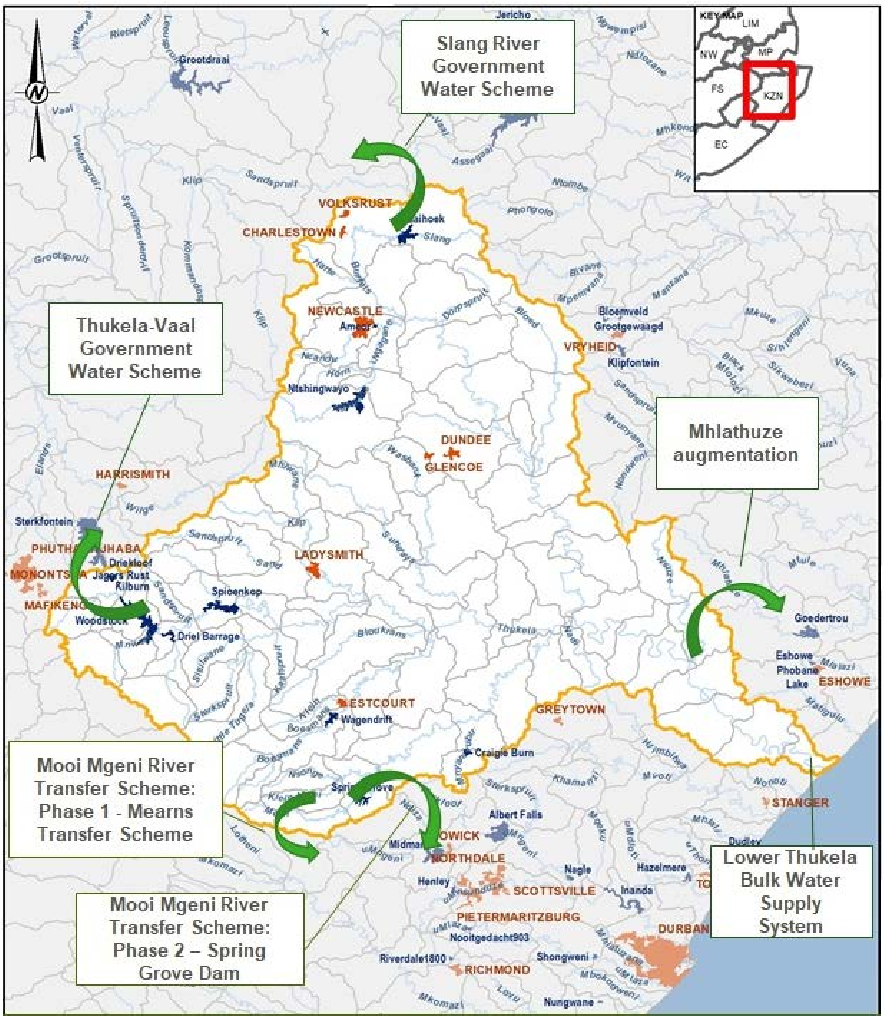

Figure 4: Inter-basin transfers

It was noted that additional to these large schemes transferring water out of the catchment there are a number of bulk water supply schemes and associated water infrastructure located within the catchment with a user requirement of approximately 155 Mm^3/annum. Return flows of treated effluent from domestic wastewater treatment works (WWTW) were reported as 81.9 Mm^3/a.

Irrigation volumes throughout the catchment were reported as approximately 398 Mm^3/a with the Mooi River catchment using approximately 15% of that water.

It was estimated that the volume of water lost due to stream flow reduction activities in the form of commercial forestry and alien invasive vegetation in the catchment is 46 Mm^3/a, mostly within the central to lower catchments.

As part of the status quo assessment, projected water supply potential was described (Table 4). For the various sectors to be used in the scenario analysis.

Table 4: Projected water supply potential

River system	Sector	Volumes as per 2015 projection (million m^3/a)		
		Requirement	**Supply**	**Percentage Supply**
Upper Thukela	Irrigation	158.8	121	76%
	Afforestation	6.8	5.6	82%
	Rural / Urban / Industrial	33.1	33.1	100%
	Transfer	631.2	498.6	79%
	Total	**829.9**	**658.3**	**79%**
Mooi/ Sundays	Irrigation	138.7	115.7	83%
	Afforestation	16.8	16.5	98%
	Rural / Urban / Industrial	23.1	20.5	89%
	Transfer	142	112.2	79%
	Total	**320.6**	**264.9**	**83%**
Buffalo	Irrigation	66.9	50.2	75%
	Afforestation	16.7	14.2	85%
	Rural / Urban / Industrial	57.1	56.5	99%
	Transfer	31.6	31.6	100%
	Total	**172.3**	**152.5**	**89%**
Lower Thukela	Irrigation	33.3	33.3	100%
	Afforestation	5.5	5.5	100%
	Rural / Urban / Industrial	58	58	100%
	Transfer	37.9	37.9	100%
	Total	**134.6**	**134.6**	**100%**

3.1.4 Socio-economics and ecosystem services

The status quo assessment highlighted that the catchment (~29 000 km^2) is relatively undeveloped (75% representing natural untransformed land, 20% agricultural and 6% human settlement land uses) with the largest towns being Newcastle, Ladysmith, Dundee, Utrecht, Volksrust and Estcourt.

The catchment supports a range of economies but predominantly agriculture and to a lesser extent manufacturing, mining, and tourism. These industries economically support much of the population. The key district municipalities include uThukela (in the south), Amajuba (in the north), uMzinyathi (in the East) with portions of iLembe, uThungulu, uMgungundlovu on the peripheries.

The demographics assessment indicated a total population of approximately 1 848 001 with approximately 414 321 households, with a higher population density in the upper and western regions of the catchment and around the towns.

It was noted that access to services varies greatly within the different regions of the Thukela catchment and between the rural and urban communities, which indicates varied levels of wellbeing of the population in this catchment. A large proportion of the population in the central and south-eastern parts of the Thukela catchment rely on rivers, streams, and dams (impoundments) as their primary source of water.

There is considerable ecological infrastructure in the catchment including large wetland systems, rivers, dams, and impoundments. Large rivers include the Thukela, Buffalo, Sundays, Mooi, Blood and Bushmans Rivers as well as their many tributaries, and significant wetland systems include those found in the upper catchments such as Wakkerstroom, Groenvlei, upper Blood River, Ntshingwayo Dam, the foothills of the Drakensberg escarpment and the Thukela mouth.

The catchment houses large extents of protected landscapes especially those found along the Drakensberg escarpment stretching from the uKhahlamba-Drakensberg Park, a Ramsar site, the Natal National Park, through various nature reserves and wilderness areas toward the coastal Thukela marine protected area.

Key ecosystem services in the Thukela catchment were identified as:

1) Water Provisioning Services provided by network of rivers, dams and impoundments and Strategic Water Source Areas (SWSA) along upper catchment escarpment
2) Provisioning and regulating services provided by complex ecosystems identified in the Thukela catchment as major wetlands and the Thukela estuary.
3) Cultural services as indicated by the distribution of protected areas, tourism, and community demographics.

The socioeconomic assessment led to the development of a Socio-Economics Zones (SEZ) map, where Socio-Economic Zones are defined as zones of relatively homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems.

The SEZs provided the socio-economic input into IUA delineation to appropriately group IUAs based on similar water use objectives to ensure, as far as possible, appropriate catchment management approaches and objectives.

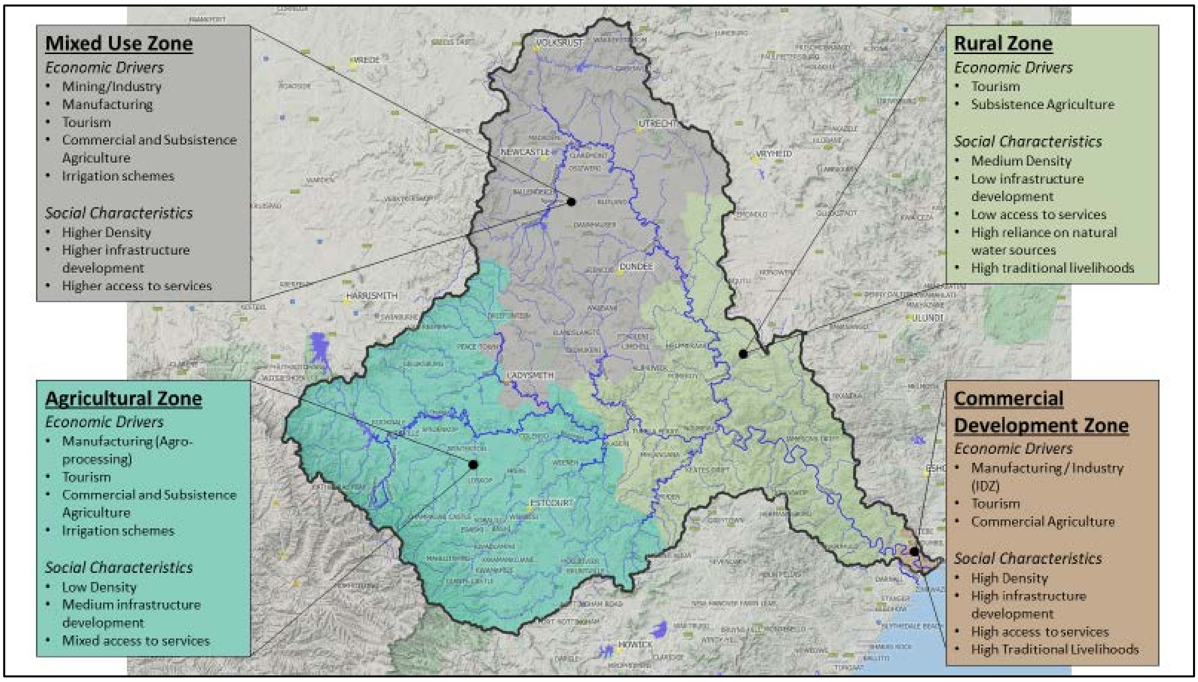

Figure 5: Socio-economic zones

3.1.5 Rivers

Each of the rivers within the network was characterised to determine how they form part of the defined network of significant water resources in terms of IUA delineation. The objective of capturing the suite of biophysical and ecological features of the rivers was to assess their uniqueness and significance in order to include them as part of the defined network and to establish nodes that characterise the target catchment's rivers at different scales. The main reivers identified are summarised in Table 5.

The status of the rivers within the Thukela Catchment were characterised based on their eco-regions, geomorphological zonation, present ecological state, ecological importance, and sensitivity (EIS) and hydrological character.

Table 5: Identified network of significant rivers in the Thukela catchment

Sub-catchment	Quaternary	Main river	Major Tributaries
V10	V11A-V11M, V12A-V12G, V13A-V13E, V14A-V14E	Upper Thukela River	Little Thukela, Putterill, Majaneni, Khombe, Mnweni; Mpandweni, Njongola, Venterspruit, Sandspruit, Mlambonja, Sterkspruit, Situlwane; Klip (and tributaries), Bloukrans (and tributaries)
V20	V20A-V20J	Mooi River	Klein-Mooi, Nsonge, Katspruit, Joubertsvlei, Mnyamvubu, Mbalane, Mhlopheni, Umdumbeni, iTshekana, Loza
V30	V31A-V31K, V32A–V32H, V33A–V33D	Buffalo River	Ngogo, Harte, Thaka, Slang, Doringspruit, Ngagane (and tributaries), Kweekspruit, Wasbankpruit, Mbabane, Blood, Tiyna, Eesteling, Sand, Totololo, Batse, Sibindi, Ngxobongo, Mangeni, Gubazi, Mazabeko
V40	V40A-V40E	Lower Thukela	Nadi, Mfongosi, Ngcaza, Manyane, Mamdleni, Nsuze and tributaries

Sub-catchment	Quaternary	Main river	Major Tributaries
V50	V50A-V50D	River	Mamba, Mambulu, Mpisi, Mati, Otimati, Nembe, Mandeni
V60	V60A-V60F	Sundays River	Dwars, Nkunzi, Wasbank (and tributaries), Nhlanyanga
	V60G-V60K	Thukela River	Sundays, Sikhehlenga, uMhlangana, Sampofu, Nadi, Mooi, Buffalo
V70	V70A-V70G	Bushmans River	Mtshezana, Ncibidwana, Klein Bushmans, Rensburgspruit, uMngwenya, Busone

In summary, the following was noted:

Eco-classificaton

- The Highveld eco-region is predominantly in the northern portion of quaternaries V31A; V31B – Wakkerstroom wetland, Zaaihoek Dam, and area of Volkrust.
- North-Eastern Uplands eco-region dominates the catchment area - Buffalo, Sundays, Klip, Thukela River; lower Bushmans, Lower Mooi
- The Eastern Escarpment Mountains eco-regions is seen in much of the escarpment area - source of the Thukela, Buffalo and Mooi rivers
- The South eastern Uplands eco-region is seen in the upper catchment of Mooi River and major portion of headwater catchments of quaternaries V50A and V50B, and
- The North Eastern Coastal belt eco-region is seen in the Thukela Estuary and portion of headwater catchments of quaternaries V50B and V50C.

Geomorphology

The geomorphological zones that occur in the Thukela catchment and their extent are listed below. The upper and lower foothills (class D and E) are dominant river geomorphological classes in the catchment. The zones were used as a basis for delineation of the IUAs.

- Class A: Mountain Headwater Stream – 2.82%
- Class B: Mountain Stream – 5.31%
- Class C: Transitional – 10.80%
- Class D: Upper Foothills – 36.26%
- Class E: Lower Foothills – 35.46%, and
- Class F: Lowland River - 9.34%.

Present Ecological State

The Thukela catchment includes 285 Sub-Quaternary (SQ) river reaches. Much of the catchment is in a C PES ecological category (112 river reaches), indicating moderate modification, with ecosystem functionality still largely intact. A number of river systems are in a very good ecological condition*,* natural to largely natural state (A and B present ecological state). A small portion of the rivers in the Buffalo River catchment are largely modified (D present ecological state), due to the impacts from land use, development, and associated activities, while three river reaches within the Ngagane, Mooi and Sundays rivers sub-catchments are in a seriously modified state (PES of an E category). No reaches are critically modified (F category). Figure 6 illustrates the PES and drivers of change.

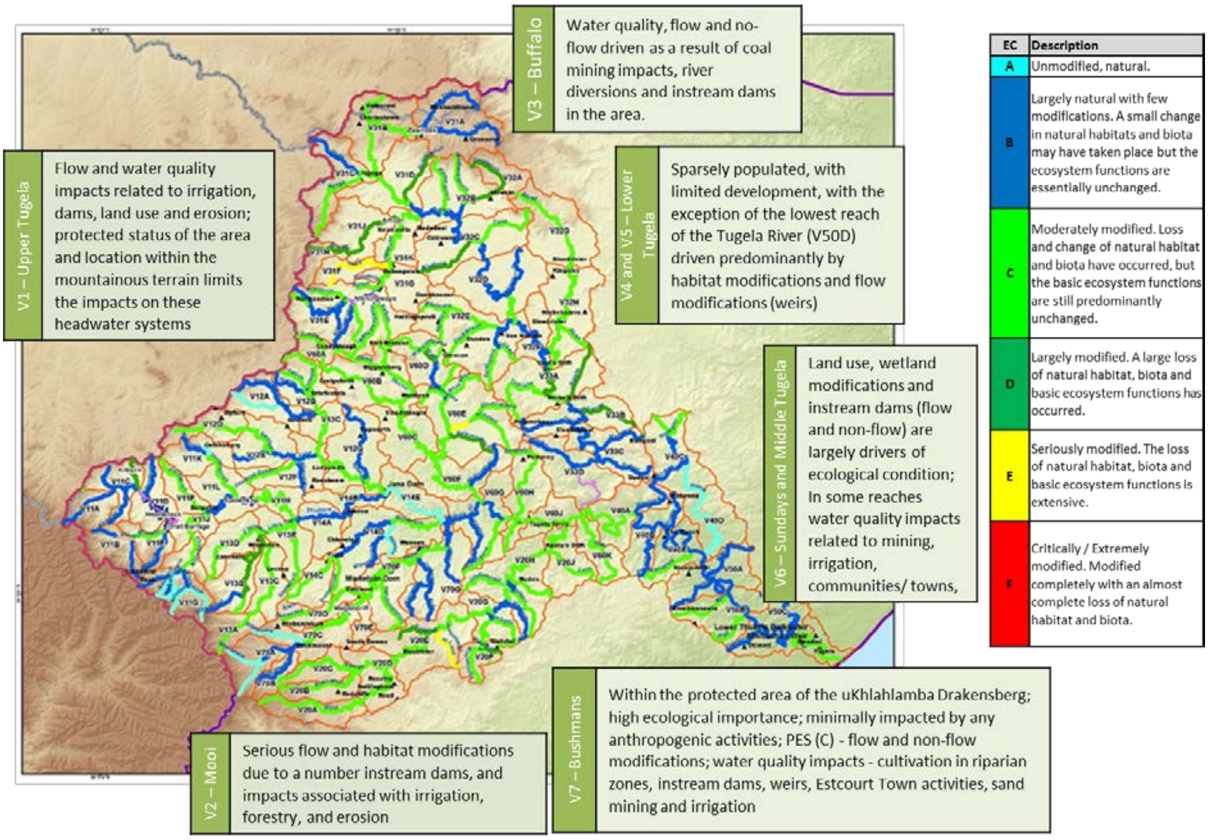

Figure 6: Present Ecological Status (PES) and drivers of change

Hydrological Character

Hydrological Index values were used to characterise hydrological variability at a quaternary catchment level throughout South Africa. The Thukela River and all its tributaries are classified as perennial rivers.

Protected Areas

The Thukela catchment includes approximately 35 protected conservation areas of high biodiversity, cultural heritage, water, and landscape importance. The uKhahlamba-Drakensberg Park is the most prominent conservation area in the catchment area, designated a World Heritage Site by UNESCO in 2000. It includes a number of pristine and primitive wilderness areas ("areas free from the sights and sounds of modern man", (Kruger *et. al*, 2011). Some smaller conservation areas and historic sites.

Other protected areas include the Royal National Park, and Weenen and the Nkandla Nature Reserves (V40D). The catchment also includes a number of ecological sensitive and biological diverse areas such as waterfalls and major gorges that are habitat to a number of rare and diverse species of flora.

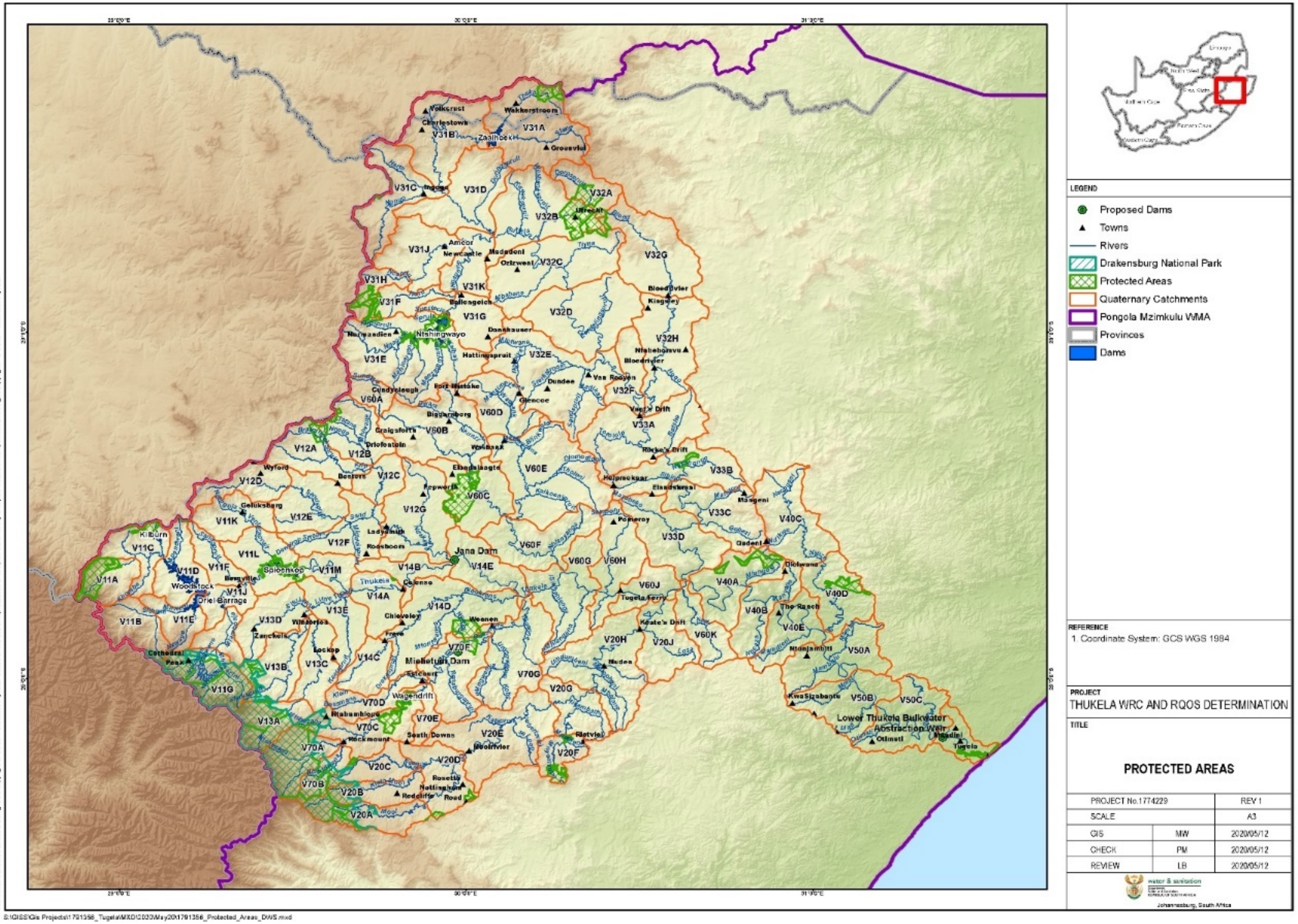

Figure 7: Protected Areas in the Thukela Catchment

Water Quality

Assessment of the present water quality status quo was based on assessing the fitness for use of the water for key water user, namely irrigation water use, domestic water use, and aquatic ecosystems, considering electrical conductivity, total dissolved salts (TDS), pH, sodium, magnesium, calcium, fluoride, chloride, sulphate, ortho-phosphate as P, ionised ammonia as N, nitrate as N. Microbiological assessment was not undertaken because of inadequate data.

The historical monitoring data for the Thukela catchment for the 10-year period 2008/2009 to 2018 was found to be limited at some sites and with infrequent and inconsistent monitoring.

The assessment indicated that the key water quality concerns include salinity and elevated nutrients. The drivers of the impacted water quality within the catchment are associated largely with localised issues around the towns, industrial areas, and mines, as well as poor agricultural practices.

- Coal Mining (coal) – the Ngagane, middle Buffalo and upper Wasbank Rivers are impacted by numerous closed coal mines in the Newcastle, Dundee and in the Sundays River catchment.
- Sand Mining – the Buffalo River from the Ngagane River confluence to the lower reaches is impacted by sand mining causing high sediment load in the river channel, further compounded by increased soil erosion due to poor land management practices in the catchment.
- Poor performing domestic wastewater treatment works (WWTWs) are a major concern and a significant source of nutrient enrichment and high organic load in the river systems of the Thukela Catchment, as well as microbiological contamination: the towns of Weenen, Wembezi and Estcourt were rated as critical risk WWTWs, and Ladysmith, Bergville, Colenso, Ekuvukeni, Winterton, Ezakheni, Utrecht and Tugela Ferry were rated as high risk WWTWs. The poor performing WWTWs, failing sewer infrastructure and overflowing sewer manholes is a major threat to the water quality of the Thukela Catchment.
- Industrial activity – large industrial development in the Newcastle area (Madadeni) impacts on the salinity levels of the Ngagane River and the downstream Buffalo River; Sappi Paper Mill at Mandini has a significant water quality impact on the Lower Thukela River; industrial discharges from various industrial activities in the Mooi River catchment, the Klip River (outside Ladysmith) and in the Bushmans River below Estcourt impact the water resources.
- Agricultural activity (commercial and subsistence) occurs extensively throughout the Thukela Catchment in the upper and middle Thukela, Buffalo River, Bushmans River, Mooi River and Sundays River catchments. Elevated salinity and nutrients were observed within these areas, likely due to the leaching of fertilisers and agro-chemicals from the soil. High irrigation-runoff is also prevalent in the middle/lower Buffalo, Blood, upper Mooi and upper Thukela River catchments. Soil erosion associated with poor agricultural and severe overgrazing, with the consequent loss of habitat and siltation of dams in the upper catchment is a potential concern in the catchment.

3.1.6 Groundwater

The status quo assessment noted that the hydrogeological characteristics of the Thukela catchment is driven by the presence of a wide range of geological formations: basement formations (*viz*. Natal Sector of the Namaqua-Natal Orogeny Province), altered sediments of the Natal Group, and glacial-marine-fluvial sediments of the Karoo Supergroup. The Karoo sedimentary sequence was finally capped by continental flood basalts deposits and an underlying network of intrusive Karoo dolerite dikes, sills and saucer-shaped sheets represent the intrusive feeder systems developed in the host rock formations. These features play a significant role on groundwater occurrences and potential.

In terms of groundwater-surface water interaction, two aspects were highlighted:

- River-alluvium aquifers; and
- Wetlands.

It was noted that uncontrolled abstraction of groundwater from (i) a river-alluvium aquifer, and (ii) within a certain distance to a groundwater-dependant wetland, should be regarded as a risk for the surface water resource. The assessment indicated that baseflow and the groundwater component of the baseflow discharges conducted during the 2009 groundwater Reserve determination study, were still applicable.

Hydrogeology, Aquifer Types and Vulnerability

The predominant aquifer types within the study area are:

- Weathered (intergranular) and Fractured Type consisting of sedimentary hard rock aquifer systems (d1 to d3 classes); and
- Fractured Type consisting of sedimentary/metamorphosed hard rock aquifer systems (b1 to b3 classes).

Other aquifer systems occurring on a lower scale include:

- Dolerite Contact Zone (hard rock) aquifers present where the Karoo Dolerite intrusions occur.
- Primary aquifers (river sediment alluvium) that are confined to a narrow strip along the coast and the middle reaches of the Thukela, Sundays, and Buffalo rivers. The primary aquifer in the immediate vicinity of the estuary provides a source of moderate quality water to the estuary during periods of low flow.

Except in the coastal area around the estuary, aquifers in the Thukela River Catchment are classified as minor aquifers, (<1.0 L/s), as per DWAF (2005) National Geohydrological Map Series. In terms of their hydraulic physical characteristics, they are regarded as low permeable types. Secondary water bearing zones exist due to secondary geological features – mainly developed during the Karoo Dolerite Intrusive event prior to the Gondwana Land breakup. Permeability of these water bearing zones could be an order of magnitude higher than the primary values.

Recharge

Average recharge values vary between 15 and 45 mm/a, or between 1 and 6% of Mean Annual Precipitation (MAP) based on the geological formations present in the catchment. Approximately 85% of the catchment consists of Beaufort Group (arenite and mudstone) and Ecca Group (shales, arenite, coal, and shale) with recharge figures of around 25 mm/a (3% of MAP).

Water levels

It was noted that the spread of water level monitoring data in the catchment is limited. The highest concentration of active monitoring geosites are limited to the Middle Buffalo and Ngagane and related to specific coal mine related monitoring. Only a few geosites are monitored in the southern parts of the catchment.

Pre-2009 water levels from eight geosites in the Thukela catchment were illustrated in the 2009 Reserve determination and reports quite stable water level conditions. Long-term, and post-2009 water level time series data from the catchment indicated water level trends with a similar pattern to the pre-2009 period. However, it was noted that a clear water table recession took place from 2012 to 2017 due to potential over abstraction and/or limited groundwater recharge due to a drier period (drought between 2014 and 2016).

Groundwater use

Based on the existing WARMS data, which was noted to be incomplete and only a fraction of the groundwater use determined in the 2009 study, it was estimated that the total groundwater use (volume abstracted) is in the order of 5.4 Mm^3/a, excluding the large irrigation and plantations. When the volume for plantations and irrigation was included, the total (2020) estimation for groundwater use was in the order of 435 Mm^3/a (with 0% increase of the plantations areas).

Groundwater Quality

Groundwater quality in the catchment is generally good, with the best quality groundwater found in the higher rainfall portions and the poorest quality found in the lower rainfall areas. Poorer quality groundwater is found in the lower reaches of the Upper Thukela, Bushmans and Mooi river catchments, probably reflecting the influence of the argillaceous sediments in this part of the study area. Groundwater pollution is generally not of significant proportions and, where present, is localised from mine decants, urban and rural sanitation impacts, agricultural impacts, and industrial discharges especially in the Newcastle and Estcourt areas.

The assessment noted that a large part of the catchment has groundwater with conductivity levels of low to moderate (a range from 0-300 mS/m) in the Middle Buffalo, Mooi, Klip, Middle Thukela, and Lower Thukela rivers. A few hotpots, such as in the Lower Mooi River catchment, showing EC> 300mS/m (Figure 6).

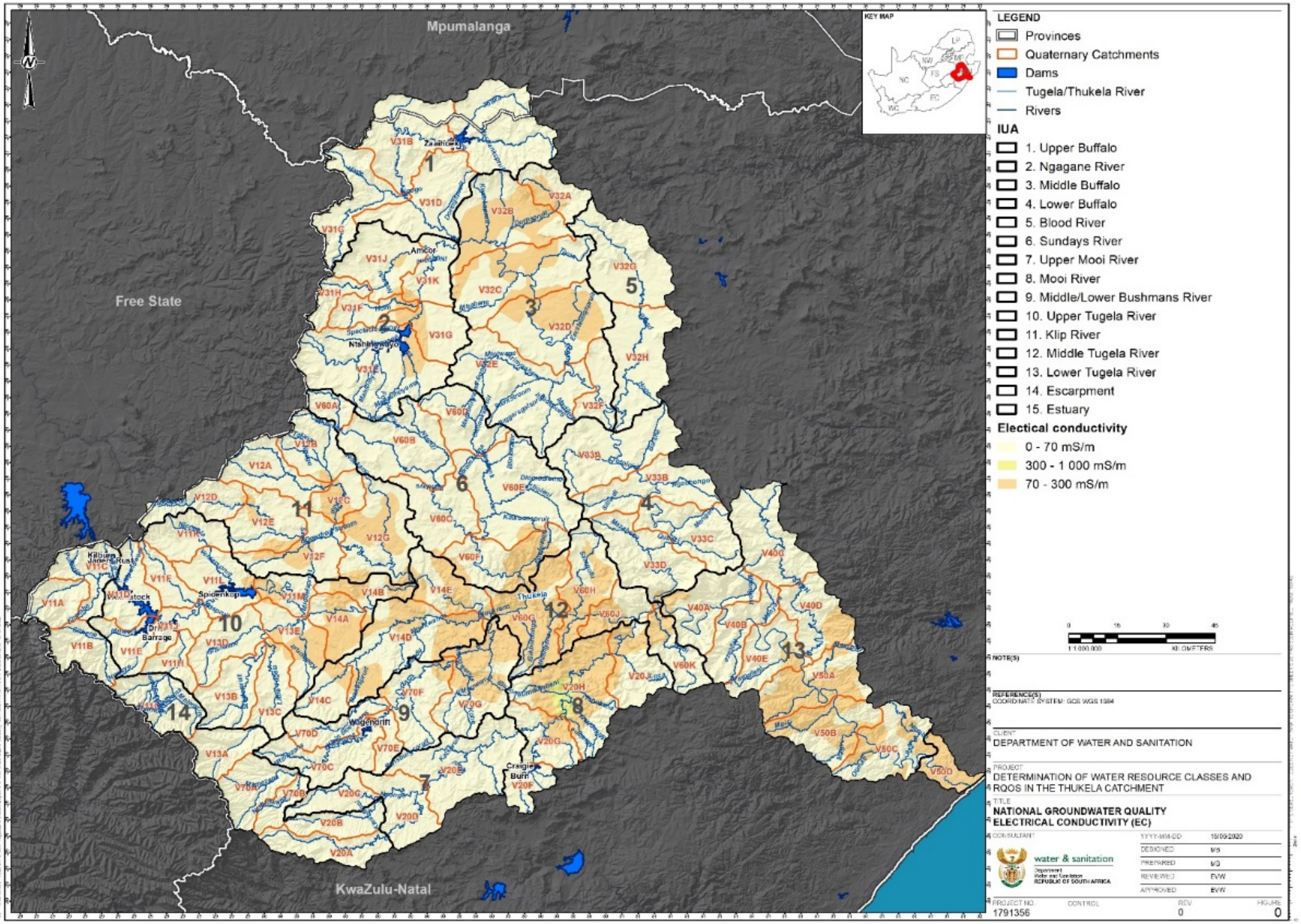

Figure 8: Groundwater quality assessment outcomes

3.1.7 Wetlands

Use was made of the National Wetland Map 5 (Van Deventer *et al*., 2018), the NFEPA wetland layer (Nel *et al*., 2011), data received from the KwaZulu Natal (KZN) Wildlife and ground-truthing to identify and map the significant wetland resources in the Thukela catchment. Five different hydro-geomorphic (HGM) wetland types have been described as occurring in the Thukela catchment:

- Seeps, being the most extensive making up 56.6% of the total wetland habitat mapped
- Channelled Valley Bottom systems making up 22.5% of wetland area
- Unchannelled Valley Bottom systems, making up 14.5% of wetland area
- Floodplains, making up 3.8% of wetland area, and
- Depressions, making up 2.5% of wetland area.

While wetlands occur in all catchments of the Thukela, at this stage eleven Priority wetland systems have been identified in seven areas, (IUAs 1, 3, 5, 6, 7, 8 and 9) of these with the Natal Drakensberg Park Ramsar Site.

The assessment showed that across the entire Thukela Catchment wetlands have been significantly impacted with 73.8% of wetland area being considered Largely to Critically Modified (wetland condition category D/E/F)

Figure 9 illustrates the conditions for prioritised wetlands.

It was noted that less than 10% of the wetland area within the Thukela Catchment is considered to still be in a Largely Natural to Natural state (wetland condition category A/B).

The Upper Buffalo sub-catchment, which includes the Wakkerstroom and Groenvlei Priority Wetlands, has the greatest extent (2 630 ha) of wetlands within a Natural to largely Natural (A/B) category, making up 15.7% of the wetlands within this catchment.

The Ngagane River catchment and Blood River catchment, which includes the Blood River Vlei Priority Wetland are reported to have 86% of the wetlands in the Largely to Critically modified (D/E/F) category.

]dsThe lowest percentage (54.7%) of Largely to Critically Modified wetlands was found within the Sundays River catchment.

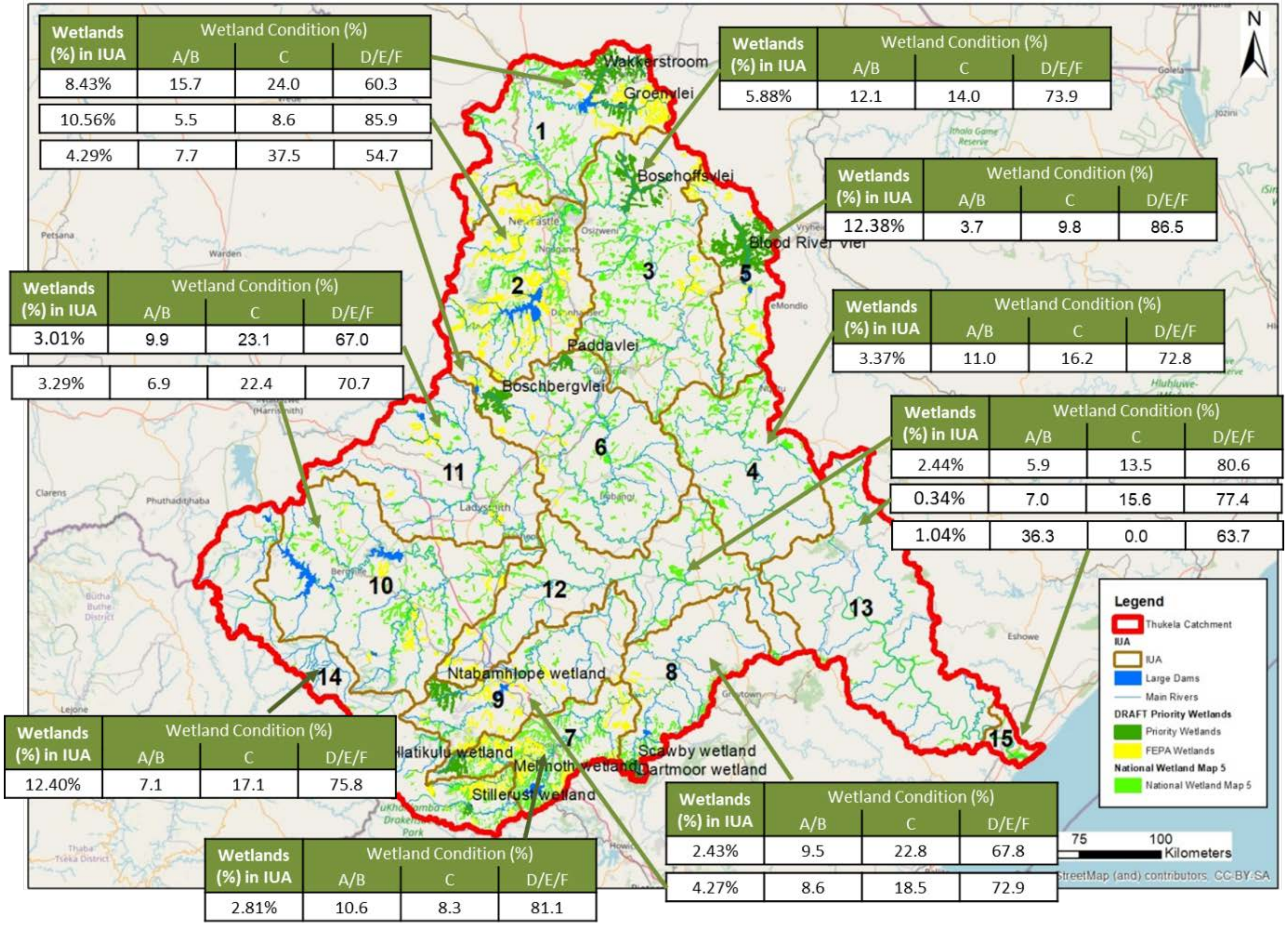

Figure 9: Prioritised wetlands

3.1.8 Thukela Estuary

Thukela estuary forms the downstream extent of the Thukela River, which is the largest river system along the KwaZulu-Natal (KZN) coastline and is located in the Marine Protected Area (MPA) gazetted in 2019. The estuarine area of the Thukela River is small, because of high riverine runoff, and the surface area of the estuary during low flow periods is approximately 0.6 km^2. The Thukela Estuary is characterised by a significant dominance of freshwater characteristics. It is unlike any other system provincially and is one of only two estuarine systems in the country that is classified as a true river mouth based on Whitfield's (1992) estuary classification scheme. This system is therefore quite unique and is evidently vulnerable to changes in the quality and quantity of flows entering and flowing through the estuary.

The findings of the National Biodiversity Assessment (NBA) undertaken in 2018, assigned the Thukela Estuary a PES of D, indicating that the estuary is heavily modified as a result of significant loss of Process and Pattern, and the estuary's importance rating was 'important' (van Niekerk *et al*. 2019), indicating the need to improve the system in respect of the following threats:

- Flow modification
- Pollution, largely attributed to agriculture in the catchment and plastic from marine and stormwater sources
- Habitat loss
- Over-fishing (almost doubling in 10 years) and bait collection, and
- Alien fish.

3.2 Integrated Units of Analysis

The outcomes of the status quo assessment informed the delineation of the integrated units of analysis (IUA). Each IUA represents a homogenous area which requires its own specification of the water resource class. The process followed in terms of IUA delineation was that described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWA, February 2007).

Fifteen IUAs were delineated for the Thukela catchment. The results of the delineation are tabled below (Table 6) and illustrated in Figure 10.

Table 6: Integrated Units of Analysis (IUA)

IUA	Delineation	Quaternary Catchment
1	Upper Buffalo	V31A; V31B; V31C and V31D
2	Ngagane River	V31E; V31F; V31G; V31H; V31J; V31K
3	Middle Buffalo	V32A; V32B; V32C; V32D; V32E; V32F;
4	Lower Buffalo	V33A; V33B; V33C; V33D
5	Blood River	V32G; V32H
6	Sundays River	V60A; V60B; V60C; V60D; V60E; V60F
7	Upper Mooi River	V20A (lower portion); V20B (lower portion); V20C; V20D; V20E
8	Middle/Lower Mooi River	V20F; V20G; V20H; V20J
9	Middle/Lower Bushmans River	V70A (lower portion) V70C; V70D; V70E; V70F; V70G
10	Upper Thukela River	V11A (lower portion), V11C; V11D; V11E; V11F; V11H; V11J; V11K; V11L; V11M; 13A (lower reaches) V13B; V13C; V13D; V13E; V14A; V14B
11	Klip River	V12A; V12B; V12C; V12D; V12E; V12F; V12G
12	Middle Thukela River	V14C; V14D; V14E; V60G; V60H; V60J; V60K
13	Lower Thukela River	V40A; V40B; V40C; V40D; V40E; V50A; V50B; V50C; V50D (upper portion)
14	Escarpment	V20A (upper reaches); V20B (upper reaches); V70A (upper reaches); V70B; V13A (upper reaches); V11G; V11B; V11A (upper reaches)
15	Thukela Estuary and upstream Thukela reach	V50D

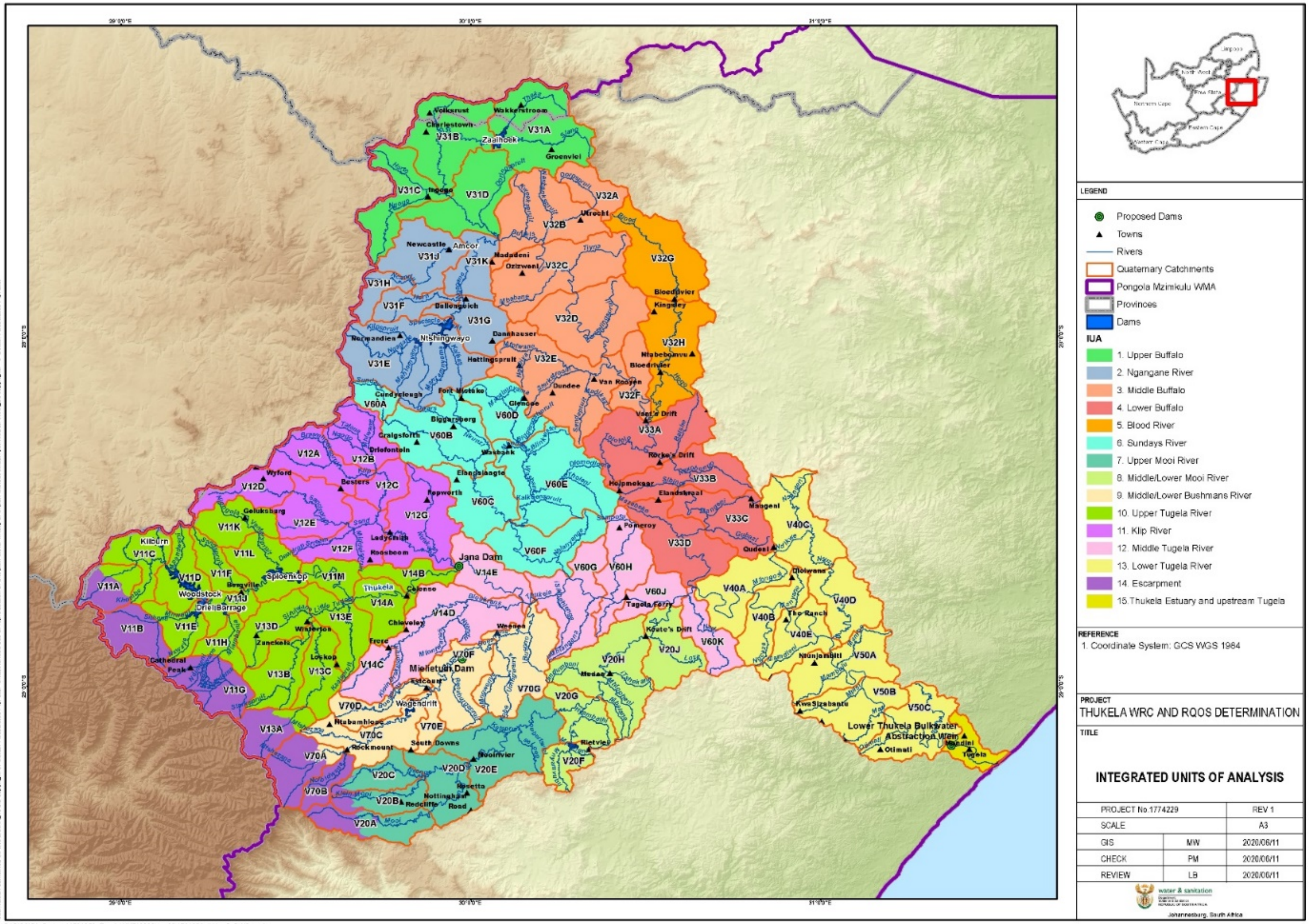

Figure 10: Integrated Units of Analysis

4 EVALUATION OF SCENARIOS WITHIN THE INTEGRATED WATER RESOURCE MANAGEMENT PROCESS

4.1 Linking the Socio-economic and Ecological Value and Condition of the Water Resources

Following delineation of integrated units of analysis and status quo assessment, linking the value and condition of the water resources is the next step required in terms of the water resource classification procedure. This step required the quantification of the relationships that link socio-economic and ecological value and condition of water resources, the selection of those linkages that were considered priority, and determination of the scoring system to be used to evaluate the catchment scenarios in later steps of the process.

The outcome of this assessment and the results of the Integrated Economic Model (IEM) developed for the Thukela catchment towards demonstrating socio-economic and ecological linkages are detailed in Report: RDM/WMA04/00/CON/CLA/0420.

As natural features in the landscape, ecosystems provide environmental, social, and economic benefits to communities. The value of ecosystems in providing these free ecosystem services to a range of formal and informal beneficiaries has been vigorously demonstrated and there is ever growing recognition of their importance to human well-being at multiple scales. Impacts or changes to ecosystems (or Ecological Infrastructure) therefore alters the ability to supply valuable services to beneficiaries, where ecological infrastructure refers to functioning ecosystems that deliver valuable services to people such as fresh water, water and climate regulation, cultural services, and soil formation.

An established approach to defining these linkages is through the use of Ecosystem Services Frameworks as formalised and refined through initiatives such as the Millennium Ecosystem Assessment (MEA 2005, MEA 2010), The Economics of Ecosystems and Biodiversity (TEEB 2013) and the Final Ecosystem Goods and Services Classification System (Landers and Nahlik 2013). Demonstrating these linkages required the development of Ecosystem Services Classification and Modelling, Physical and Financial Water Accounts and Quasi-Social Accounting Matrix (QSAM) for the Thukela catchment. The results were then used to inform the evaluation of scenarios.

Key ecosystem services identified and prioritised across the Thukela catchment as per IUA included:

- Fresh Water Provisioning
- Water Quantity Regulation
- Food, Raw Materials and Wild Collected Products Provisioning
- Erosion Regulation
- Water Quality Regulation: Purification and Waste Management
- Spiritual, Landscape and Amenity Services
- Tourism and Recreational Services, and
- Biodiversity Support.

Beneficiaries, as per those identified through the QSAM, of prioritised ecosystem services were consolidated per ecosystem service (Table 7).

Table 7: Ecosystem Service linkages with QSAM beneficiaries in the Thukela catchment

Intermediate Ecosystem Service	Final Ecosystem, Services	General Sector	QSAM Beneficiary Class
Water Quality Regulation Water Quantity Regulation Erosion and Soil Regulation	Food Provisioning	Informal Households	Non-observed, informal, non-profit, households
		Agriculture	Agriculture
	Fresh Water (Water quantity) Provisioning	Households	Non-observed, informal, non-profit, households
			Households
		Agriculture	Agriculture (Irrigation)
		Forestry	Forestry
		Manufacturing	Food
			Beverages and tobacco
			Tanning and dressing of leather
			Paper
			Other chemical products, man-made fibres
			Rubber
			Plastic
			Glass
			Basic iron and steel, casting of metals
			Basic precious and non-ferrous metals
			Machinery and equipment
			Electrical machinery and apparatus
			Radio, television, communication equipment and apparatus
			Motor vehicles, trailers, parts
			Other transport equipment
			Furniture
			Manufacturing (not already included above), recycling
		Mining	Mining of coal and lignite
			Other mining and quarrying
		Government Services	Electricity, gas, steam, and hot water supply
			Collection, purification, and distribution of water
			Sewage and refuse disposal
	Raw Materials Provisioning	Informal Households	Non-observed, informal, non-profit, households,
	Medicinal resources Provisioning	Informal Households	Non-observed, informal, non-profit, households,
	Landscape & amenity values	Households	Non-observed, informal, non-profit, households,
			Households
			Real estate activities
	Ecotourism & recreation	Accommodation	Hotels and restaurants
		Recreation/Activities	Recreational, cultural, and sporting activities

Through the development of the IEM, several key linkages and insights were revealed. The Thukela catchment contributes an estimated R79.3 billion to the economy of South Africa. This economy is relatively small representing only 1.9% of the national GDP of R4.17 trillion (Stats SA 2017). The largest sectors include the government sector, agriculture, hotels and restaurants and real estate activities which represent 14.5%, 10.3%, 4.9% and 4.9% contribution to the catchment respectively.

Only 29 of the 56 sectors identified to be operating within the Thukela catchment were directly linked as beneficiaries of ecosystem services. The links are predominantly through the provisioning and regulation of much needed fresh water, but also through cultural services, including tourism and recreation, and landscape amenity values. The 29 sectors constitute 45% of total Gross Value Added (GVA) (R35 billion GVA) and provide approximately 125 000 jobs. Although the value added by the 29 sectors in their entirety cannot be directly attributed to ecosystem services, the support these services provide through enabling or opportunity benefits, is significant. The natural contributions can therefore be linked as a proportion of the total size of the sectors.

In respect of the management of water, the agricultural (specifically irrigated agriculture), agricultural manufacturing, households, and government sectors were highlighted as key contributors to the water economy in the Thukela. These contributions indicate linkages between the requirements of fresh-water provisioning services on the sectors themselves and therefore indicate linkages between production and natural benefits.

The agriculture sector, by total GVA, is the largest sector within the Thukela catchment relying heavily on water provisioning services. The sector contributes 10.3% to the Thukela total GVA, and provides an estimated 44,000 jobs, making it a valuable economic driver of total socio-economic wellbeing of the catchment.

Agricultural manufacturing represents a group of economic sectors which are involved in manufacturing goods from raw materials sourced directly from agriculture. These include the food processing, beverage, and tobacco, tanning and dressing of leather, and paper production industries. Agricultural manufacturing contributes to the catchment's water economy through the purchase of both natural water (raw water) and distributed water (treated water), representing 28.8% of total water purchases, in financial terms. This illustrates the relatively high reliance of water provisioning in this sector's functioning. The broader manufacturing sector is responsible for 11.3% of all treated water transactions. Although the agricultural manufacturing sector is relatively small representing only 3.75% of the total Thukela GVA it provides an estimated 6,800 jobs which, as described above, is directly supported by the water provisioning services.

Households represent the largest purchaser of treated water, accounting for 38.8% of the total distributed treated water purchases. Use of water in government operations such as but not limited to the maintaining of municipal infrastructure and parks (please note this sector excludes water distribution, collection, and purification operations; and the education and health sectors) contributes 22.5% of total treated water transactions. Accounting for 14.5% of the region's GVA, the total government sector represents the largest economic sector in Thukela.

Tourism is a key economic driver in the catchment and is represented here by the hotel and restaurant and the recreational, cultural, and sporting activities sectors. The linkages with water provisioning services are not as clear as the sectors described above with the sectors associated with tourism representing only 3.9% of total transactions in the water economy (treated water). The linkages with cultural ecosystem services provided by key ecological infrastructure on the other hand was clearer, with direct linkages to the presence of ecological features associated with tourism and recreational activities, such as the Drakensberg escarpment, protected areas (both government and private), large dams, the midlands, the coast, and the Thukela estuary. The total sector is observed to make a relatively large contribution, at 4.9%, to catchment GVA, providing 10,700 jobs.

It was noted that while linkages between beneficiaries within the Thukela catchment have been demonstrated and linked with the opportunity value of water, the total opportunity value is in fact underestimated when only looking at sectors within the Thukela catchment. The various water transfers out of the catchment provide additional linkages to beneficiaries which represent increased opportunity value to sectors in the greater region.

The catchment has a highly rural character, and the economy is relatively small from a formal economic perspective and there is an important informal economy. These beneficiaries reside specifically within the rural and traditionally owned land which constitutes approximately 26% of the catchment extent and 44% of the total population. Subsistence-based livelihoods are prevalent within these communities having intimate relationships with the natural systems represented by direct linkages to a broader range of ecosystem services. The benefits are realised predominantly through provisioning of food, collection of raw materials, medicine and fresh water, regulation of water and soils and cultural and spiritual services provided by the traditionally significant landscape.

It was noted that the value of these natural benefits to communities who rely directly on them, coupled with limited access to alternatives translates very differently to Rands and Cents compared to economic production. For instance, the value of drinking water (which is necessary for survival) versus the value of irrigation water (which is necessary for production).

4.2 Ecological Water Requirements

The approach undertaken for the quantification of ecological water requirements is detailed in Report Number: RDM/WMA04/00/CON/CLA/0620. The report describes the approaches, methods and models used to determine the EWR for priority rivers in the Thukela catchment at selected sites. These determinations are on the various levels of detail as described in volume 3 of the RDM methodology of 1999 (DWAF, 1999). Where available and applicable, information from previous Reserve studies were utilised and updated with new information from field surveys undertaken during September 2020.

A differentiated approach was followed for the quantification of the ecological water requirements, including:

(i) New Rapid I, II and III assessments (surveys in September 2020) included:
- Information collected during the field surveys,
- Results from the Eco-classification process (Present Ecological State (PES), Ecological Importance (EI), Ecological Sensitivity (ES) and Recommended Ecological Category (REC),
- Desktop Reserve Model (DRM) within SPATSIM for the integration of data produced from the surveys and Eco-classification to quantify the EWRs,
- Results from the hydraulic modelling (cross-sectional profile and discharge) to evaluate the DRM requirements, and
- Evaluation of the water quality at specific selected sites where quality was identified as an issue.

(ii) Revisit of existing EWR sites from previous studies (mainly 2003 comprehensive sites). The surveys at these sites were undertaken to assess the PES due to increased or proposed new water uses in the upper catchments, e.g., Mooi River with the Spring Grove Dam that was constructed after the 2003 study.

(iii) River reaches where no existing EWR sites were present (e.g., Upper Thukela after Thukela and Little Thukela confluence, Blood River IUA). These were undertaken at desktop level, using the Desktop PES/EI/ES results, as no additional information was available.

(iv) IUA14 was defined as the Escarpment IUA with most of the river reaches in protected areas. The EWR for these were undertaken at desktop level, using the Desktop PES/EI/ES results as no additional information was available.

(v) Extrapolation to the outlets of IUAs where the existing EWR sites are not at the outlet. The information from the lowest EWR site in the IUA was used for the extrapolation, and

(vi) The results from all the other existing EWR sites where no additional information was obtained have been accepted as is and the adjustments were made where the hydrology used in this study differed significantly.

As part of the scenarios analysis some trade-offs had to be made for some of the EWRs. The final outcomes with comments on which changes had to be made, are included in Table 8.

Table 8: Summary of final PES (dam outlet capacity constraints) and TEC (socio-economic trade-offs) and flows (million m^3 per annum)

IUA	EWR site	Sub-reach	River	Final PES	Final TEC	Comments wrt trade-offs	nMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
							Flows in million m^3 per annum (%MAR)				
IUA1	THU_EWR23	V31D-02370	Upper Buffalo	C	C	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	221.96	52.03 (23.44)	33.13 (14.93)	8.6 (3.86)	18.90 (8.51)
IUA2	May13_EWR2	V31F-02600	Horn	C	C	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	21.61	7.27 (33.65)	4.94 (22.84)	0.7 (3.50)	2.34 (10.81)
	THU_EWR19	V31J-02487	Ncandu	C		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	50.83	11.82 (23.25)	6.33 (12.45)	2.01 (3.95)	5.49 (10.81)
					B/C			14.9 (29.36)	8.78 (17.28)	2.01 (3.95)	6.14 (12.09)
	May13_EWR3	V31G-02618	Ngagane	C		PES – Adjust for dam constraints (reduce floods, freshets) TEC - Reduce freshets, floods further for Nov-Mar	160.12*	35.98 (22.47)	21.33 (13.32)	8.15 (5.09)	14.66 (9.15)
					C/D			31.13 (19.44)	21.33 (13.32)	8.15 (5.09)	9.80 (6.12)
	Ngagane_dsk[#]	V31K-02516	Ngagane	C		PES – Adjust for dam constraints (reduce floods, freshets) TEC - Reduce freshets, floods further for Nov-Mar	240.84	45.45 (18.87)	23.33 (9.69)	8.94 (3.71)	22.12 (9.18)
					C/D			39.00 (16.19)	23.33 (9.69)	8.94 (3.71)	15.67 (6.51)
IUA3	THU_EWR13A	V32D-02699	Buffalo	D		PES – Reduce large flood in Feb TEC – Reduce large flood in Feb, increase ML flows	626.68	96.04 (15.32)	24.76 (3.95)	22.43 (3.58)	71.28 (11.37)
					C/D			113.73 (18.15)	42.45 (6.77)	22.43 (3.58)	71.28 (11.37)
	Thukela_EWR13	V32F-02707	Middle Buffalo	D		PES – Reduce large flood in Feb TEC – Reduce large flood in Feb, increase ML flows	695.05	100.31 (14.43)	27.34 (3.93)	24.77 (3.56)	72.97 (10.50)
					C/D			120.65 (17.36)	47.08 (6.77)	25.31 (3.64)	73.57 (10.58)
IUA4	Thukela_EWR14	V33B-03090	Lower Buffalo	B/C		No changes to EWR due to dam constraints (PES) TEC – Reduce drought flows to 0.4cumec Oct-Dec	831.09	193.14 (23.24)	84.27 (10.14)	19.98 (2.40)	108.87(13.10)
					C			193.14 (23.24)	84.27 (10.14)	19.19 (2.31)	108.87 (13.10)

IUA	EWR site	Sub-reach	River	Final PES	Final TEC	Comments wrt trade-offs	nMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
							Flows in million m^3 per annum (%MAR)				
IUA5	Blood_ dsk	V32H-02834	Blood	C	C	PES – Change category from B/C to C TEC – No changes to EWR due to dam constraints or trade-offs	94.71	20.23 (21.36)	11.83 (12.49)	6.01 (6.35)	8.40 (8.87)
IUA6	THU_ EWR7A	V60B-02826	Upper Sundays	C/D		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	50.69	14.65 (28.90)	5.49 (10.82)	2.87 (5.66)	9.16 (18.07)
					C			15.96 (31.48)	6.8 (13.41)	2.87 (5.66)	9.16 (18.07)
	Thukela_ EWR7	V60C-03031	Sundays	C/D	C/D	PES – Change category from B/C to C/D TEC – Reduce maintenance low flows. Reduced floods in Feb, Mar	90.28	17.79 (19.71)	9.83 (10.89)	5.14 (5.69)	7.96 (8.81)
	Thukela_ EWR8	V60F-03210	Sundays	D	D	PES – No changes to EWR due to dam constraints TEC – Reduce flood in Feb	197.03	38.52 (19.55)	13.30 (6.75)	8.96 (4.55)	25.22 (12.80)
								32.41 (16.45)	13.30 (6.75)	8.96 (4.55)	19.10 (9.70)
IUA7	THU_ EWR20	V20C-03919	Nsonge	C		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	27.13	6.2 (22.84)	3.88 (14.32)	2.94 (10.84)	2.31 (8.52)
					B/C			7.86 (28.99)	5.35 (19.73)	2.94 (10.84)	2.51 (9.26)
	EWR_ Mooi_N3	V20E-03884	Mooi	E	D	Reduce floods for Jan-Mar due to dam constraints for PES and TEC	265.81*	48.75 (18.34)	32.85 (12.36)	19.75 (7.43)	15.90 (5.98)
	Thukela_ EWR11	V20E-03742	Mooi	C/D	C/D (short term)	PES – Change category from B/C to C/D for short term TEC – Reduce floods for Jan-Mar	301.14*	61.96 (20.57)	40.62 (13.49)	17.67 (5.87)	21.33 (7.08)
					B/C (long term)			106.65 (35.41)	74.53 (24.75)	18.27 (6.07)	32.12 (10.67)
IUA8	THU_EW R21	V20G-03853	Mnyamvubu	C	C	Adjust PES and TEC for dam constraints (reduce	31.71	6.32 (19.94)	4.18 (13.20)	2.12 (6.69)	2.14 (6.75)

IUA	EWR site	Sub-reach	River	Final PES	Final TEC	Comments wrt trade-offs	nMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
							Flows in million m³ per annum (%MAR)				
						maintenance flows, floods, freshets)					
	THU_ EWR12A	V20H-03500	Mooi	C/D		Reduce large floods Dec-Mar for PES and TEC	361.85	90.04 (24.88)	58.21 (16.09)	37.69 (10.42)	31.83 (8.80)
					C			107.89 (29.82)	76.07 (21.02)	37.69 (10.42)	31.83 (8.80)
	Mooi_ dsk##	V20J-03467	Mooi	C	C	Reduce large floods Dec-Mar for PES and TEC	388.66	113.53 (29.21)	81.94 (21.08)	40.68 (10.47)	31.59 (8.13)
IUA9	Thukela_ EWR5	V70F-03548	Middle Bushmans	B/C		PES – No changes to EWR due to dam constraints TEC – Reduce freshets and floods	281.45	99.59 (35.39)	62.93 (22.36)	19.75 (7.02)	36.66 (13.03)
					C			81.73 (29.04)	45.01 (15.99)	21.37 (7.59)	36.71 (13.04)
	THU_EW R6A	V70G-03515	Bushmans	D		PES – No changes to EWR due to dam constraints, reduce freshets, floods TEC – Reduce freshets and floods	298.37	87.97 (29.48)	50.08 (16.79)	21.95 (7.36)	37.89 (12.70)
					C/D			121.19 (40.62)	83.30 (27.92)	21.95 (7.36)	37.89 (12.70)
	Thukela_ EWR6	V70G-03440	Bushmans	B/C		PES – No changes to EWR due to dam constraints, reduce freshets, floods TEC – Reduce freshets and floods	303.14	110.52 (36.46)	67.34 (22.21)	21.14 (6.97)	43.8 (14.24)
					C			92.38 (30.47)	49.20 (16.23)	22.12 (7.30)	43.18 (14.24)
IUA 10	Thukela_ EWR1	V11L-03301	Thukela	D		PES – No changes to EWR due to dam constraints TEC – No freshets and floods	705.42	122.08 (17.31)	49.67 (7.04)	44.73 (6.34)	72.41 (10.26)
					D			49.67 (7.04)	49.6 (7.04)	44.73 (6.34)	No floods
	Thukela_ EWR2	V11M-03280	Thukela	C		PES - Change category from C to C/D, reduce freshets and floods TEC – Reduce freshets and floods to same as for PES	798.4	145.78 (18.26)	88.82 (11.12)	33.82 (4.24)	56.96 (7.13)
					C/D			141.07 (17.67)	88.82 (11.12)	33.82 (4.24)	52.25 (6.54)

IUA	EWR site	Sub-reach	River	Final PES	Final TEC	Comments wrt trade-offs	nMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
							Flows in million m³ per annum (%MAR)				
	Thukela_ EWR3	V13E-03362	Little Thukela	C/D	C/D	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	285.2	70.47 (24.71)	31.70 (11.11)	18.22 (6.39)	38.78 (13.60)
	Thukela1 _dsk	V14B-03296	Thukela	C		PES – Change category from B to C, reduce flood in Feb TEC – Change category from C to C/D, reduce freshets and floods	1145.2	343.38 (29.98)	126.78 (11.07)	48.10 (4.20)	216.60 (18.91)
					C/D			209.93 (18.33)	127.05 (11.09)	48.10 (4.20)	82.88 (7.24)
IUA 11	THU_ EWR22	V12A-03003	Klip	C	C	Reduce freshets Dec-Feb for PES and TEC	52.44	11.61 (22.15)	7.09 (13.51)	2.99 (5.70)	4.53 (8.64)
	Klip_dsk#	V12G-03256	Klip	C	C	Reduce freshets Dec-Feb for PES and TEC	253.09	50.62 (20.00)	34.29 (13.55)	14.43 (5.70)	16.33 (6.45)
IUA 12	Thukela_ EWR4B	V14E-03233	Middle Thukela	C	C	No changes to EWR due to dam constraints (PES) or trade-offs (TEC) Increase to a minimum drought requirement of 2 cumecs for both PES and TEC	1423.8	357.20 (25.09)	129.37 (9.09)	99.59 (6.99)	227.83 (16.00)
	Thukela_ EWR9	V60J-03395	Little Thukela	D	D	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	2050.8	415.40 (20.26)	125.17 (6.10)	69.55 (3.39)	290.24 (14.15)
	Thukela2 _dsk	V60K-03419	Thukela	C	C	Reduce large flood in Feb for PES and TEC	2461.2	637.80 (25.91)	313.78 (12.75)	128.08 (5.20)	324.02 (13.16)
IUA 13	Thukela_ EWR15	V40B-03429	Thukela	C	C	Reduce large flood in Feb for PES and TEC	3424.0*	752.45 (21.98)	436.93 (12.76)	177.72 (5.19)	315.52 (9.21)
	THU_ EWR16	V50D-03903	Thukela	C	C	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	3679.8*	1,391.96 (37.83)	685.34 (18.62)	351.01 (9.54)	706.62 (19.20)
IUA 14	V11A_ dsk#	V11A-03277	Thukela	B	B	No changes, will set strict RQOs for high flows and no zero flows	66.9		19.70 (29.45)	6.08 (9.09)	100% nMAR
	V11B_ dsk#	V11B—3410 V11B-03470	Sithene Thonyelana	B	B		142.69		42.02 (29.45)	12.97 (9.09)	100% nMAR

IUA	EWR site	Sub-reach	River	Final PES	Final TEC	Comments wrt trade-offs	nMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
							Flows in million m^3 per annum (%MAR)				
	V11G_ dsk#	V11G-03572 V11G-03582	Mlambonja Mhlwazini	B	B		191.00		55.75 (29.04)	16.58 (8.63)	100% nMAR
	V13A_ dsk#	V13C-03495	Little Thukela	C			82.32		12.22 (14.85)	7.10 (8.62)	100% nMAR
					B				21.00 (25.51)	7.10 (8.62)	100% nMAR
	V70A_ dsk#	V70A-03876	Bushmans	B	B		113.46		29.40 (25.92)	9.84 (8.68)	100% nMAR
	V70B_ dsk#	V70B-03927	Nsibidwana	B	B		44.16		11.45 (25.92)	3.83 (8.68)	100% nMAR
	V20A_ dsk#	V20A-04023	Mooi	C			42.90		6.03 (14.05)	3.72 (8.66)	100% nMAR
					B				10.3 (24.13)	3.72 (8.66)	100% nMAR
	V20B_ dsk#	V20B-04034	Little Mooi	C			10,32		1.48 (14.32)	0.89 (8.65)	100% nMAR
					B/C				2.04 (19.73)	0.89 (8.65)	100% nMAR
IUA 15	THU_ EWR17	V50D-03903	Thukela	D	C	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	3690.5*	1,394.65 (37.79)	688.03 (18.64)	352.55 (9.55)	706.62 (19.15)

NOTES:
nMAR: naturalised Mean annual run-off
** New nMAR lower/ higher than original study nMAR, thus different percentages but volumes the same*
 # low confidence
low to medium confidence

4.3 Assessment of Scenarios

An integral component of the water resource classification process is the scenario configuration and evaluation, an iterative process that assesses the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible for the catchment being classified, in this case the Thukela catchments, to support the recommended water resource management class options. Details of the scenario analysis is recorded in Report No: RDM/WMA04/00/CON/CLA/0121.

Scenario evaluation was incorporated into the integrated water resource management process (Figure 11) so that a subset of catchment scenarios could be recommended towards proposed management classes that would be gazetted. The following activities were undertaken as part of the water resource classification process:

- Assessment of the current scenario (2025) including the key current infrastructure developments in the Thukela catchment, and future development scenarios: a medium-term scenario (2030), and a long term scenario (2040 - 2045)
- Water Resources Planning and Water Resource Yield Model analysis and adjustment
- Reporting of ecological consequences and IUA- level ecological condition
- Assessment of water quality implications
- Description of the macro-economic implications
- Evaluation of the overall scenario implications for the Thukela catchment, and
- Selection of a subset of recommended scenarios.

Biophysical nodes

Biophysical nodes represent flow requirements and ecological state relevant for the IUA and are established to account for interactions between ecosystems. Allocation nodes are established to account for specific catchment issues or socio-economic aspects and to serve as modelling points for the scenario evaluation process in a catchment by assessing the response of upstream water resources to changes in water quality, quantity, and timing. Biophysical nodes should be located at interactions between ecosystems and at the end points of eco-system reaches to account for interactions and allocation nodes should be located at the downstream edge of a reach of interest, for modelling and to allow for meaningful trade-offs.

Biophysical nodes were selected within the study components (river, wetland, groundwater, and estuary) for analysis. These nodes represent the significant water resources that have a high ecological importance and/ or sensitivity that could be under threat due to its importance for water resource use and/ or where water use is high and/ or where water quality is impacted. The selected nodes are presented per water resource component.

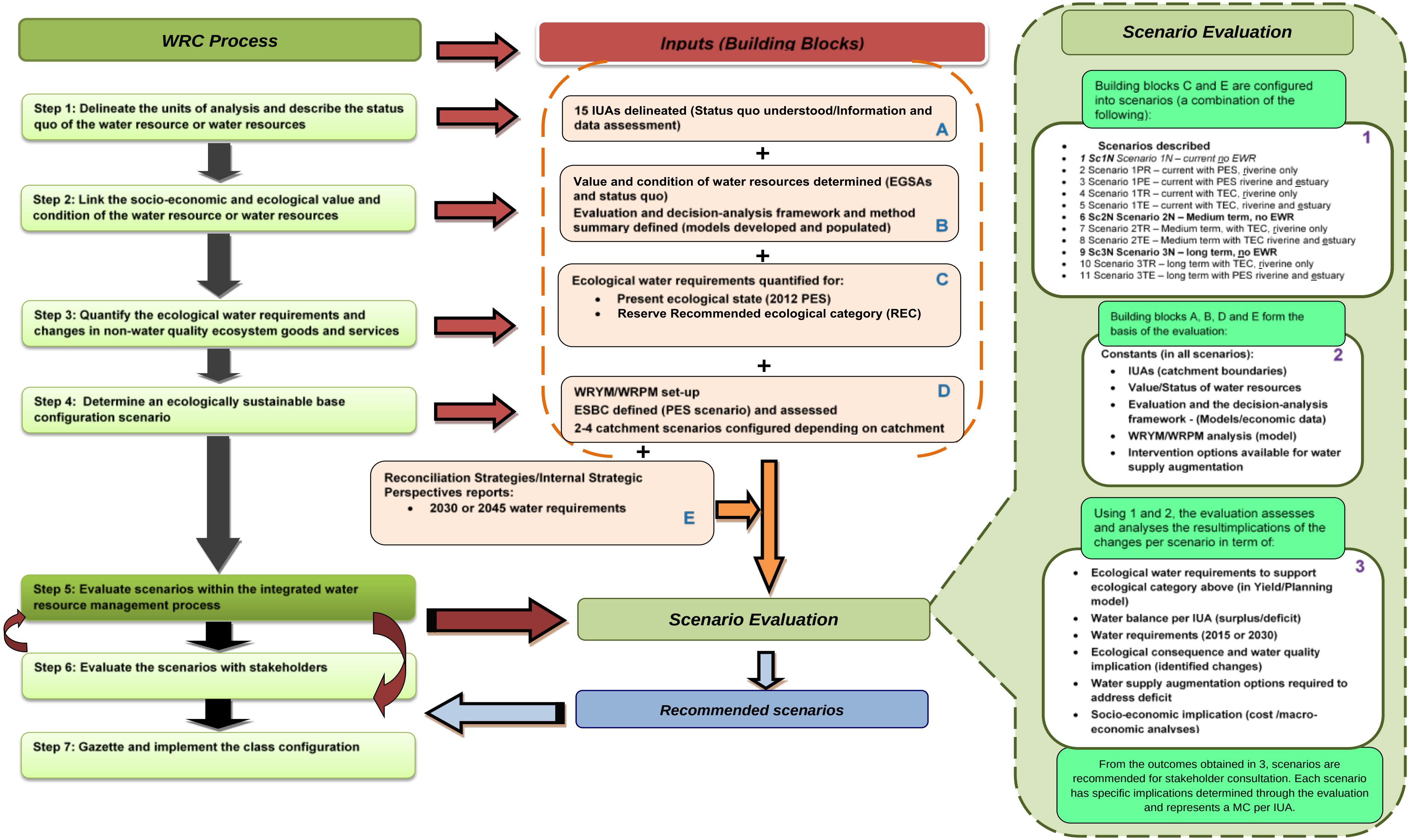

Figure 11: Scenarios evaluation within the integrated water resource management systems

The biophysical hydronodes per IUA used for the scenario evaluation and their level of assessment are listed in Table 9. These sites were modelled and used to evaluate the ecological consequences and macroeconomic implications for the defined development scenarios, and key hydronodes, highlighted, where hydraulics information and biological survey data were available, were selected per IUA to evaluate the ecological consequences in detail.

Table 9: Biophysical nodes per IUA in the Thukela Catchment

IUA	Name	River	Quaternary	Level	Lat	Long
1	**THU_EWR23**	**Upper Buffalo**	**V31D**	**Rapid III**	**-27.6221**	**29.9617**
2	May13_EWR2	Horn	V31F	Rapid III	-27.888	29.921
	THU_EWR19	Ncandu	V31J	Rapid III	-27.8017	29.8840
	May13_EWR3	**Ngagane**	**V31K**	**Rapid III**	**-27.819**	**29.987**
	Ngagane_dsk	Lower Ngagane	V31K	Desktop	Outlet V31K	
3	THU_EWR13A	Middle Buffalo	V32F	Rapid II	-28.0107	30.3931
	Thukela_EWR13	**Middle Buffalo**	**V32H**	**Comprehensive**	**-28.153**	**30.476**
4	**Thukela_EWR14**	**Lower Buffalo**	**V33B**	**Comprehensive**	**-28.437**	**30.595**
5	Blood_dsk (1)	Blood	V32H	Desktop	Outlet of V32H	
6	THU_EWR7A	Upper Sundays	V60B	Rapid II	-28.3479	29.9682
	Thukela_EWR7	**Upper Sundays**	**V60C**	**Comprehensive**	**-28.458**	**30.053**
	Thukela_EWR8	Lower Sundays	V60F	Comprehensive	-28.636	30.204
7	THU_EWR20	Nsonge/ Hlatikulu	V20C	Rapid III	-29.2377	29.7853
	EWR_Mooi_N3	Mooi	V20E	Rapid III	-29.210	30.002
	Thukela_EWR11	**Mooi**	**V20G**	**Comprehensive**	**-29.116**	**30.135**
8	THU_EWR21	Mnyamvubu	V20G	Rapid II	-29.1610	30.2884
	THU_EWR12A (2)	**Mooi**	**V20H**	**Rapid III**	**-28.9191**	**30.4192**
	Mooi_dsk	Mooi	V20J	Desktop	Outlet of V20J	
9	Thukela_EWR5	Middle Bushmans	V70F	Comprehensive	-28.897	30.035
	THU_EWR6A	**Lower Bushmans**	**V70G**	**Rapid III**	**-28.8483**	**30.1496**
	Thukela_EWR6	Lower Bushmans	V70G	Comprehensive	-28.801	30.167
10	Thukela_EWR1	Upper Thukela	V11J	Comprehensive	-28.722	29.378
	Thukela_EWR2	**Upper Thukela**	**V11M**	**Comprehensive**	**-28.717**	**29.621**

IUA	Name	River	Quaternary	Level	Lat	Long
	Thukela_EWR3	Little Thukela	V13E	Comprehensive	-28.383	29.616
	Thukela1_dsk	Thukela	V14B	Desktop	Outlet of V14B	
11	**THU_EWR22**	**Klip**	**V12A**	**Rapid III**	**-28.3952**	**29.7197**
	Klip_dsk	Klip	V12G	Desktop	Outlet of V12G	
12	**Thukela_EWR4B**	**Middle Thukela**	**V14E**	**Comprehensive**	**-28.747**	**30.145**
	Thukela_EWR9	**Middle Thukela**	**V60J**	**Comprehensive**	**-28.769**	**30.515**
	Thukela2_dsk	Middle Thukela	V60K	Desktop	Outlet of V60K	
13	Thukela_EWR15	Lower Thukela	V40B	Comprehensive	-28.785	30.911
	THU_EWR16	**Lower Thukela**	**V50C**	**Intermediate**	**-29.1603**	**31.3373**
14 (3)	V11A_dsk	Thukela	V11A	Desktop	66% V11A	
	V11B_dsk	Mnweni	V11B	Desktop	100% V11B	
	V11G_dsk	Mlambonja	V11G	Desktop	100% V11G	
	V13A_dsk	Little Thukela	V13A	Desktop	77% V13A	
	V70A_dsk	Bushmans	V70A	Desktop	87% V70A	
	V70B_dsk	Nsibidwana	V70B	Desktop	100% V70B	
	V20A_dsk	Mooi	V20A	Desktop	21% V20A	
	V20B_dsk	Little Mooi	V20B	Desktop	42% V20B	
15	THU_EWR17 (4)	Lower Thukela	V50D	Intermediate	-29.1677	31.4037

(1) No EWR site selected, thus no hydraulics or biological data available for scenario evaluation
(2) Replaces Thukela_12 (comprehensive site of 2003 study) just downstream of new site
(3) No EWR sites selected as in protected area and no upstream water use or scenarios defined
(4) Estuary was used for assessment

Water Resource Planning Analysis

Considering that the Thukela River Catchment is a strategically important catchment with a number of existing large water resources developments and plans for future developments, the various planning scenarios that may be used to assess current and future development in the Thukela River Catchment needed to cover a suitable range of likely futures and consider the plans of the Department of Water and Sanitation (DWS), as well as other government water services authorities, water service providers and the general public.

Table 10 describes the current dams, and abstractions and conveyance infrastructure, and Table 11 sets out the anticipated and proposed major developments in the Thukela catchment. Additional to these large development's numerous irrigation schemes, industrial supply, as well as domestic and rural water supply schemes data was included in the water resource planning model (WRPM) runs.

Table 10: Main dams in the catchment

Name	Sub - catchment	Purpose
Dams		
Woodstock/ Driel Barrage	Upper Thukela	Water transfer
Spioenkop	Upper Thukela	Water transfer (but now used for water supply and irrigation)
Zaaihoek	Buffalo	Water transfer
Ntshingwayo	Buffalo (Ngagane River)	Water supply and irrigation
Spring Grove	Mooi	Water Transfer and Irrigation
Mearns Weir	Mooi	Water Transfer and Irrigation
Craigieburn	Mooi (Mnyamvubu River)	Water supply and irrigation
Wagendrift	Boesmans	Water supply and irrigation
Qedusizi	Upper Thukela (Klip River)	Flood Control
Abstractions and Water conveyance infrastructure		
Thukela Vaal Scheme	Upper Thukela	Water transfer and hydropower
Buffalo Vaal Scheme	Buffalo	Water transfer
Mooi Mgeni Transfer Scheme (phase 1 and 2)	Mooi	Water transfer
Thukela to Mhlathuze scheme (also known as the Middledrift transfer)	Lower Thukela	Water Transfer
Lower Thukela Bulk Water Supply Scheme (phase 1)	Lower Thukela	Bulk Water supply

Table 11: Anticipated and proposed major developments in the Thukela Catchment

No.	Development	Timing (driver)	Timing (date)	Area of Supply	Status
1	Thukela – Jana and Mielietuin dams	Once yield of LHWP-2 has been used	2040 - 2050	Vaal	Pre-feasibility
2	Thukela – Mhlathuze phase 2	Already commenced	2020/2021	Richards Bay and Mhlathuze	Under construction

No.	Development	Timing (driver)	Timing (date)	Area of Supply	Status
3	LTBWSS – Phase 2	North Coast Water Requirements	2024/2025	North coast	Feasibility and partial design
4	uMWP-1 (affects MMTS)	Completion date of uMWP1	2026 – 2030	Coastal Metro areas	Feasibility
5	Little Mooi dams (Dartington & Hlatikhulu)	Irrigators' plans & EWR gazetting	Unknown	Irrigators	Design
6	Greytown Water Supply Scheme (from Craigieburn Dam)	Construction already started but currently on hold	Short term	Greytown and surrounding area	Under construction
7	Ladysmith Supply augmentation – bulk scheme	Ladysmith urgently needs around 50ML/d, new supply	Umgeni Water	Ladysmith and Surrounds	First 50ML/d needs urgent planning. Long term 150 to 200 ML/d needs study
8	Newcastle Supply Augmentation – Water resource development	A new long-term resource is anticipated for Newcastle	Unknown - Long Term need	Newcastle, Dundee, and Glencoe	Feasibility Study needed

In respect of undertaking the water resources planning modelling, the medium-term scenario catered for the committed infrastructure that was already in advanced stages of planning or construction, specifically:

1. Phase 2 of the Mhlathuze Transfer.
2. Phase 2 of the Lower Thukela bulk water supply scheme (BWSS).
3. Growing water supply to the Ladysmith/ Ezakheni area. This could be achieved by either:
    a. Supply from the Thukela at the proposed Mielietuin Dam (a new WTP in the order of 50 ML/d is being considered by Umgeni Water), but without Mielietuin Dam itself), or
    b. Supply from the Spioenkop Dam, with the possibility of the dam being raised but the timing before 2030 is uncertain. The choice of these two options is still being investigated in a feasibility study to select the best option.
4. The support to the uMgeni River from Smithfield Dam (uMWP-1) not yet effective (so as to impose the full transfer requirement from the Mooi River).
5. The LHWP-2 completed, but the full Thukela - Vaal transfer still required to address growing needs in the Greater Vaal River System (GVRS).
6. Water requirements at around a 2028 development level (for period just before 2030).

The long term (ultimate) scenario encompassed all the planned long-term developments and likely depicts the catchment in its most stressed state. The scenario included:

1. The options from the medium-term scenario, but with a greater volume (anticipated to be in the order of 150 ML/d by Umgeni Water) abstracted for Ladysmith / Ezakheni at the proposed Mielietuin Dam, or at the raised Spioenkop Dam.
2. The Jana and Mielietuin Dams completed for the next phase of transfer to the Vaal.
3. The uMWP-1 completed and support to the Mooi according to long term needs in the upper Mgeni and the rest of the system.
4. The inclusion of:
   a. A new dam on the Little Mooi River for irrigation.
   b. A new dam on the Buffalo River (if Newcastle/Dundee requirements cannot be met), or
   c. An increase of up to 3 m^3/s for the transfer to the Mhlathuze River Catchment.
   d. These iterations may be conducted simultaneously or in combination, depending on water supply realities to be confirmed at the time.
5. Water requirements at the 2045 development level as a practical planning horizon.

The above scenarios were simulated using the Water Resources Planning Model, with the operating rules associated with those developments currently followed or planned for. It was noted that initial EWR scenarios included the flood flows for the EWRs. The ability for these to be released was reviewed against both the outlet capacities of the dams where releases are required, and the ability for the system to provide the releases and achieve a balance between environmental protection and socio-economic support and development. This was conducted as part of the trade-off scenarios, where needed.

A summary of the scenarios run is set out in Table 10.

Table 12: Summary of scenarios run

Scenarios			ID	
1	Current day with all existing major transfers operating based on current rules	• Scenario 1N – current no EWR	Sc1N	Sc1
		• Scenario 1PR – current with PES, riverine only	Sc1PR	Sc2
		• Scenario 1PE – current with PES riverine and estuary	Sc1PE	Sc3
		• Scenario 1TR – current with TEC, riverine only	Sc1TR	Sc4
		• Scenario 1TE – current with TEC, riverine and estuary	Sc1TE	Sc5
2	Medium-term with all major planned infrastructure (that is in the construction phase, or well progressed planning stages) before 2030	• Scenario 2N – Medium term, no EWR	Sc2N	Sc6
		• Scenario 2TR – Medium term, with TEC, riverine only	Sc2TR	Sc7
		• Scenario 2TE – Medium term with TEC riverine and estuary	Sc2TE	Sc8

Scenarios			ID	
3	Long-term "ultimate" scenario with all major infrastructure implemented and projected water requirements around 2045. Some iterations of this scenario may be required that relate to an irrigation dam on the Mooi River, a new development on the Buffalo River for Newcastle, another phase of the transfer to the Mhlathuze, or the raising of Spioenkop Dam	• Scenario 3N – long term, no EWR	Sc3N	Sc9
		• Scenario 3TR – long term with TEC, riverine only	Sc3TR	Sc10
		• Scenario 3TE – long term with TEC riverine and estuary	Sc3TE	Sc11

In respect of the ecological consequences, scenarios Sc1 to Sc5 (all the present day demands) were assessed with and without EWR with either the PES or TEC and including the rivers only or both the rivers and estuary. However due to the fact that Sc2 and Sc3 (PES) and scenarios Sc4 and Sc5 (TEC) were almost the same due to the lower Thukela River having similar requirements as the Estuary, Sc2 and Sc4 were not further investigated.

These were then reviewed and trade-offs between the EWRs and the projected water requirements, as well as socio-economic concerns, were considered to define the most appropriate trade-off. In addition, as part of the scenario refinements, the outlet capacities for the various dams in the Thukela River Catchment were incorporated into the hydrological model to assess the capability of each dam to release the required freshets or floods for each of the EWR scenarios, specifically for the dams located in close proximity upstream of an EWR site. The EWR freshet/ flood requirements were adjusted where the dam outlet capacities were lower than the requirement. The TEC requirements were further adjusted during where socio-economic impacts were high. This was especially for Thukela_EWR1, downstream Woodstock Dam, where all floods were removed to ensure adequate water to be transferred to Gauteng. The medium term (Sc6) and long term (Sc9) scenarios without EWR, were also assessed to evaluate the water available for the EWR after all demands have been met. The results of Sc6 and Sc9 will be used to set specific conditions and requirements for compliance with the EWR in the implementation plan.

4.4 Ecological Base Case Configuration (ESBC)

The process followed in terms of the establishment of the Ecologically Sustainable Base Configuration (ESBC) was as described in the WRCS Guidelines, Volumes 1 and 2 (Overview and the 7-step classification procedure; and Ecological, hydrological and water quality guidelines for the 7-step classification procedure) (DWAF, February 2007a and 2007b).

The ESBC scenario, which could permit the maximum water use scenario, requires that the base condition for each water resource is at minimum established as either a D category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However, where the ecological condition requires it, a higher ecological category should be set. The ESBC scenario is established once this base condition is hydrologically and ecologically tested to ensure that it is feasible and can be achieved. In other words, the results will reflect whether the catchment water balance would be in surplus or deficit by implementing a D category EWR.

However, in terms of the Thukela catchment, the D ecological category was not selected as the default ESBC, rather the selected ecological category per IUA was the Present Ecological State (PES), because of the fact that most of the ecological categories were above a D category. Additional to the establishment of the ESBC, the Target Ecological Category (TEC) was also determined as an alternate scenario at the nodes. Table 13 sets out the ESBC (PES), TEC and Ecological Importance and Sensitivity (EI/ES).

Table 13: ESBC (PES) and TEC for the Thukela catchment

IUA	EWR site	Sub-reach	River	PES	EI/ES	TEC
IUA1	THU_EWR23	V31D-02370	Upper Buffalo	C	High	C
IUA2	May13_EWR2	V31F-02600	Horn	C	Low	C
	THU_EWR19	V31J-02487	Ncandu	C	Very high	B/C
	May13_EWR3	V31G-02618	Ngagane	C	Low	C/D
	Ngagane_dsk	V31K-02516	Ngagane	C	Moderate/ High	C/D
IUA3	THU_EWR13A	V32D-02699	Buffalo	D	Moderate/ High	C/D
	Thukela_EWR13	V32F-02707	Buffalo	D	Moderate	C/D
IUA4	Thukela_EWR14	V33B-03090	Buffalo	B/C	High	C
IUA5	Blood_dsk	V32H-02834	Blood	C	High	C
IUA6	THU_EWR7A	V60B-02826	Sundays	C/D	High	C
	Thukela_EWR7	V60C-03031	Sundays	C/D	Moderate	C/D
	Thukela_EWR8	V60F-03210	Sundays	D	Moderate	D
IUA7	THU_EWR20	V20C-03919	Nsonge	C	Very high / High	B/C
	EWR_Mooi_N3	V20E-03884	Mooi	E	Moderate	D
	Thukela_EWR11	V20E-03742	Mooi	C/D	Moderate	C/D
IUA8	THU_EWR21	V20G-03853	Mnyamvubu	C	High	C
	THU_EWR12A	V20H-03500	Mooi	C/D	High	C
	Mooi_dsk	V20J-03467	Mooi	C	High	C
IUA9	Thukela_EWR5	V70F-03548	Bushmans	B/C	Moderate	C
	THU_EWR6A	V70G-03515	Bushmans	D	High	C/D
	Thukela_EWR6	V70G-03440	Bushmans	B/C	High	C
IUA10	Thukela_EWR1	V11L-03301	Thukela	D	Moderate	D
	Thukela_EWR2	V11M-03280	Thukela	C	Moderate	C/D
	Thukela_EWR3	V13E-03362	Little Thukela	C/D	Moderate	C/D
	Thukela1_dsk	V14B-03296	Thukela	C	High	C/D
IUA11	THU_EWR22	V12A-03003	Klip	C	High / Very high	C
	Klip_dsk	V12G-03256	Klip	C	High	C
IUA12	Thukela_EWR4B	V14E-03233	Thukela	C	High	C

IUA	EWR site	Sub-reach	River	PES	EI/ES	TEC
	Thukela_EWR9	V60J-03395	Thukela	D	Moderate	D
	Thukela2_dsk	V60K-03419	Thukela	C	High	C
IUA13	Thukela_EWR15	V40B-03429	Thukela	C	High	C
	THU_EWR16	V50D-03903	Thukela	C	High / Moderate	C
IUA14	V11A_dsk	V11A-03277	Thukela	B	High / Very high	B
	V11B_dsk	V11B—3410 V11B-03470	Sithene Thonyelana	B	Moderate/ High	B
	V11G_dsk	V11G-03572 V11G-03582	Mlambonja Mhlwazini	B	Moderate / High	B
	V13A_dsk	V13C-03495	Little Thukela	C	High/ Very high	B
	V70A_dsk	V70A-03876	Bushmans	B	High	B
	V70B_dsk	V70B-03927	Nsibidwana	B	High	B
	V20A_dsk	V20A-04023	Mooi	B	High	B
	V20B_dsk	V20B-04034	Little Mooi	B/C	High	B/C
IUA15	THU_EWR17	V50D-03903	Thukela	C	High	C

4.5 Scenario Results

Water Resources

The preliminary results showed that some IUAs will be impacted, and some were projected to have shortages even without EWRs implemented in the future. The preliminary perspective was the following users (or some users within these sectors) are projected to experience water supply challenges:

- IUA 1 – some irrigation and the Zaaihoek transfer to the Vaal
- IUA 6 – Irrigation and some domestic supply
- IUA 7 – Irrigation
- IUA 8 – Irrigation near the lower reaches
- IUA 10 – Irrigation and some domestic supply
- IUA 11 – Irrigation and some domestic supply
- IUA 13 – Irrigation and LTBWSS phase 2

Ecological category

A summary of integrated ecological categories for Sc1 and Sc 3 defined in Table 12 is set out in Table 14, illustrating non-compliance in IUA 2, Ngagane and IUA 7, in the middle Mooi River catchment.

Table 14: Integrated ecological categories

IUA	River	EWR sites	QC	2021 PES	2020 TEC	Revised PES	Revised TEC	FIFHA Results			
								Sc1	Sc3	Sc1	Sc3
								Integrated EC		TEC Met	
1	Upper Buffalo	EWR23	V31D	C	C	C	C	B/C	B/C	√	√
2	Ngagane	May13_ EWR3	V31K	C	C	C	C	E	A/B	X	√
3	Middle Buffalo	EWR13	V32H	D	C/D	D	C/D	C	A/B	√	√
4	Lower Buffalo	EWR14	V33B	B/C	B/C	B/C	C	C	C	√	√
6	Upper Sundays	EWR7	V60C	B/C	C	D	C/D	C	C/D	√	√
7	(Middle) Mooi	EWR11	V20G	B/C	B/C	C/D	C/D	E	A/B	X	√
	Nsonge	EWR20	V20C	C	B/C	C	B/C	D	B/C	X	√
8	Lower Mooi	EWR12a	V20H	C/D	C	C/D	C	C	B/C	√	√
9	Bushmans	EWR6a	V70G	D	C/D	D	C/D	D	A/B	X	√
10	Upper Thukela	EWR2	V11M	C	C	D	C/D	C	C	√	√
11	Klip	EWR22	V12A	C	C	C	C	B/C	B/C	√	√
12	Middle Thukela	EWR4b	V14E	C	B/C	C	B/C	B/C	B/C	√	B/C
		EWR9	V60J	D	D	D	D	B/C	B/C	√	
13	Lower Thukela	EWR16	V50C	C	C	C	C	C/D	A/B	X	√

Table 15 summarise the overall scenarios outcomes highlighting the areas of shortfalls and the need for EWR trade-offs. The amended final TEC is shown.

Table 15: Summary of overall scenarios outcomes and need for EWR trade-offs showing amended final TEC

IUA	River	Overall scenarios outcome	EWR trade-offs	EWR site	Final TEC
IUA1	Upper Buffalo	There is currently not sufficient water available in IUA1 to effectively supply the current demands (93% in scenario 1). As the urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_ EWR23	C
IUA2	Horn	There is currently not sufficient water available in IUA2 to effectively supply the current demands (97% in scenario 1). As urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	May13_ EWR2	C
	Ncandu		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_EWR19	B/C
	Ngagane		PES – Adjust for dam constraints (reduce floods, freshets) TEC - Reduce freshets, floods further for Nov-Mar	May13_ EWR3	C/D
	Ngagane		PES – Adjust for dam constraints (reduce floods, freshets) TEC - Reduce freshets, floods further for Nov-Mar	Ngagane_dsk[#]	C/D
IUA3	Buffalo	There is currently not sufficient water available in IUA3 to effectively supply the current demands (99% in scenario 1). As urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	PES – Reduce large flood in Feb TEC – Reduce large flood in Feb, increase ML flows	THU_EWR13A	C/D
	Middle Buffalo		PES – Reduce large flood in Feb TEC – Reduce large flood in Feb, increase ML flows	Thukela_EWR13	C/D
IUA4	Lower Buffalo	There is currently sufficient water available in IUA4 to effectively supply the current demands (excludes EWR). As urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	No changes to EWR due to dam constraints (PES) TEC – Reduce drought flows to 0.4cumec Oct-Dec	Thukela_EWR14	C
IUA5	Blood	There is currently not sufficient water available in IUA5 to effectively supply the current demands (98% in scenario 1). The demands do not however increase into the future.	PES – Change category from B/C to C TEC – No changes to EWR due to dam constraints or trade-offs	Blood_dsk	C
IUA6	Upper Sundays	There is currently not sufficient water available in IUA6 to effectively supply the current demands (only 56% of demands in scenario 1). As the urban demands increase into the future, the various	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_EWR7A	C
	Sundays		PES – Change category from B/C to C/D	Thukela_EWR7	C/D

IUA	River	Overall scenarios outcome	EWR trade-offs	EWR site	Final TEC
		scenarios describe variations in water allocation between the socio economic and ecological needs over time.	TEC – Reduce maintenance low flows. Reduced floods in Feb, Mar		
	Sundays		PES – No changes to EWR due to dam constraints TEC – Reduce flood in Feb	Thukela_EWR8	D
IUA7	Nsonge	There is currently not sufficient water available in IUA 7 to effectively supply the current demands (88% in scenario 1, 6 and 9). The demands do not increase into the future.	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_EWR20	B/C
	Mooi		Reduce floods for Jan-Mar due to dam constraints for PES and TEC	EWR_Mooi_N3	D
	Mooi		PES – Change category from B/C to C/D for short term TEC – Reduce floods for Jan-Mar	Thukela_EWR11	C/D (short term) B/C (long term)
IUA8	Mnyamvubu	There is currently not sufficient water available in IUA 8 to effectively supply the current demands (92% for scenario 1, 6 and 9). These demands are not expected to increase in the future.	Adjust PES and TEC for dam constraints (reduce maintenance flows, floods, freshets)	THU_EWR21	C
	Mooi		Reduce large floods Dec-Mar for PES and TEC	THU_EWR12A	C
	Mooi		Reduce large floods Dec-Mar for PES and TEC	Mooi_dsk[##]	C
IUA9	Middle Bushmans	There is currently not sufficient water available in IUA 9 to effectively supply the current demands (99% in scenario 1). As urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	PES – No changes to EWR due to dam constraints TEC – Reduce freshets and floods	Thukela_EWR5	C
	Bushmans		PES – No changes to EWR due to dam constraints, reduce freshets, floods TEC – Reduce freshets and floods	THU_EWR6A	C/D
	Bushmans		PES – No changes to EWR due to dam constraints, reduce freshets, floods TEC – Reduce freshets and floods	Thukela_EWR6	C
IUA 10	Thukela	There is currently not sufficient water available in IUA 10 to effectively supply the current demands (75% in scenario 1). As the urban and transfer demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	PES – No changes to EWR due to dam constraints TEC – No freshets and floods	Thukela_EWR1	D
	Thukela		PES - Change category from C to C/D, reduce freshets and floods TEC – Reduce freshets and floods to same as for PES	Thukela_EWR2	C/D
	Little Thukela		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	Thukela_EWR3	C/D
	Thukela		PES – Change category from B to C, reduce flood in Feb	Thukela1_dsk	C/D

IUA	River	Overall scenarios outcome	EWR trade-offs	EWR site	Final TEC
			TEC – Change category from C to C/D, reduce freshets and floods		
IUA 11	Klip	There is currently not sufficient water available in IUA 11 to effectively supply the current demands (89% of scenario 1). As urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	Reduce freshets Dec-Feb for PES and TEC	THU_EWR22	C
	Klip		Reduce freshets Dec-Feb for PES and TEC	Klip_dsk#	C
IUA 12	Middle Thukela	There is currently not sufficient water available in IUA 12 to effectively supply the current demands (92% in scenario 1). As the urban demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	No changes to EWR due to dam constraints (PES) or trade-offs (TEC) Increase to a minimum drought requirement of 2 cumecs for both PES and TEC	Thukela_EWR4B	C
	Little Thukela		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	Thukela_EWR9	D
	Thukela		Reduce large flood in Feb for PES and TEC	Thukela2_dsk	C
IUA 13	Thukela	There is currently not sufficient water available in IUA 13 to effectively supply the current demands (97% as per scenario 1). As urban and transfer demands increase into the future, the various scenarios describe variations in water allocation between the socio economic and ecological needs over time.	Reduce large flood in Feb for PES and TEC	Thukela_EWR15	C
	Thukela		No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_EWR16	C
IUA 14	Thukela	There are currently no water demands nor are there water demands proposed for IUA 14. As a result, the IUA is not at risk of activities proposed across the various scenarios.	No changes, will set strict RQOs for high flows and no zero flows	V11A_ dsk#	B
	Sithene Thonyelana			V11B_ dsk#	B
	Mlambonja Mhlwazini			V11G_ dsk#	B
	Little Thukela			V13A_ dsk#	B
	Bushmans			V70A_ dsk#	B
	Nsibidwana			V70B_ dsk#	B
	Mooi			V20A_ dsk#	B
	Little Mooi			V20B_ dsk#	B/C
IUA 15	Thukela	IUA 15 experiences extreme low flows and the current EWR is not met by half due to cumulative effect of extensive upstream extractions. Reduced baseflow will alter the processes within the river mouth which eventually has a direct link on the estuary metasystem (Continental shelf and Tugela banks)	No changes to EWR due to dam constraints (PES) or trade-offs (TEC)	THU_ EWR17	C

Water Quality

The water quality assessment reflected that overall, the quality of water at the EWR sites is in a good to fair condition, with only a few constituents reflecting concentrations that exceed the water quality specifications of a D/E condition at some sites. However, while the water quality on its own may not reflect a poor condition, the present state requires improvement to support the ecological health of the fish and biota that live within these systems.

Estuary

The estuary assessment indicated that It is evident that siltation has occurred in the Thukela Estuary over the last 19 to 24 years. This is likely due to no recent large floods scouring the Thukela Estuary, increased fine sediment input from the catchment and reductions in low flows that can transport the fine sediment through the estuary to the coast. Management of the Thukela River system needs to be improved to prevent siltation of the estuary. This includes changes to reduce soil erosion in the catchment, allow for higher base flow releases from dams and limit abstraction from the river channel or weirs for the middle and lower catchment.

It was noted that mouth closures have been recorded for river flows of 7.7 m^3/s and lower, but the relationship is very dynamic due to high sediment influx into the estuary during coastal storm events, and the two observed closure events for 2020 occurred at flow rates of 6.3m^3/s (closed for 1 day) and 7.6 m^3/s to 8.9 m^3/s (closed for at least 8 days; breached artificially) respectively.

4.6 Setting the Water Resource Class

The approach applied to determining the proposed water resource class for each of the IUAs was to follow the guidelines of the WRCS. In summary the WRCS guidelines recommend that the water resource class be determined based on the ECs of the biophysical nodes residing in an IUA.

Table 16 sets out the IUA classes for the IUAs in the Thukela catchments for the ESBC (PES) scenario based on percentage representation of indicated ecological category groups and Figure 12 illustrates the proposed classes

Table 16: Proposed water resource classes for Thukela IUAs for ESBC (PES) scenario based on percentage representation of indicated EC groups

IUA	Percentage (%) of nodes in the IUA falling into the indicated EC groups					Proposed water resource class
	A or A/B	B or B/C	C or C/D	D	>D	
1		36	55	9		III
2		31.25	56.25	6.25	6.25	III
3		39.13	52.17	8.70		III
4		64.29	14.29	21.43		II
5			100.00			III
6		12.00	72.00	12.00	4.00	III

IUA	Percentage (%) of nodes in the IUA falling into the indicated EC groups					Proposed water resource class
	A or A/B	B or B/C	C or C/D	D	>D	
7			66.67	22.22	11.11	III
8		33.33	61.11	5.56		III
9	20.00	40.00	40.00			III
10	3.70	44.44	44.44	7.41		III
11	10.53	42.11	47.37			III
12	13.64	31.82	50.00	4.55		III
13	3.70	70.37	25.93			II
14	80.00	16.00	4.00			I
15			100			III

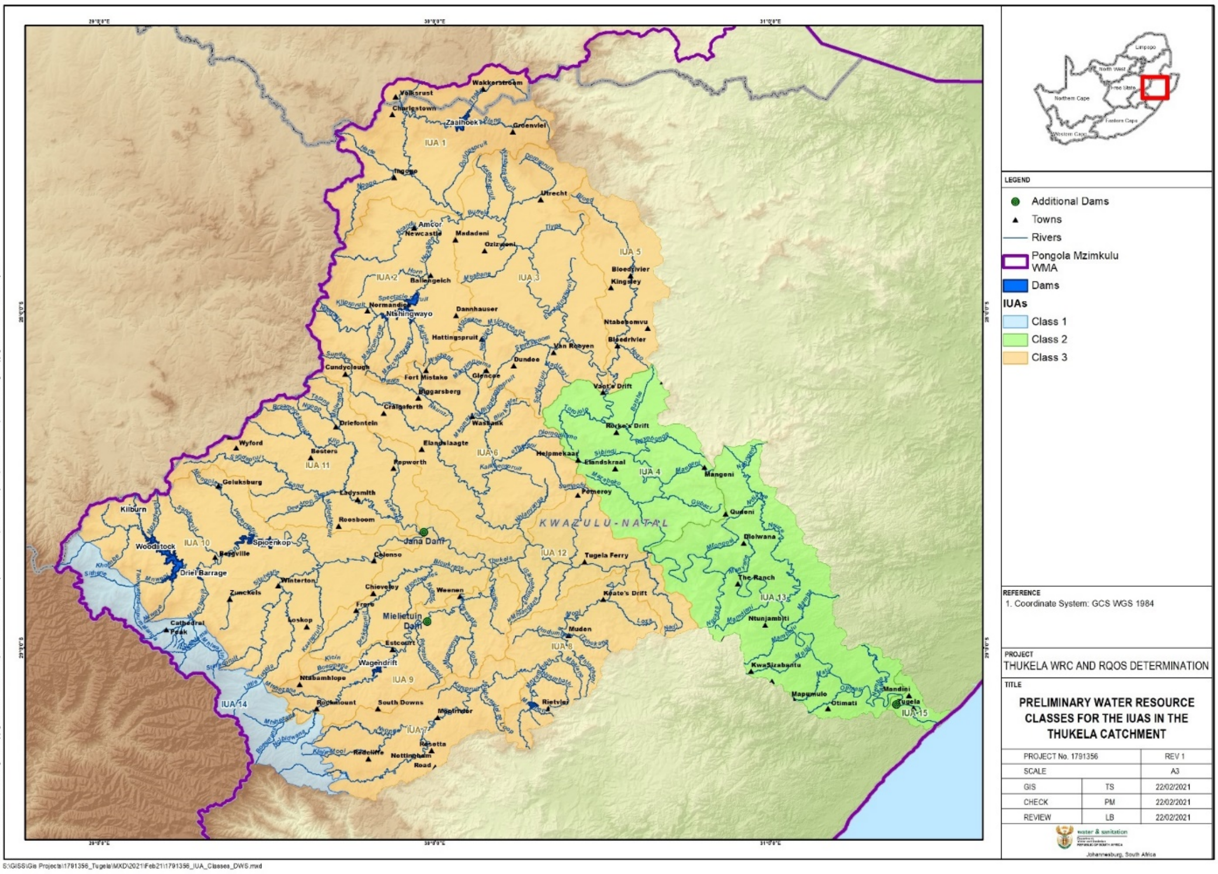

Figure 12: Proposed Water Resource Classes for the Thukela catchments

5 DETERMINING THE RESOURCE QUALITY OBJECTIVES

5.1 Resource Units

The delineation and prioritisation of resource units (RU) is required to facilitate effective management within the catchments and necessitates the breakdown of a river into discrete manageable units, primarily from an ecological perspective. The resource units are generally ecologically homogenous in nature. The delineation of Integrated Units of Analysis (IUA) and prioritisation of RUs are undertaken as the initial steps of the water resource classification and Resource Quality Objectives (RQO) processes.

RQOs are then developed per RU within the context of the IUA catchment perspective. In this study for the Thukela catchment RQOs for rivers, groundwater, dams, wetland resources and the estuary have been determined as follows:

- Rivers on a RU scale (river RUs),
- Priority dam resources on a RU scale,
- Priority wetland resources on a RU scale,
- Groundwater resources on a groundwater RU scale which is comparable with river RUs, and
- Priority groundwater resources on a system specific scale (priority groundwater units).

The details of the approach taken to delineate resource units are set out in Report Number: RDM/WMA04/00/CON/CLA/0520.

In summary the resource unit delineation was done based on assessment of the following considerations and components:

- IUA boundaries, quaternary, and sub-quaternary boundaries: this formed the basis of delineation (alignment to the water resource classification) and is of relevance from a management and implementation perspective.
- EWR sites and location of biophysical nodes: relevant from an ecological point of view (EWR sites) and important in meeting the classification ecological categories to be specified at the nodes. The nodes are of relevance in setting water quality and flow related resource quality objectives.
- Water resource management classes to be set - considered to determine the level of protection required within an IUA.
- PES/EIS desktop assessment of sub-quinary reaches: to determine the reaches that require higher protection and areas that are degraded and need to be improved within an IUA.
- Ecological condition (based on the EWR and node information): understanding of ecological condition and ensuring implementation of the Reserve.

- Protected and conservation areas: areas that are of importance from a biodiversity and conservation point of view (different to the higher impacted areas), that would need RQOs that support the conservation status.
- Operation of the system: How the water resources in the system area regulated and managed from a system point of view. This relates more importantly to regulation of the dams, and their influence of the river surface water flow, transfers, strategic water resources, etc.
- Water quality impacts: The water quality status/condition of the resources influences the delineation of the resource units in terms of where specific RQOs would be required. Highly impacted, poor water quality areas would need RQOs and similarly areas of good water quality would require protection in line with the water resource management classes and ecological condition.
- Land use and anthropogenic activities: the activities within the IUAs, were considered – the nature, intensity, scale, type and extent of impact. This influenced the delineation of resource units in terms of the management required and the RQOs that would be required to ensure the water resources are sustainably used.
- User dependence: the reliance of users on the water resources for domestic water supply.
- Groundwater units: the priority groundwater resources and their importance to the system and users; and
- Wetlands: the priority wetland areas and systems and their importance from their value, support to the ecosystem and services they provide, and to the users.

Based on the consideration and integration of the above aspects, as well as using expert knowledge including discussions with specialists and catchment water resource managers, 75 RUs were delineated for the Thukela catchments (Figure 13).

While the RQO determination procedure proposes that RQOs be set for each resource unit, due the large number of RUs delineated for the Thukela catchment, a rationalisation process developed as part of the RQO Determination Procedure (DWA, 2011) was used to prioritise and select those RUs that would benefit most for RQO determination. The criteria assessed per RU include:

- Position of RUs within an IUA,
- Importance of the RU to users,
- Threat posed to water resource quality for users,
- Threat posed to water resource quality for the environment,
- Ecological considerations,
- Practical Constraints, and
- Management Considerations.

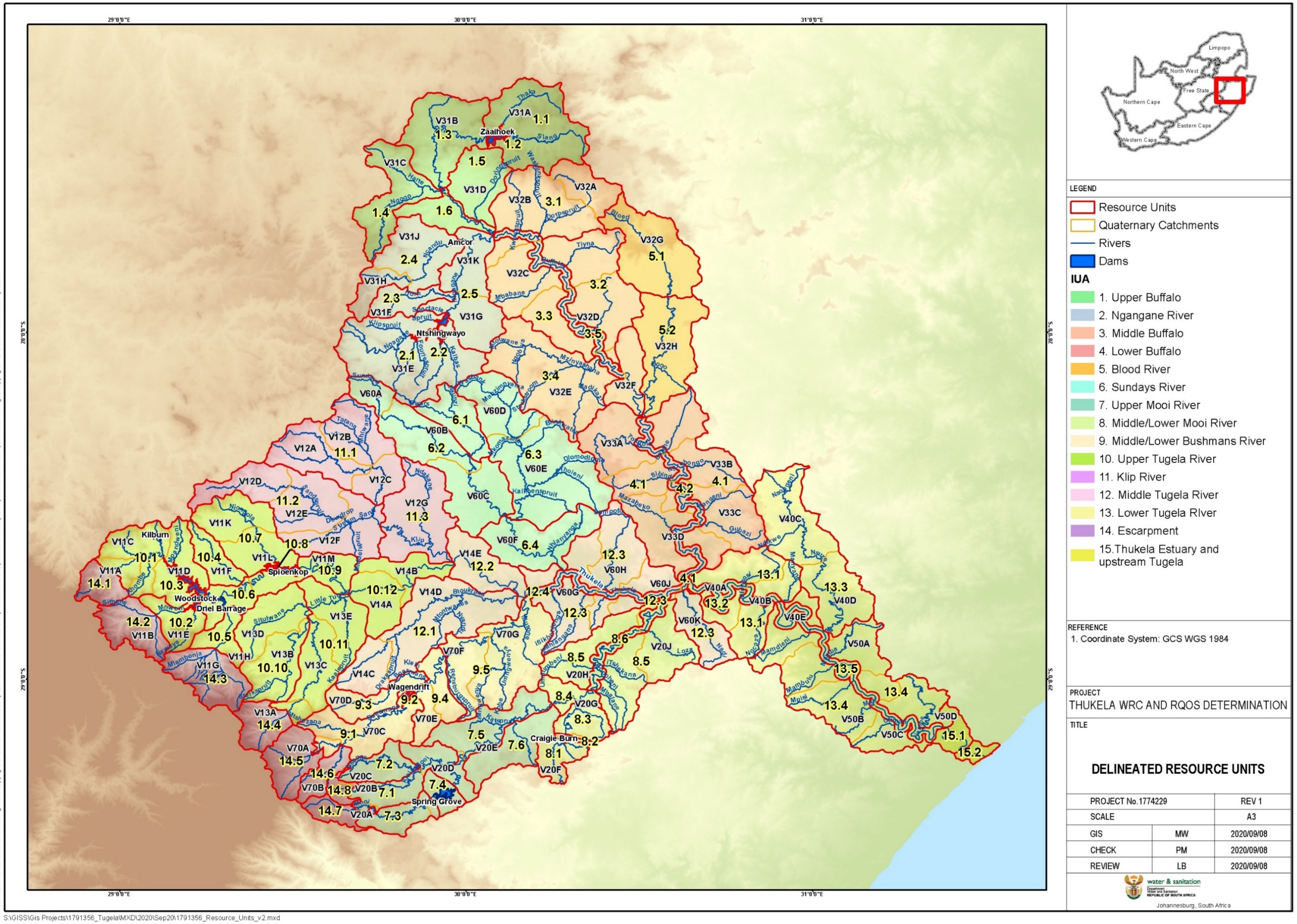

Figure 13: 75 Resource Units delineat

Figure 14 lustrates the outcomes of the ranking process which resulted in fifty-four (54) RUs for which RQOs were ultimately set. This included:

- Six dam RUs
- Groundwater priority RU areas were identified with areas of high stress index and aquifers of strategic importance in IUA 2, IUA 3, IUA 5, IUA 7, IUA 8, IUA 10, and IUA 11
- Twelve (12) wetland clusters were prioritised in the catchment area, and
- The Estuary comprises two RUs, both prioritised.

5.2 Sub-components and Indicators

As part of this study, RQOs for rivers, groundwater, dams, wetland resources and the Thukela estuary were determined. While there are a wide range of sub-components and indicators for which RQOs were ultimately set, it was not practical or necessary to set RQOs for all sub-components in every resource unit. A rationalisation process therefore took place to evaluate and prioritise the sub-components for RQO determination.

The selection of components and the identification of proposed sub-components and indicators for which RQOs were set, had two key objectives: to identify and prioritise sub-components including habitat, quantity, quality and biota that may be important to users or the environment; and to select those sub-components and associated indicators such as flow, salinity, fish and invertebrates, for which RQOs and numerical limits would be developed.

Report Number RDM/WMA04/00/CON/CLA/0620 details the approach taken and the outcomes in identifying sub-components and relevant indicators for the water resources in the Upper Thukela, Mooi/ Sundays, Buffalo and Lower Thukela Sub-catchments of the Thukela catchment, which formed the basis for development of RQOs and numerical limits.

Resource Units 3.1, 3.2, 6.1, 6.2, 6.3, 9.1, 10.1, 10.4, 10.9, 10.11 and 10.12 have been prioritised for groundwater Resource Quality Objectives.

The resource units that have been prioritised for wetland specific sub-components are Resource Units 1.1 and marginally into 1.2, 3.1 and marginally into 3.5, 5.1 and marginally into 5.2, 6.2, 7.2, 7.3 marginally into 7.1, 8.1, 9.3, 14.7 and 14.8.

Sub-components that may be important to either the users or the environment have been prioritised. This step also requires consideration of the impacts of land-based activities on the water resource.

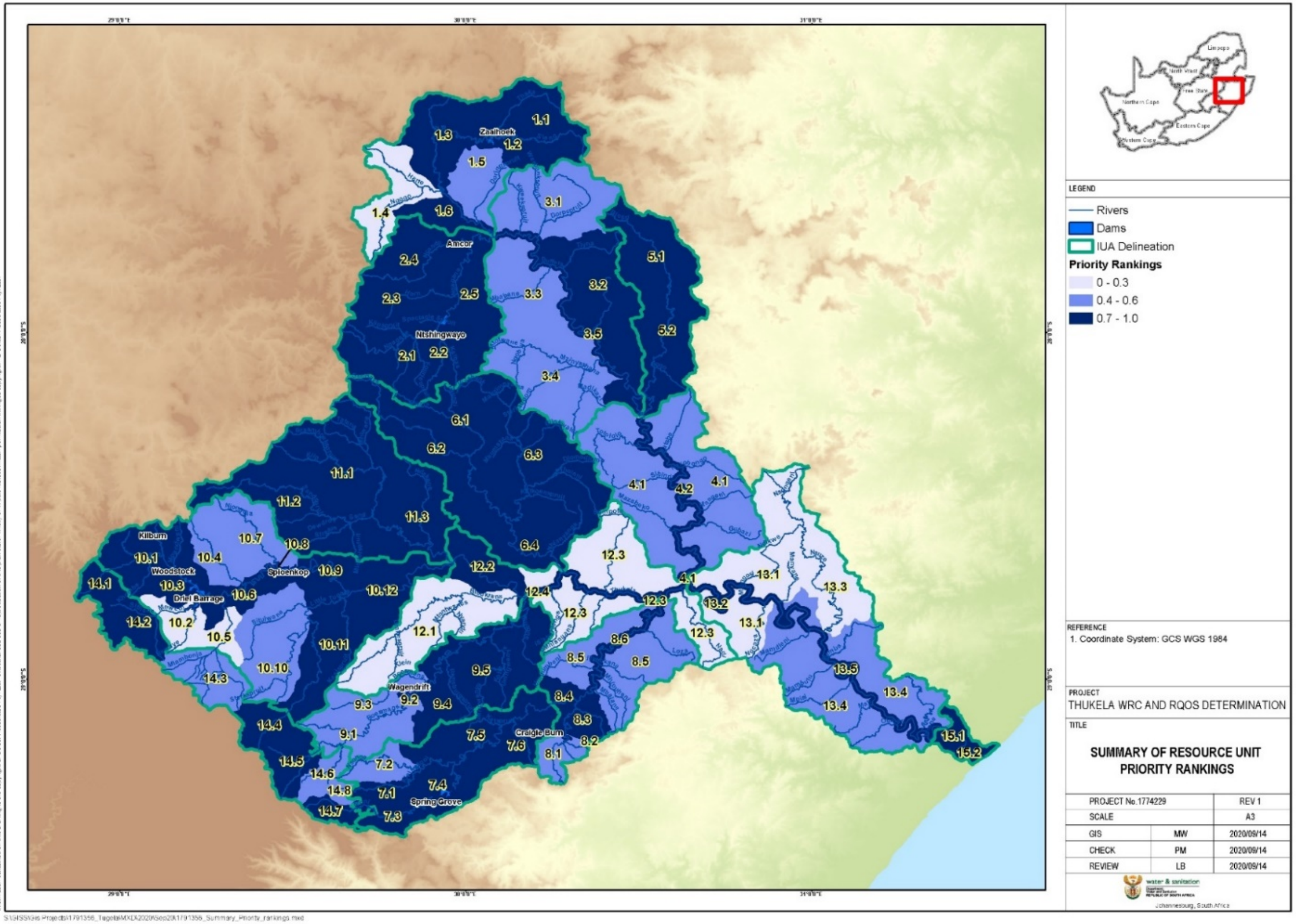

Figure 14: Summary of the Prioritisation ratings of RUs (Dark blue being of higher priority in terms of setting RQOs)

Sub-components for rivers and dams include:

- **Quantity**
  - Low Flows
  - High Flows
- **Quality**
  - Nutrients
  - Salts
  - Systems variables
  - Toxics
  - Pathogens
- **Habitat**
  - Instream habitat
  - Riparian habitat
- **Biota**
  - Fish
  - Aquatic and riparian plant species
  - Mammals
  - Birds
  - Amphibians and reptiles
  - Periphyton
  - Aquatic invertebrates
  - Diatoms

Sub-components related to wetlands include the evaluation and prioritisation of the sub-components focused primarily on the availability of data. For all prioritised wetlands the sub-components Quality, Quantity and Habitat were selected for RQO development. Biota was included as a sub-component where available species data was available to support RQO development.

The sub-components identified for groundwater RQOs include:

- Quantity (abstraction),
- Aquifer water level,
- Water quality, and
- Protection zones

For the estuary, the following sub-components and indicators have been considered.

- **Quantity**
  - Low Flows
  - High Flows (Floods)
- **Hydrodynamics**
  - Mouth Condition
  - Abiotic states
- **Quality**
  - Salinity
  - Dissolved inorganic nitrogen
  - Dissolved inorganic phosphate
  - Water clarity
  - Dissolved oxygen
  - Toxic substances
  - Pathogens
- **Physical Habitat**
  - Intertidal
  - Subtidal
  - Substrate type
- **Biota**
  - Microalgae
  - Macrophytes
  - Invertebrates
  - Fish
  - Birds

6. SUMMARY PER INTEGRATED UNIT OF ANALYSIS

The following chapter summarises the overall outputs of the study per IUA highlighting the water resources class, quaternary catchments, resource units with main rivers and dams, wetlands, and groundwater prioritised areas, EWR sites, Target Ecological Category, and the components for which RQOs have been set. Details of the Resource Quality Objectives determined for each of the prioritised resource units are described fully in Report Number RDM/WMA04/00/CON/CLA/0221.

6.1 IUA 1: Upper Buffalo River

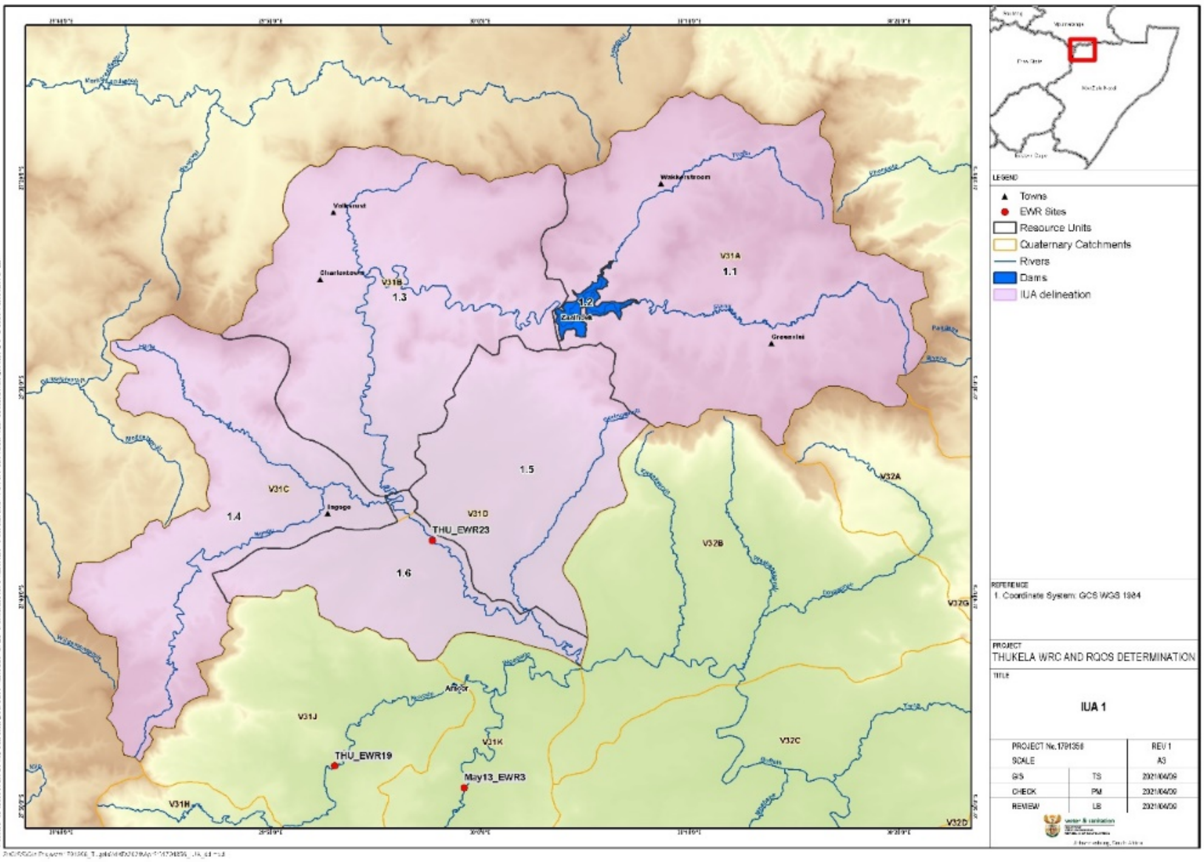

Figure 15: IUA 1: Upper Buffalo River

Table 17: Summary for IUA 1: Upper Buffalo River

Water Resource Class		III			
Quaternary Catchments		V31A	V31A	V31B	V31D
Resource Unit		**1.1**	**1.2**	**1.3**	**1.6**
River		Wetland resource unit: Wakkerstroom	Zaaihoek Dam	Buffalo and Slang rivers	Buffalo to confluence to Ngagane
EWR sites		THU_EWR23			
Target Ecological Category (TEC)		C			
Rivers RQOs	**Quantity**	X		X	X
	Quality	X		X	X
	Habitat			X	X
	Biota	X		X	X
Dams RQOs	**Quantity**		X		
	Quality		X		
Priority Wetlands for which RQOs have been determined		Prioritised wetlands: • Wakkerstroom • Groenvlei			
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)			

6.2 IUA 2: Ngagane River

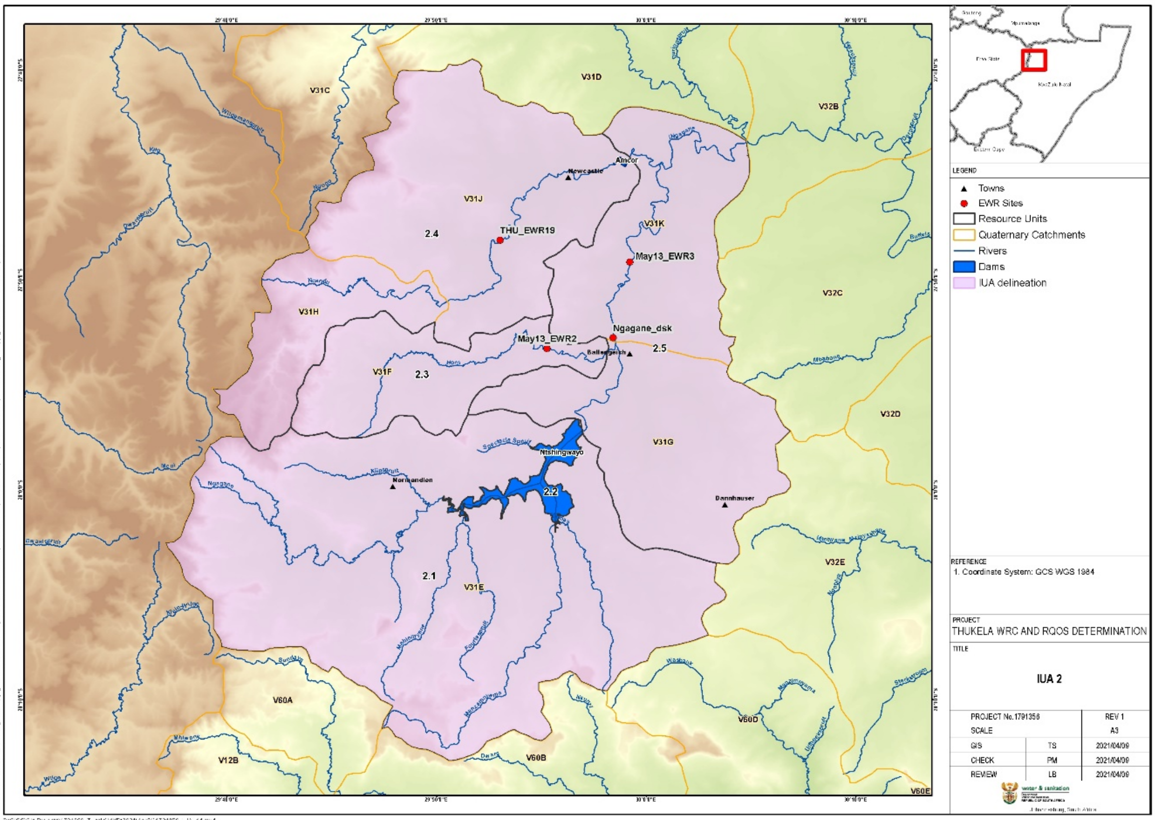

Figure 16: IUA 2: Ngagane River

Table 18: Summary for IUA 2: Ngagane River

Water Resource Class		III				
Quaternary Catchments		V31E	V31E	V31F	V31H, J	V31G, K
Resource Unit		**2.1**	**2.2**	**2.3**	**2.4**	**2.5**
River		Upper Ngagane to Ntshingwayo Dam	Ntshingwayo Dam	Horn to confluence with Ngagane	Ncandu to confluence with Ngagane	Ngagane from Ntshingwayo Dam to confluence with Buffalo
EWR sites		May13_ EWR2; THU_EWR19; May 13_EWR3; Ngagane_dsk#				
Target Ecological Category (TEC)		C; B/C; C/D; C/D				
Rivers RQOs	**Quantity**	X		X	X	X
	Quality	X		X	X	X
	Habitat	X		X	X	X
	Biota	X		X	X	X
Dams RQOs	**Quantity**		X			
	Quality		X			
	Habitat		X			
	Biota		X			
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)				

6.3 IUA 3: Middle Buffalo

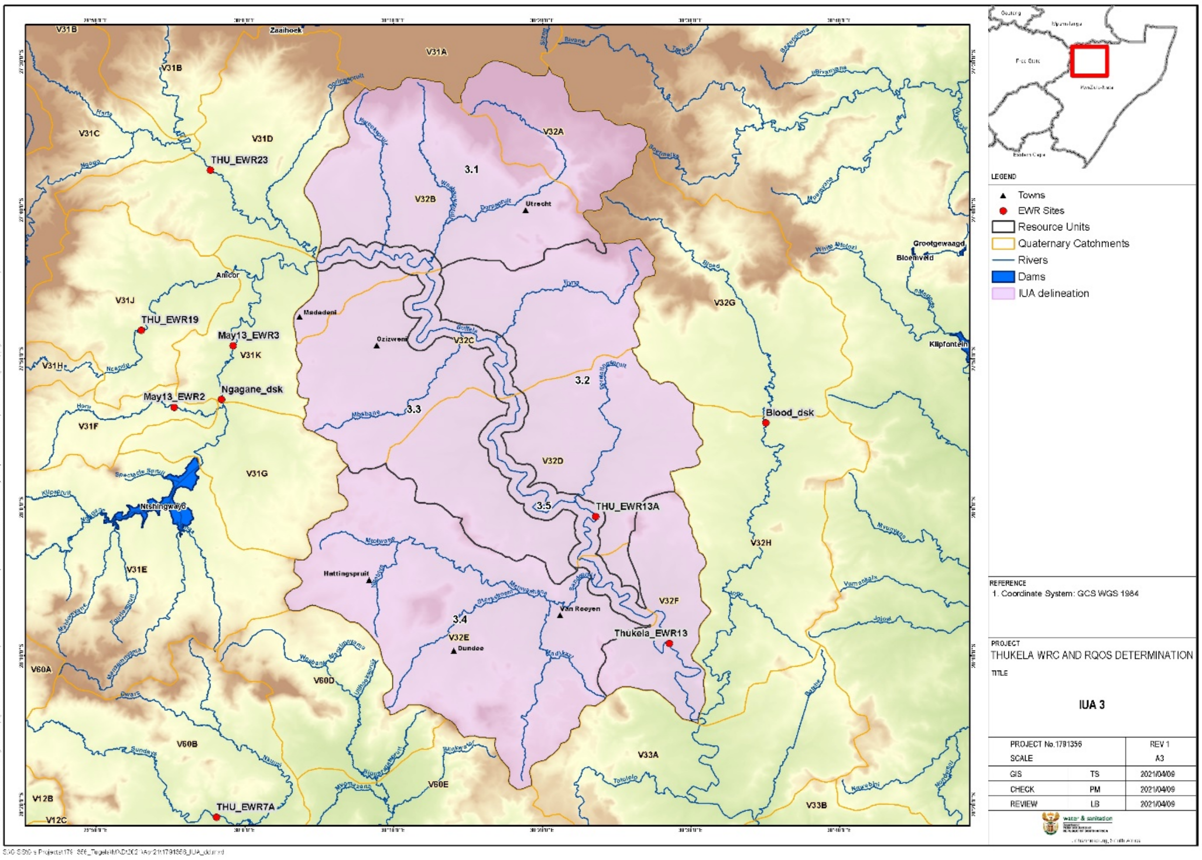

Figure 17: IUA 3: Middle Buffalo

Table 19: Summary for IUA 3: Middle Buffalo

Water Resource Class		**III**			
Quaternary Catchments		V32A, B	V32D		V32F
Resource Unit		**3.1**	**3.2**	**3.4**	**3.5**
River		Dorps (including Kweek and Wasbankspruit) to confluence with Buffalo	Tiyna, Eerstelingsfontein	Mzinyashana including Sterkstroom and Sandspruit	Middle Buffalo River
EWR sites		Thukela_EWR13; Thukela_EWR13			
Target Ecological Category (TEC)		C/D			
Rivers RQOs	**Quantity**		X		
	Quality		X		X
	Habitat		X		
	Biota	X	X	X	X
Priority Wetlands for which RQOs have been determined		• Boschoffsvlei			
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)			

6.4 IUA 4: Lower Buffalo River

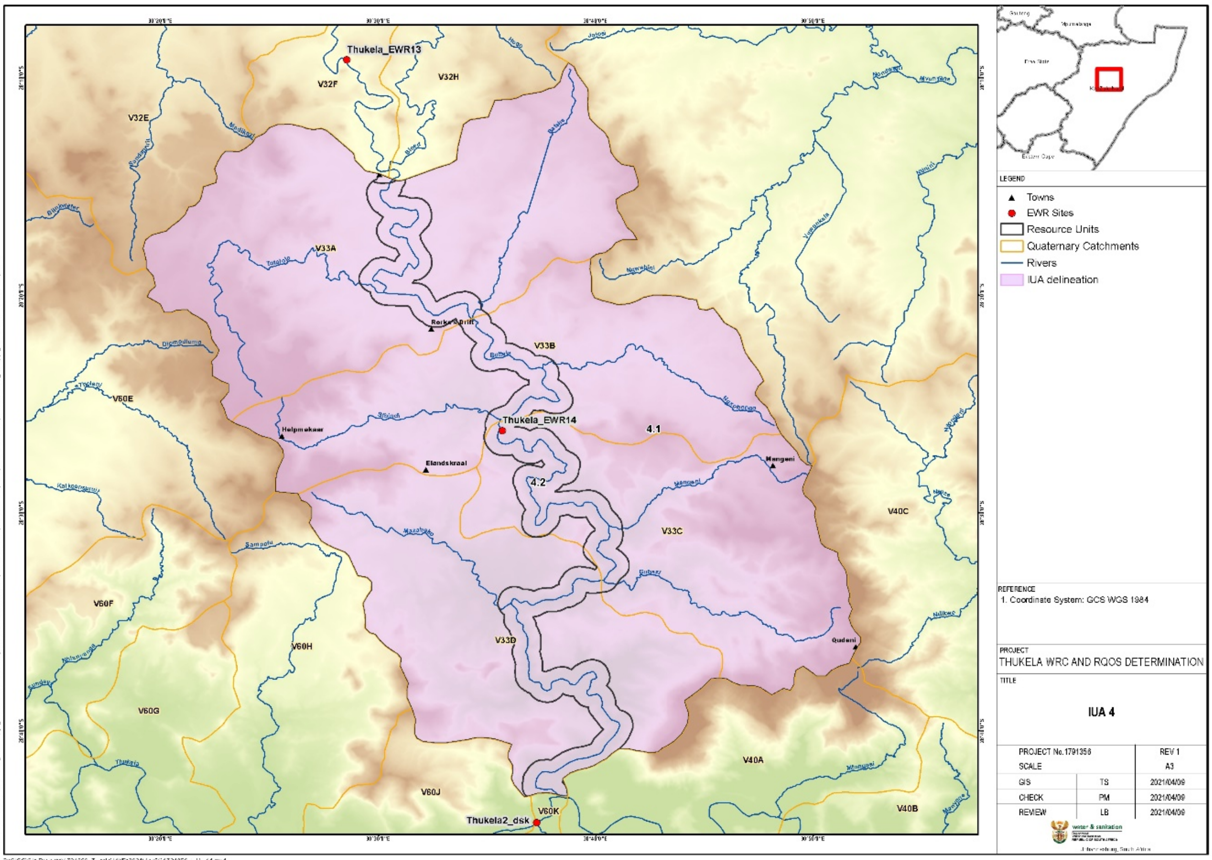

Figure 18: IUA 4: Lower Buffalo River

Table 20: Summary for IUA 4: Lower Buffalo River

Water Resource Class		**II**
Quaternary Catchments		V33C
Resource Unit		**4.2**
River		Buffalo
EWR sites		Thukela_EWR14
Target Ecological Category (TEC)		B/C
Rivers RQOs	**Quantity**	X
	Quality	X
	Habitat	X
	Biota	X
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)

6.5 IUA 5: Blood River

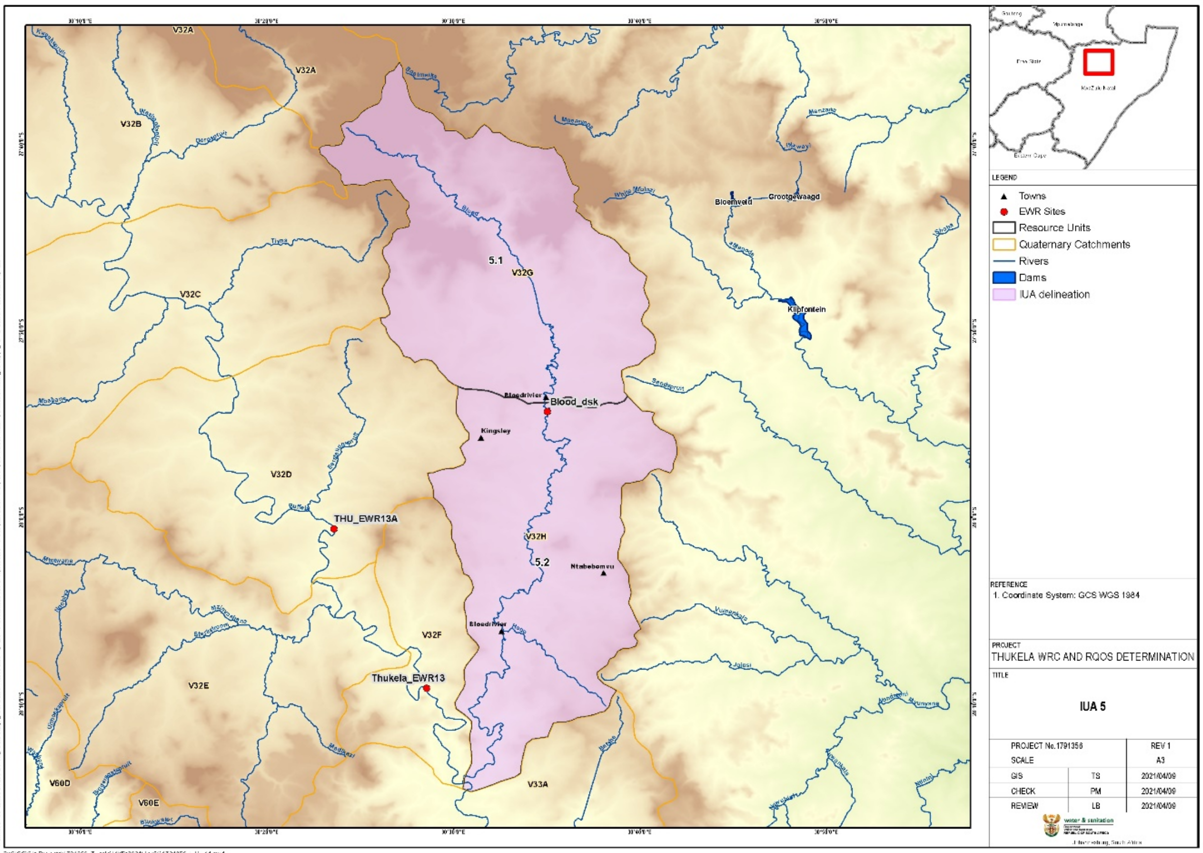

Figure 19: IUA 5: Blood River

Table 21: Summary for IUA 5: Blood River

Water Resource Class		**III**	
Quaternary Catchments		V32G	V32H
Resource Unit		**5.1**	**5.2**
River		Blood River (Wetland RU)	Blood River
EWR sites		Blood_dsk	
Target Ecological Category (TEC)		C	
Rivers RQOs	**Quantity**		**X**
	Quality	**X**	**X**
	Habitat		**X**
	Biota	**X**	**X**
Priority Wetlands for which RQOs have been determined		• Blood River Vlei • Upper Blood River wetlands	
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)	

6.6 IUA 6: Sundays River

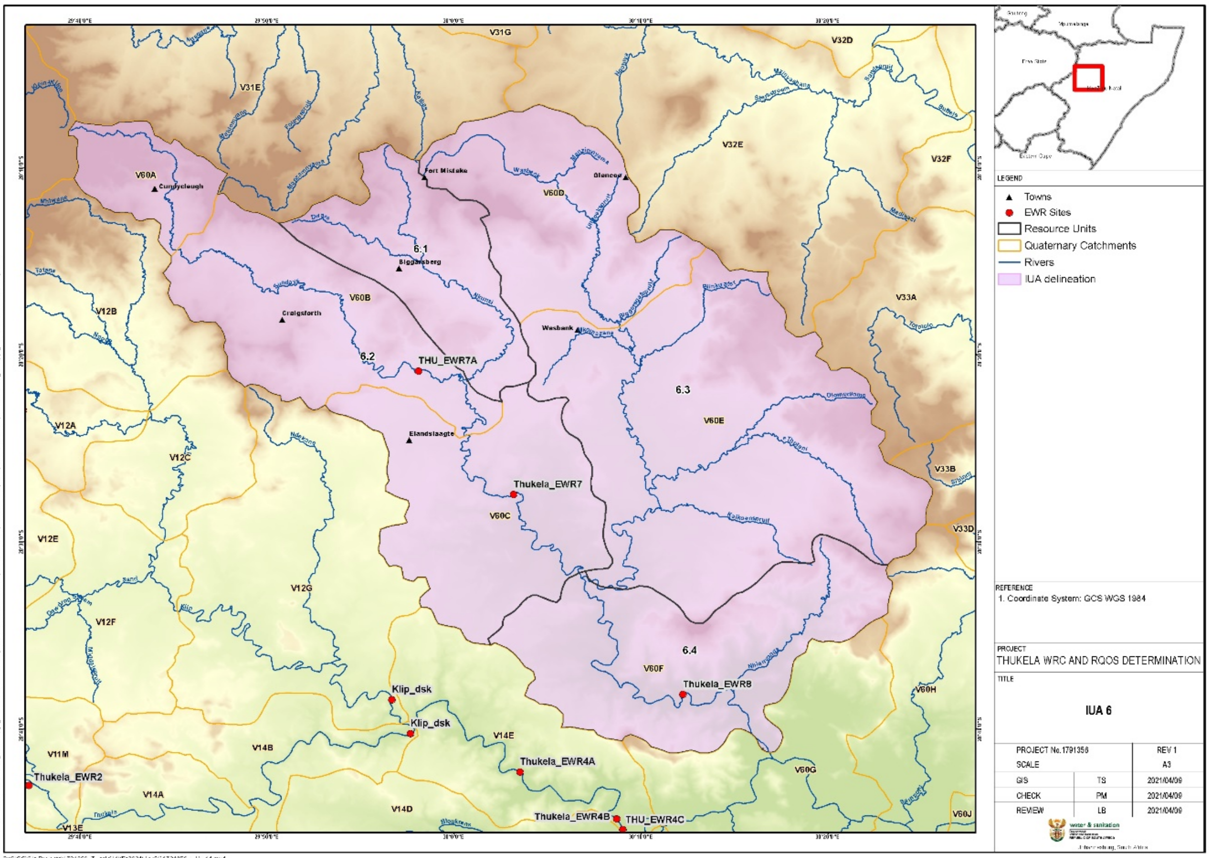

Figure 20: IUA 6: Sundays River

Table 22: Summary for IUA 6: Sundays River

Water Resource Class		III			
Quaternary Catchments		V60B	V60C	V60D, E	V60F
Resource Unit		6.1	6.2	6.3	6.4
River		Nkunzi to confluence with Upper Sundays River	Upper Sundays River	Wasbank to confluence with Sundays	Lower Sundays River
EWR sites		THU_EWR7A; Thukela_EWR7; Thukela_EWR8			
Target Ecological Category (TEC)		C/D; C/D; D			
Rivers RQOs	**Quantity**	X	X	X	X
	Quality	X	X	X	X
	Habitat	X	X	X	X
	Biota	X	X	X	X
Priority Wetlands for which RQOs have been determined		• Boschbergvlei • Paddavlei			
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)			

6.7 IUA 7: Upper Mooi River

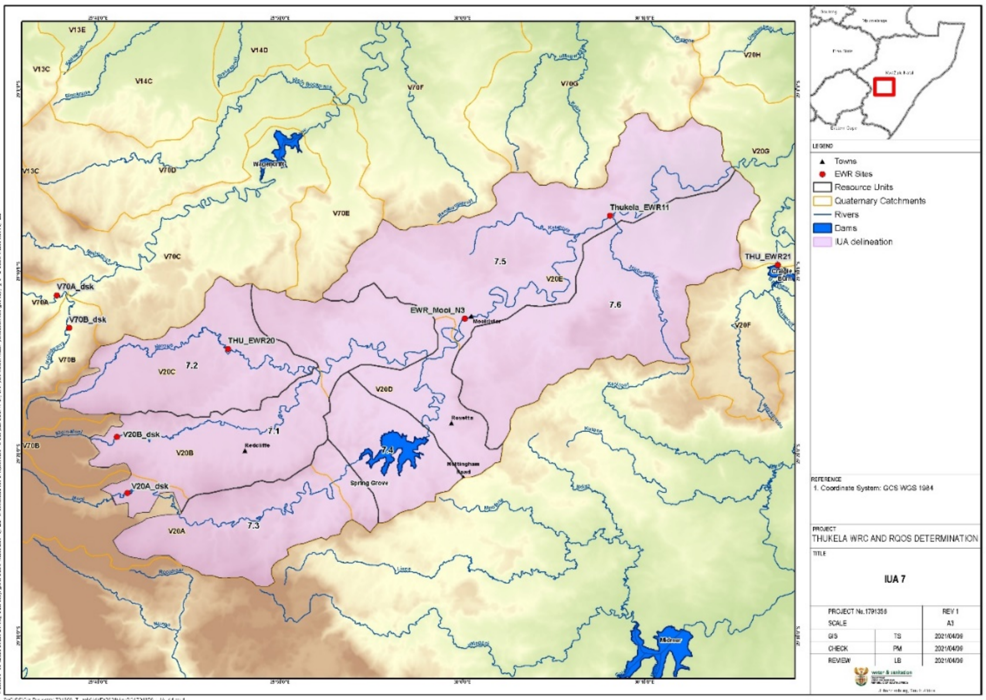

Figure 21: IUA 7: Upper Mooi River

Table 23: Summary for IUA 7: Upper Mooi River

Water Resource Class		III						
Quaternary Catchments		V20B (lower portion), D	V20C	V20A (lower portion), D (upper)	V20D	V20E		V20E
Resource Unit		**7.1**	**7.2**	**7.3**	**7.4**	**7.5 a**	**7.5b**	**7.6**
River		Klein - Mooi from source to Mooi confl.	Nsonge River	Mooi upstream of Spring Grove Dam	Spring Grove Dam/ Mearns Weir	Mooi River (Short-term)	Mooi River (Long term)	Joubertsvlei to confl. with Mooi
EWR sites		THU_EWR20; EWR_Mooi_N3; Thukela_EWR1						
Target Ecological Category (TEC)		B/C; D; C/D						
Rivers RQOs	**Quantity**	X	X	X	X	X	X	
	Quality	X	X	X	X	X	X	X
	Habitat	X	X			X	X	
	Biota	X	X	X	X	X	X	X
Priority Wetlands for which RQOs have been determined		• Stillerust • Hlatikhulu						
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)						

6.8 IUA 8: Middle/ Lower Mooi River

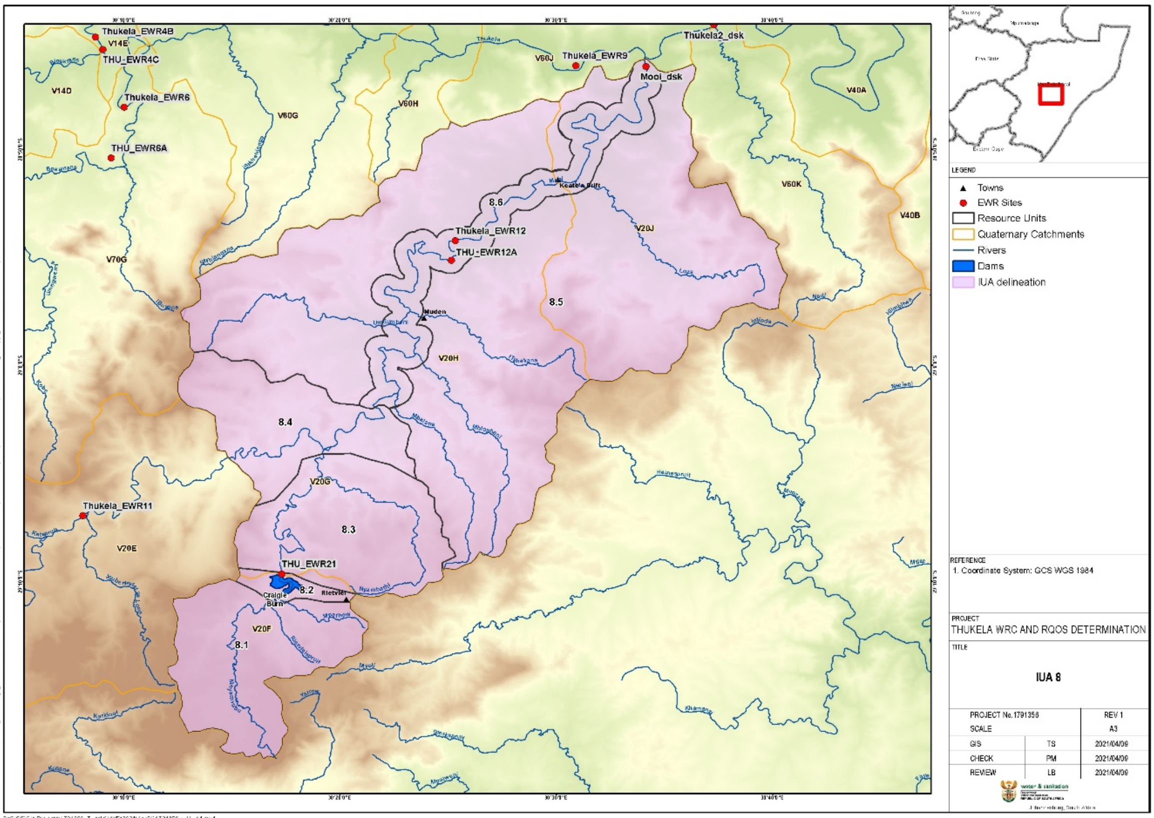

Figure 22: IUA 8: Middle/ Lower Mooi River

Table 24: Summary for IUA 8: Middle/ Lower Mooi River

Water Resource Class		III			
Quaternary Catchments		V20F	V20F	V20G	V20H
Resource Unit		**8.1**	**8.2**	**8.3**	**8.6**
River		Mnyamvubu upstream Craigieburn Dam	Craigieburn Dam	Mnyamvubu River	Mooi River
EWR sites		THU_EWR21; THU_EWR12A			
Target Ecological Category (TEC)		C			
Rivers RQOs	**Quantity**			X	X
	Quality			X	X
	Habitat			X	X
	Biota			X	X
Dams RQOs	**Quantity**		X		
	Quality		X		
	Biota		X		
Priority Wetlands for which RQOs have been determined		• Scawby, Dartmoor and Melmoth			
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)			

6.9 IUA 9: Middle/ Lower Bushman's River

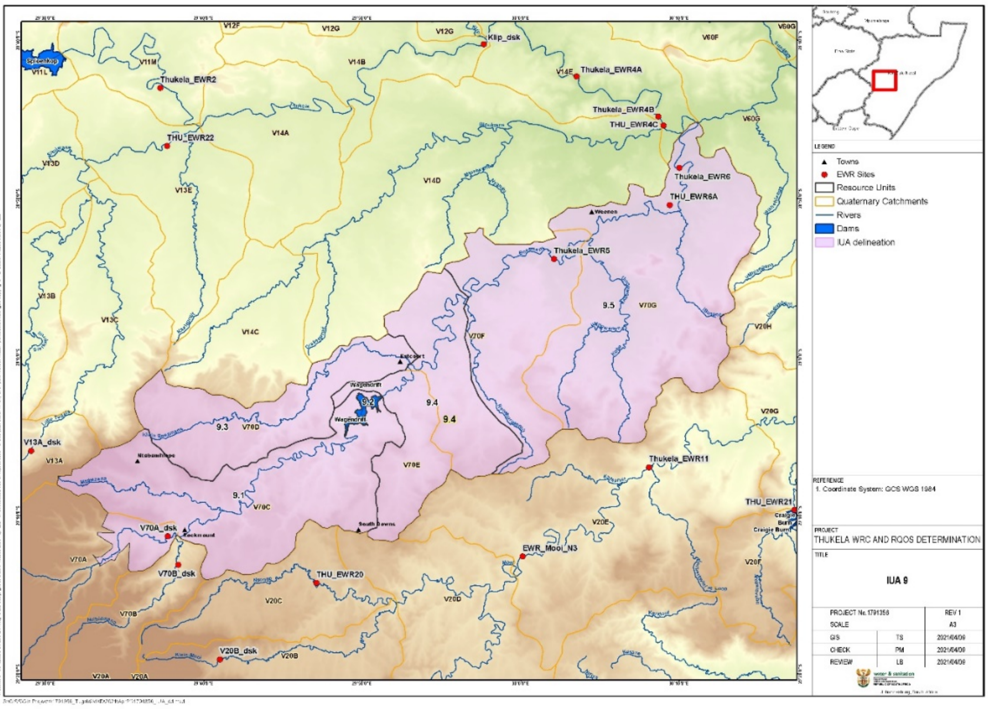

Figure 23: IUA 9: Middle/ Lower Bushman's River

Table 25: Summary for IUA 9: Middle/ Lower Bushman's River

Water Resource Class		III				
Quaternary Catchments		V70C	V70D	V70E, F (upper part)	V70F (lower)	V70G
Resource Unit		9.2	9.3	9.4	9.5a	9.5b
River		Wagendrift Dam	Little Bushman's to confluence with Bushman's	Bushman's from Wagendrift Dam to confl. with Rensburg spruit d/s of Estcourt	Middle Bushman's River	Lower Bushman's River
EWR sites		Thukela_EWR5; THU_EWR6A				
Target Ecological Category (TEC)		C; C/D				
Rivers RQOs	**Quantity**				X	X
	Quality		X	X	X	X
	Habitat		X		X	X
	Biota		X		X	X
Dams RQOs	**Quantity**	X				
	Quality	X				
	Biota	X				
Priority Wetlands for which RQOs have been determined		Ntabamhlope				
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)				

6.10 IUA 10: Upper Thukela River

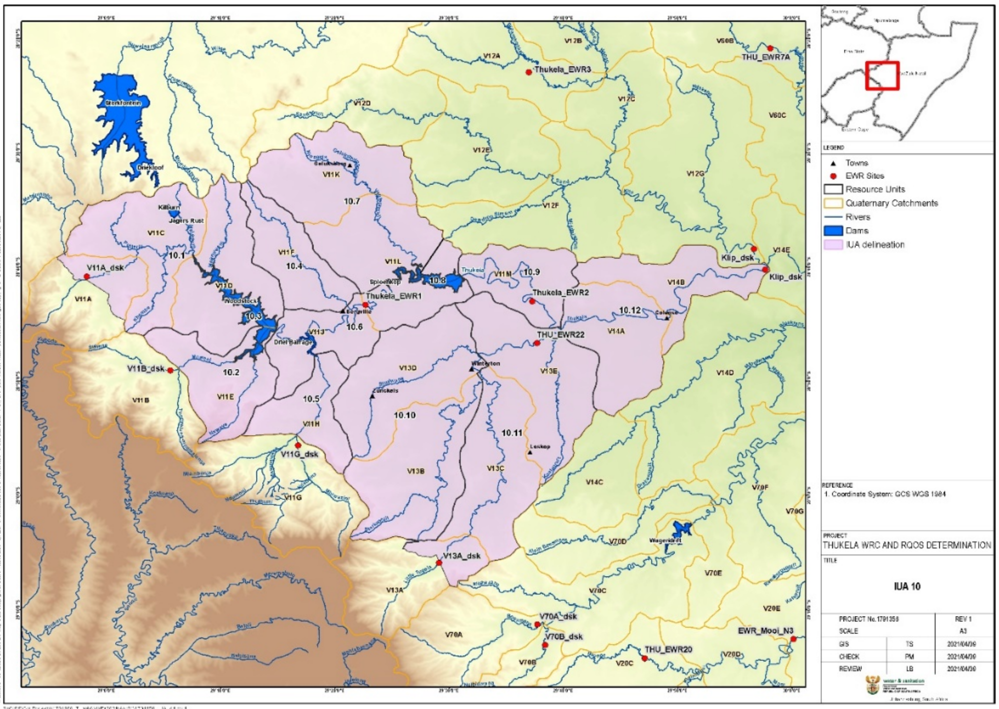

Figure 24: IUA 10: Upper Thukela River

Table 26: Summary for IUA 10: Upper Thukela River

Water Resource Class		III							
Quaternary Catchments		V11A (lower portion), C, D	V11D, E	V11F	V11L	V11M	V13B, D	V13 E	V14B
Resource Unit		**10.1**	**10.3**	**10.4**	**10.8**	**10.9**	**10.10**	**10.11**	**10.12**
River		Thukela, Putterill, Majaneni ,Khombe tributary catchments	Wood stock Dam	Sand spruit tributary catchment	Spioen kop Dam	Upper Thukela River	Sterk spruit, Situlwane tributary catchment	Little Thukela River	Thukela River
EWR sites		Thukela_EWR1; Thukela_EWR2; Thukela_EWR3; Thukela1_dsk							
Target Ecological Category (TEC)		D; C/D: C/D: C/D							
Rivers RQOs	**Quantity**					X		X	X
	Quality	X		X		X	X	X	X
	Habitat	X		X		X	X	X	X
	Biota	X		X		X	X	X	X
Dams RQOs	**Quantity**		X		X				
	Quality		X		X				
	Biota		X		X				
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)							

6.11 IUA 11: Klip River

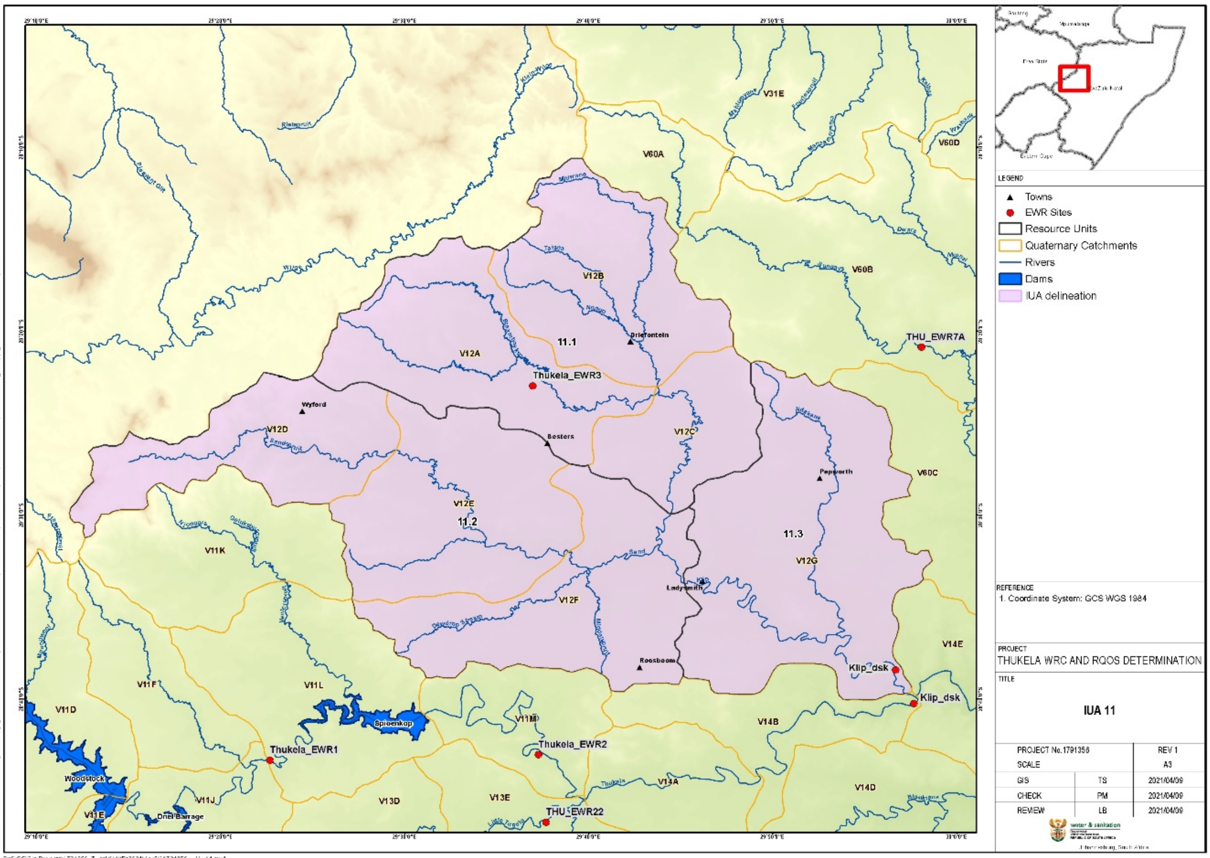

Figure 25: IUA 11: Klip River

Table 27: Summary for IUA 11: Klip River

Water Resource Class		III		
Quaternary Catchments		V12D, E and F	V12A, B, C,	V12G
Resource Unit		11.1	11.2	11.3
River		Sandspruit and tributaries	Klip River	Klip River
EWR sites		THU_EWR22; Klip_dsk		
Target Ecological Category (TEC)		C		
Rivers RQOs	**Quantity**		X	X
	Quality	X	X	X
	Habitat	X	X	X
	Biota	X	X	X
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)		

6.12 IUA 12: Middle Thukela River

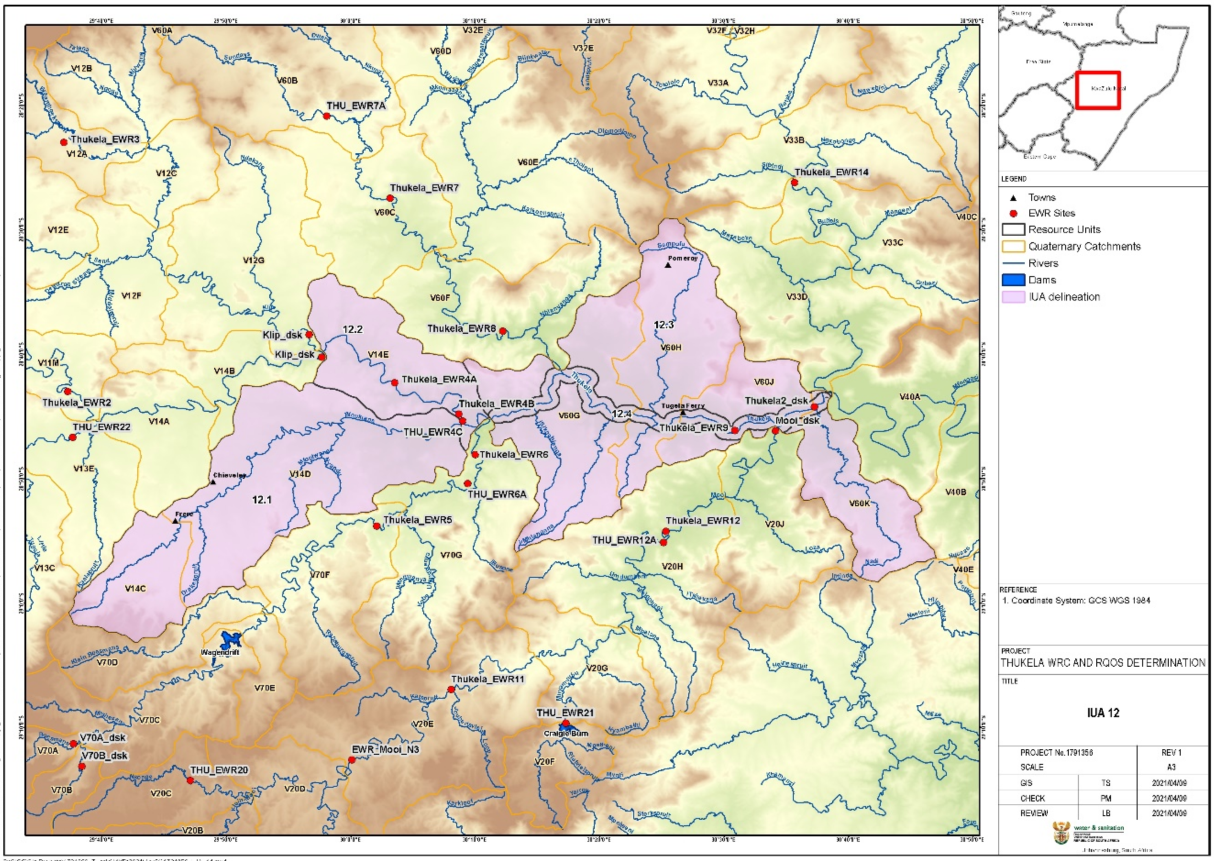

Figure 26: IUA 12: Middle Thukela River

Table 28: Summary for IUA 12: Middle Thukela River

Water Resource Class		**III**	
Quaternary Catchments		V14E	V60J
Resource Unit		**12.2**	**12.4**
River		Middle Thukela River	Middle Thukela River
EWR sites		Thukela_EWR4B; Thukela_EWR9	
Target Ecological Category (TEC)		C; D	
Rivers RQOs	**Quantity**	X	X
	Quality		X
	Habitat	X	X
	Biota	X	X
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)	

6.13 IUA 13: Lower Thukela River

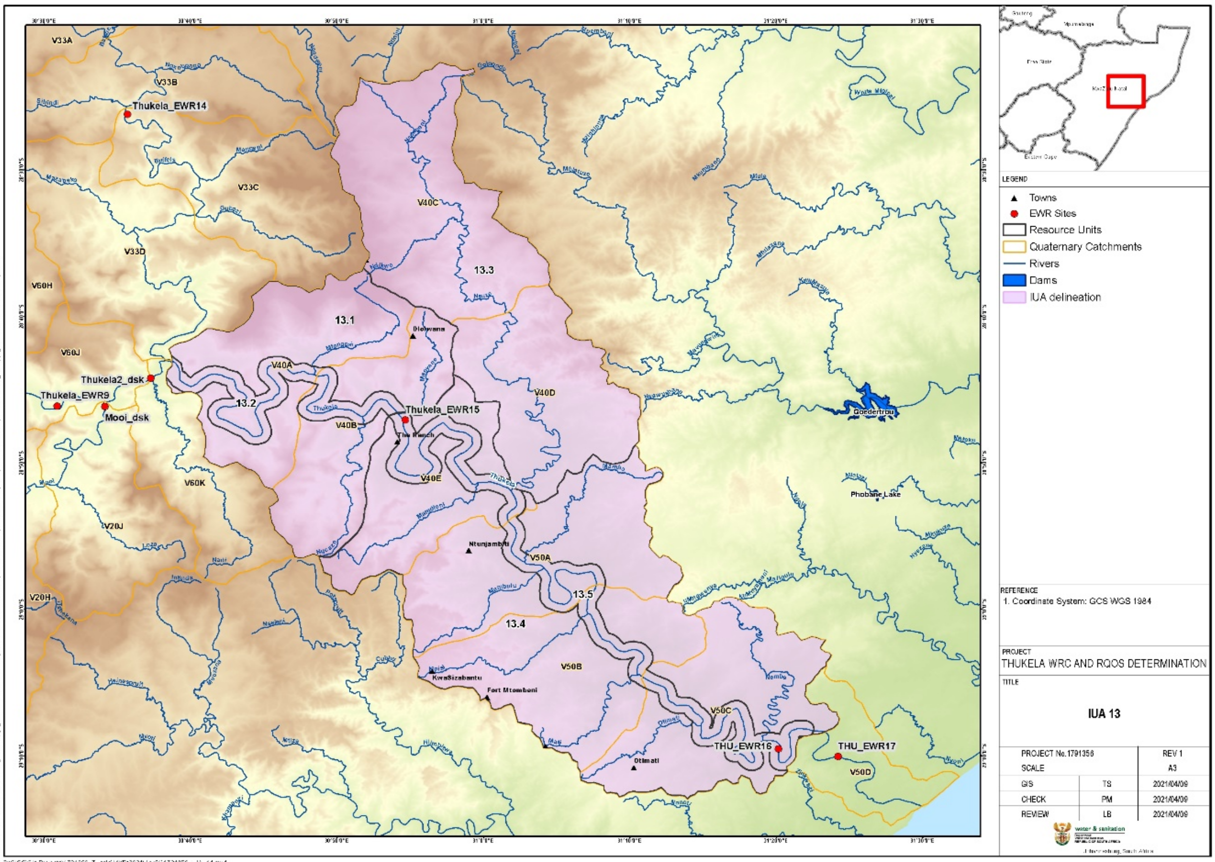

Figure 27: IUA 13: Lower Thukela River

Table 29: Summary for IUA 13: Lower Thukela River

Water Resource Class		II	
Quaternary Catchments		V40A, B	V40A, B
Resource Unit		**13.2**	**13.5**
River		Lower Thukela River	Lower Thukela River
EWR sites		Thukela_EWR15; THU_EWR16	
Target Ecological Category (TEC)		C	
Rivers RQOs	**Quantity**	X	X
	Quality	X	X
	Habitat	X	X
	Biota	X	X
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)	

6.14 IUA 14: Escarpment

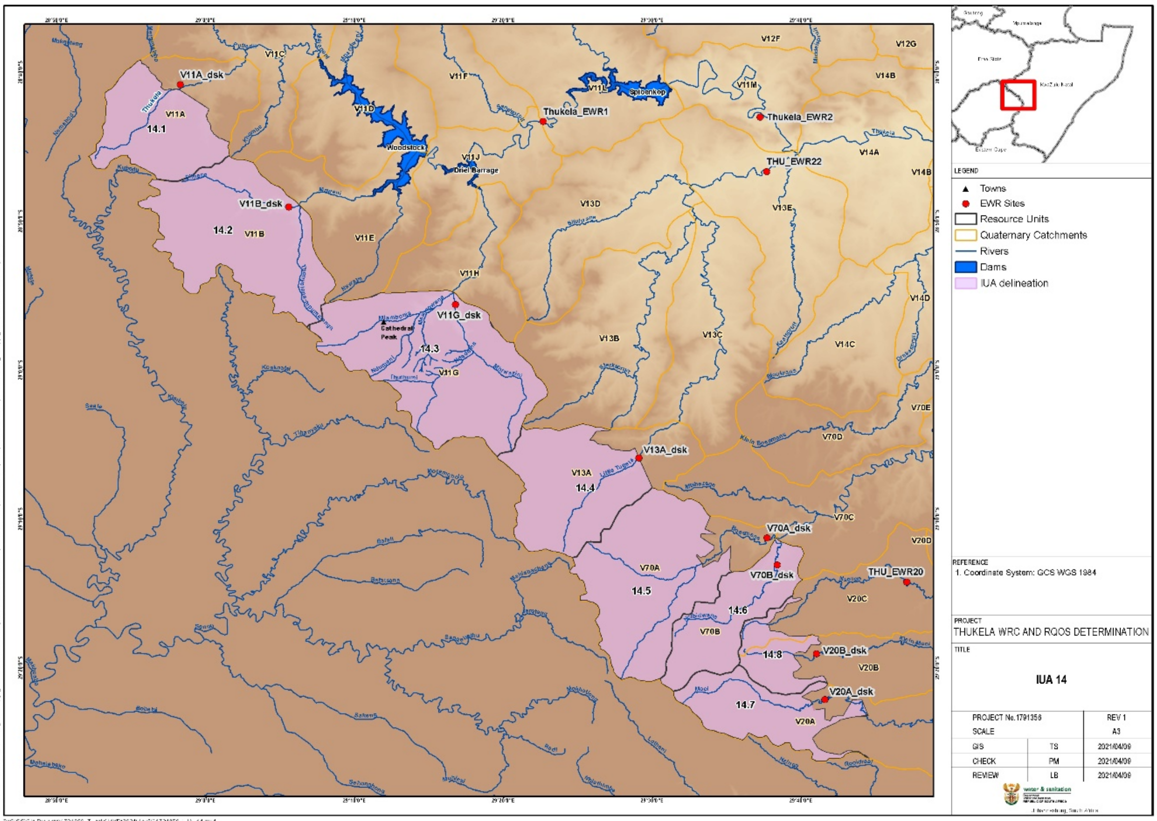

Figure 28: IUA 14: Escarpment

Table 30: Summary for IUA 14: Escarpment

Water Resource Class		**I**							
Quaternary Catchments		V11A	V11B	V11G	V13A	V70A	V70B	V20A	V20B
Resource Unit		**14.1**	**14.2**	**14.3**	**14.4**	**14.5**	**14.6**	**14.7**	**14.8**
River		Upper Thukela River	Mnweni River	Mlambonja River	Little Thukela River	Upper Bushman's River	Ncibidwana River	Upper Mooi River	Little Mooi River (upper)
EWR sites		V11A_dsk; V11B_dsk; V11G_dsk; V13A_dsk; V70A_dsk; V70B_dsk; V20A_dsk; V20B_dsk*							
Target Ecological Category (TEC)		B; B/C*							
Rivers RQOs*	**Quantity**	X	X	X	X	X	X	X	X
Groundwater RQOs		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)							

* Very important Strategic Water Source Areas

6.15 IUA 15: Thukela Estuary

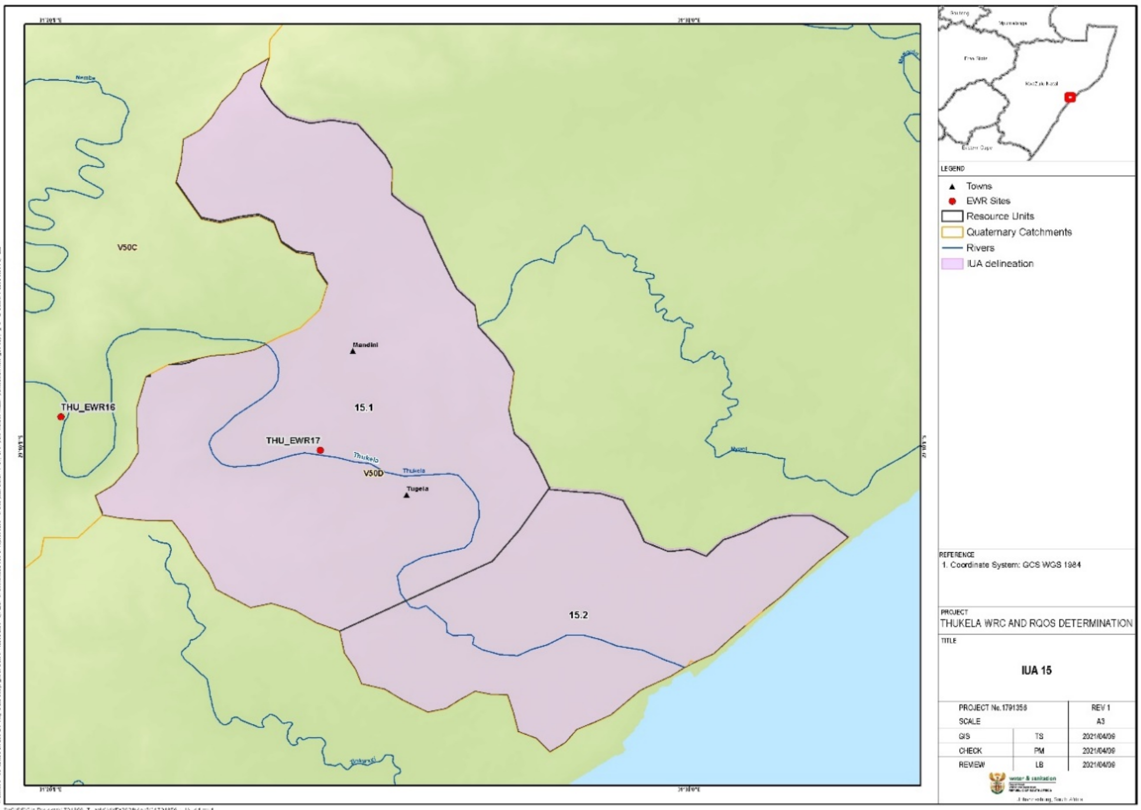

Figure 29: IUA 15: Thukela Estuary

Table 31: Summary for IUA 15: Thukela Estuary

Water Resource Class		II	
Quaternary Catchments		V50D	V50D
Resource Unit		**15.1**	**15.2**
River		Lower Thukela River	Estuary
EWR sites		Thukela_EWR17	
Target Ecological Category (TEC)		C	
Rivers RQOs	**Quantity**	X	
	Quality	X	
	Habitat	X	
	Biota	X	
Estuary RQO	**Quantity**		X
	Hydrodynamics		X
	Quality		X
	Physical Habitat		X
	Biota		X
Groundwater RQOs (15.1)		• Quantity (stress Index and water depth) • Quality • Protection criteria (water level and quality trends)	

7. CONCLUSIONS

The project undertaken by Department of Water and Sanitation, Chief Directorate Water Ecosystems Management, has produced water resource classes for 15 Integrated Units of Analysis in the Thukela Catchment. Seventy five (75) resource units within the IUAs were delineated of which fifty four (54) were prioritised and RQOs were set for rivers, dams, groundwater, wetlands, and the estuary, as appropriate.

It is noted that the RQOs that have been set provide a set of objectives that were based on available data, information, previous studies, the Water Resource Classification component and inputs from external specialists and stakeholders. These proposed water resource classes and RQOs and associated numerical limits were taken through various stakeholder consultation processes and were based on guidance received and best available information sources at the time of development.

The team feels confident that implementation of the RQOs will maintain or improve the water resources (rivers, dams, groundwater, wetlands, and the estuary) in the Thukela catchment.

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