DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems

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

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

WP 11255

Study Report No.

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TERMINOLOGY AND ABBREVIATIONS

Acronym	Description
AIP	Alien invasive plants
ARD	Acid Rock Drainage
BWSS	Bulk Water Supply Scheme
CD: WE	Chief Directorate: Water Ecosystems
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
D: RQIS	Directorate: Resource Quality Information Services
EC	Ecological Category
EcoSpecs	Ecological Specifications
EGSAs	Ecosystem Goods, Services and Attributes
ERC	Ecological Recommended Category
EI	Ecological Importance
ES	Ecological Sensitivity
ES	Ecosystem Services
ESFs	Ecosystem Service Frameworks
EIS	Ecological Importance and Sensitivity
EFZ	Estuarine Functional Zone
EWR	Ecological Water Requirements
FEGS-CS	Final Ecosystem Goods and Services Classification System
GDP	Gross Domestic Product
GHS	General Household Survey
GIS	Geographic Information Systems
GGP	Gross Geographic Product
GRU	Groundwater Resource Unit
ha	Hectares

Acronym	Description
HGM	Hydrogeomorphic
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
KZN	KwaZulu-Natal
LTBWSS	Lower Thukela Bulk Water Supply Scheme
mamsl	Meters above mean sea level
MAR	Mean Annual Run-off
mbgl	Metres below ground level
MEA	Millennium Ecosystem Assessment
MMTS	Mooi Mgeni Transfer Scheme
NCMP	National Chemical Monitoring Programme
NFEPA	National Freshwater Ecosystem Priority Areas
NGO	Non- Governmental Organisation
NWA	National Water Act
PA	Protected Areas
PES	Present Ecological Sate
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RDM	Resource Directed Measures
RUs	Resource Units
SQ	Sub-quaternary
SWSA	Strategic Water Source Areas
SeCT	Socio-Economic Comparison Tool
TEEB	The Economics of Ecosystems and Biodiversity

Acronym	Description
TDS	Total Dissolved Solids
TWP	Thukela Water Project
TWPDSP	Thukela Water Project Decision Support Phase
UNESCO	United Nations Educational, Scientific and Cultural Organization
VB	Valley Bottomed
WMA	Water Management Area
WMS	Water Management System
WRC	Water Research Commission
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model
WWTW	Wastewater Treatment Works

EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) has commissioned the study, the *Determination of Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment.* The purpose of this study is to coordinate the implementation of the Water Resource Classification System (WRCS) in the Thukela in order to determine water resources classes and resource quality objectives for all significant water resources.

The Thukela catchment is situated in central KwaZulu-Natal forming the drainage basin for the Thukela, Buffalo and Sundays Rivers. The catchment drains an area of 29 040 km^2. The headwaters of the basin are situated in the Drakensberg escarpment range and drain east and south eastward flowing approximately 512 km through the eastern slopes, the midlands to discharge into the Indian Ocean at the Thukela Mouth Estuary. The escarpment represents national Strategic Water Source Areas (SWSA) and a World Heritage Site. The catchment is bordered by the Upper Vaal (to the west), Usuthu to Mhlatuze (to the east) and Mvoti to Umzimkulu catchment (to the south).

The determination of the water resource classes is necessary to facilitate a balance between protection and use of water resources. In determining the class, it is important to recognise that different water resources will require different levels of protection which requires due consideration of the social and economic needs of competing interests by all who rely on the water resources. The WRCS is applied taking account of the local conditions, socio-economic imperatives and system dynamics within the context of the catchment. The process also requires a wide range of complex trade-offs to be assessed and evaluated at a number of scales.

The first step of the Classification process is to assess status quo of water resources and delineate the units of analysis *i.e.* the spatial units that will be defined as a network of significant water resources.

The purpose of this report is thus to describe the 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 here. The socio-economic analysis of the catchment has also been undertaken and a perspective is presented in the report.

This information was then used to delineate socio-economic zones and IUAs and provide background information to assist with the next steps of the classification process. This report in addition presents proposed biophysical nodes, for the EWR quantification step that is to follow.

Integrated Units of Analysis (IUAs)

Each integrated unit of analysis (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).

Delineation of units of analysis is required as it would not be appropriate to set the same water resource class for all water resources in a catchment. The delineation of a catchment into IUAs for the purpose of determining the water resource class is done primarily according to a number of socio-economic criteria and drainage region (catchment area) boundaries. IUAs are thus a combination of socio-economic zones and watershed boundaries (DWA, 2007). Ecological information also plays a role in the delineation.

The following was considered for delineation of IUAs within the Thukela Catchment:

- Socio-economic zones (SEZs);
- Catchment area boundaries (drainage regions and water resource systems);
- The resolution of the hydrological analysis and available water resource network configurations within the water resource models;
- Location of significant water resource infrastructure;
- Land use characteristics;
- Distinctive functions of the catchments in context of the larger system;
- The Present Ecological State (PES) of each biophysical node was considered, the type of impacts and the homogeneity of the status and impacts;
- The practicalities of the existing model setup and network in terms of the scenario evaluation of each IUA;
- Present status of water resources, and
- Stakeholder input.

IUA Delineation Results

Fifteen IUAs have been delineated for the Thukela catchment. The results of the delineation are tabled below and illustrated in Figure E1. Detail descriptions of each IUA is presented in the report.

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

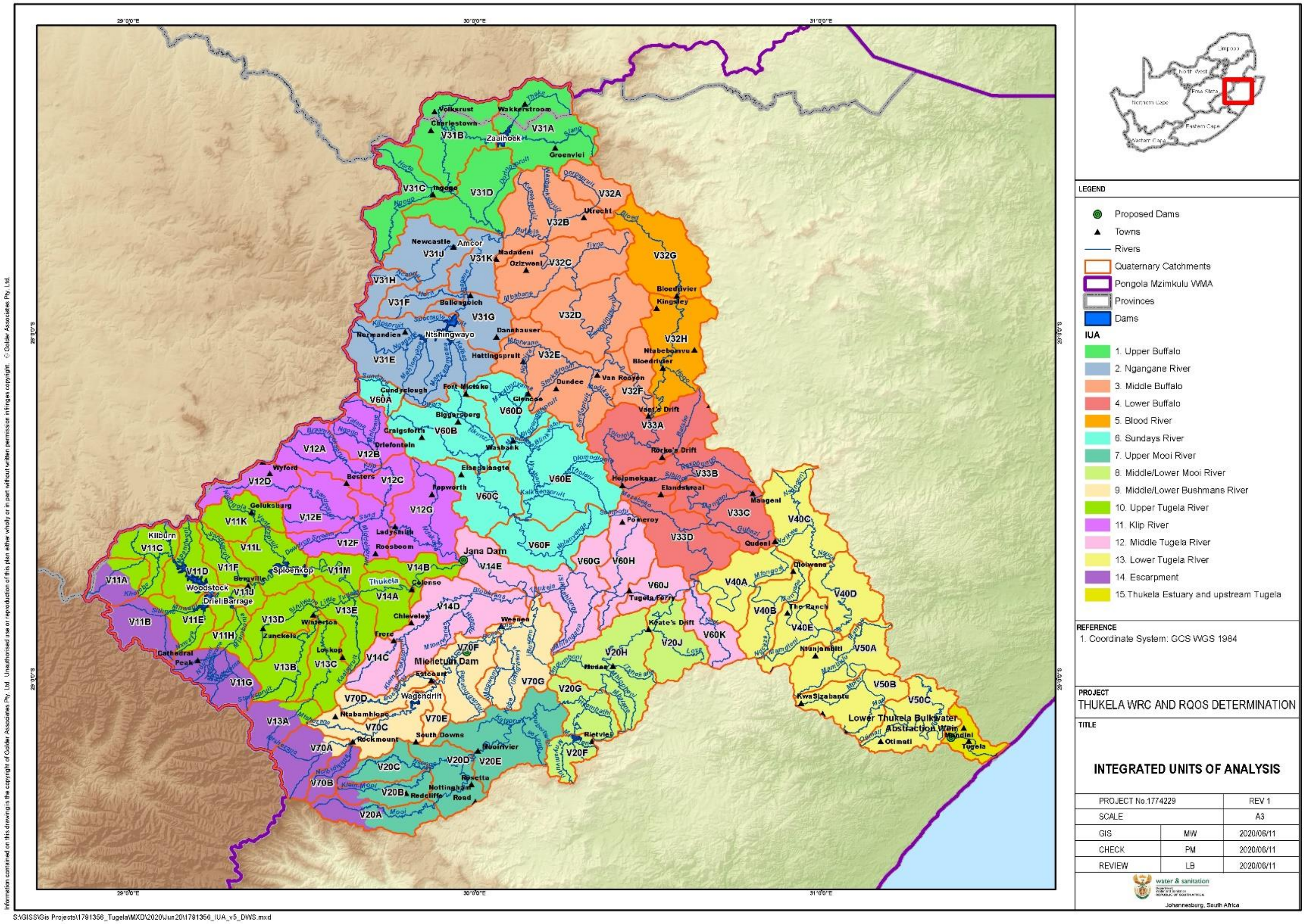

Figure E1: IUAs delineated for the Thukela catchment

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1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) is presently undertaking a study to determine Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment which falls within the Pongola to Mtamvuma Water Management Area (WMA 4).

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). The Resource Directed Measures are intended to ensure comprehensive protection of all water resources. Protection is about the quantity and quality (overall health) of the water resource. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical, and affordable. Once the water resources class and the Reserve have been established, RQOs are determined to give effect to those water resource classes and the Reserve.

The DWS is progressively underway with the process to set water resources classes for all water resource systems in South Africa to ensure their protection and sustainable use. The Thukela River Catchment in KwaZulu-Natal is the current river system being classified, the second of the Pongola to Mtamvuma WMA. The significant water resources in the Mvoti to Umzimkulu catchment have been classified and RQOs set.

1.2 PURPOSE OF THE STUDY

The main objective of this study is to co-ordinate the implementation of the Water Resource Classification System (WRCS) (Regulation 810) and to undertake the implementation of the RQO determination procedure (7 step process) in the Thukela Catchment for all significant water resources (including rivers, groundwater, wetlands and estuary). The setting of water resource classes and associated RQOs is aimed at facilitating sustainable use of the catchment's water resources, balanced with maintenance or improvement of ecological integrity. Protection of strategic water resources and specifically water source areas is of critical importance in the Thukela Catchment.

This study is reliant on the preliminary Reserve determination studies undertaken for the rivers, groundwater and the estuary in the Thukela Catchment and is guided by other water resource management initiatives in the catchment.

Successful determination of the water resource classes and RQOs is also dependent on the buy-in and agreement of stakeholders on the selected scenarios through consultative processes. Specialist technical assessment and stakeholder engagement are thus key components of the process.

The integrated eight step process developed for the resource directed measures (DWS, 2017) which is based on the gazetted WRCS is being followed for the study (refer to Figure 1).

1.3 PURPOSE OF THE REPORT

This report represents Step 2 of the RDM process. The purpose of this report is to describe and document the status quo task which includes various components such as water resources and systems, water use, economy, river and wetland ecology, water quality problems and ecosystem services and attributes. This information has been used to define the integrated units of analysis (IUAs), also presented in this report. IUAs are the spatial units that will be defined as significant water resources. Each IUA represents a homogenous socio-economic area which requires its own specification of a water resource class.

Based on the IUAs delineated, Resource Units (RUs) and biophysical nodes will be identified for different levels of Ecological Water Requirements (EWR) assessment and setting of RQOs. This task therefore describes the baseline information for the decision-making to be undertaken within the integrated water resources management framework for the catchment to set the water resource classes and RQOs. The decision analysis framework is also presented in this report. Step 1 is completed concurrently with the status quo and IUA delineation when the EWRs of the preliminary Reserve determinations are confirmed.

Step 1: Confirm, quantify and finalise EWRs (concurrently with Step 2);

↓

Step 2: Describe status quo and delineate the study area into Integrated Units of analysis (IUAs);

↓

Step 3: Identify and model scenarios within IWRM, and evaluate with stakeholders ;

↓

Step 4: Determine water resource classs based on catchment configurations for identified scenarios;

↓

Step 5: Determine resource quality objectives (narrative and numerical limits) (priority resource units, sub-components and indicators);

↓

Step 6: Agree on water resource classes and RQOs with stakeholders;

↓

Step 7: Finalise and prepare integrated gazette template and implementation plan

Figure 1: Water resource classes and RQOs determination in the Thukela catchment (integrated process in adherence to Regulation 810 of Government Gazette 33541)

1.4 STUDY AREA OVERVIEW

The study area is the catchment of the Thukela River illustrated in Figure 2. The Thukela River catchment is the largest river system within the Pongola to Mtamvuma Water Management Area (WMA 4). The Thukela Catchment drains an area of 29 040 km^2, rising on the escarpment of the Drakensberg and flowing approximately 512 km through the eastern slopes, the midlands and discharging into the Indian Ocean, via the Thukela Estuary.

The catchment has two main drainage systems: Upper Thukela and Buffalo rivers. This is attributed to the great Thukela Fault which runs in an east-west direction through the catchment as far as Colenso. The topography of the catchment varies dramatically, ranging from steep areas to gentle slopes. The Thukela Catchment lies predominantly in the KwaZulu-Natal Province, except for a narrow strip in the extreme north which falls in Mpumalanga Province.

The resources of the Thukela River are predominantly used to support requirements for water in other parts of the country, with large transfers of water to neighbouring catchments (DWS, 2004). The river is relied upon for transfers into the Vaal System, the Mhlatuze Catchment to the north-west and Mooi-Mgeni System in the south. The catchment includes eight major dams; however, for the most part, the Thukela River remains largely unregulated. Relatively large potential for further development of surface resources exists in the catchment, and several options have been investigated in this respect.

Although significant quantities of water could be abstracted from groundwater in the catchment, the actual utilisation is small. This is mainly attributable to the generally well-watered nature of the catchment and the wide occurrence of perennial surface steams, which reduces the need for groundwater abstraction.

The uThukela, Amajuba, uMgungundlovu and uMzinyathi district municipalities, with various local municipalities and traditional authorities, provide the institutional backbone of the region. The catchment includes the major towns of Newcastle, Dundee, Ladysmith and Estcourt. The catchment also includes the districts of Msinga, Nkandla and Nquthu which, despite being predominantly rural, are nevertheless heavily settled. Most people in the catchment are dependent on agriculture for their livelihood. Subsistence farming is practised on communal land, which covers much of the catchment. The agriculture includes large areas of beef and dairy pastures, some sugar cane near the coast and around Weenen (both dry land and irrigated), vegetables and nuts, and some citrus farming on the coast near Mandini. There is some forestry in the southern and eastern areas of this catchment. The catchment also includes a paper mill at Mandini close to the estuary. Irrigation is a significant water use. Coal mining is also predominant in the Thukela Catchment. The main mining area is the Buffalo River catchment. Tourism and ecotourism are growing economic sectors primarily focussed on the beauty and splendour of the Drakensburg Mountains, game farming and water sport.

The uKhahlamba-Drakensberg Park is the most prominent conservation area in the catchment. Some smaller conservation areas and historic sites are also found in the catchment.

1.5 REPORT OUTLINE

This Status Quo Report defines the current status quo of the water resources in the study area and presents the delineated IUAs. The report outline is as follows:

- Sections 2 – 8 outline the various approaches adopted during this task and provides the findings of the various Status Quo assessments.
- Section 9 provides information on the delineated IUAs and a description per IUA.
- Section 10 outlines the general approach to identifying hotspots and the results of this process.
- Section 11 outlines the process of selecting biophysical nodes for which EWRs will be assessed and the level of EWR assessment is also discussed.
- Section 12 presents the decision analysis framework with the IWRM context that will be applied.
- References are listed in Section 14.

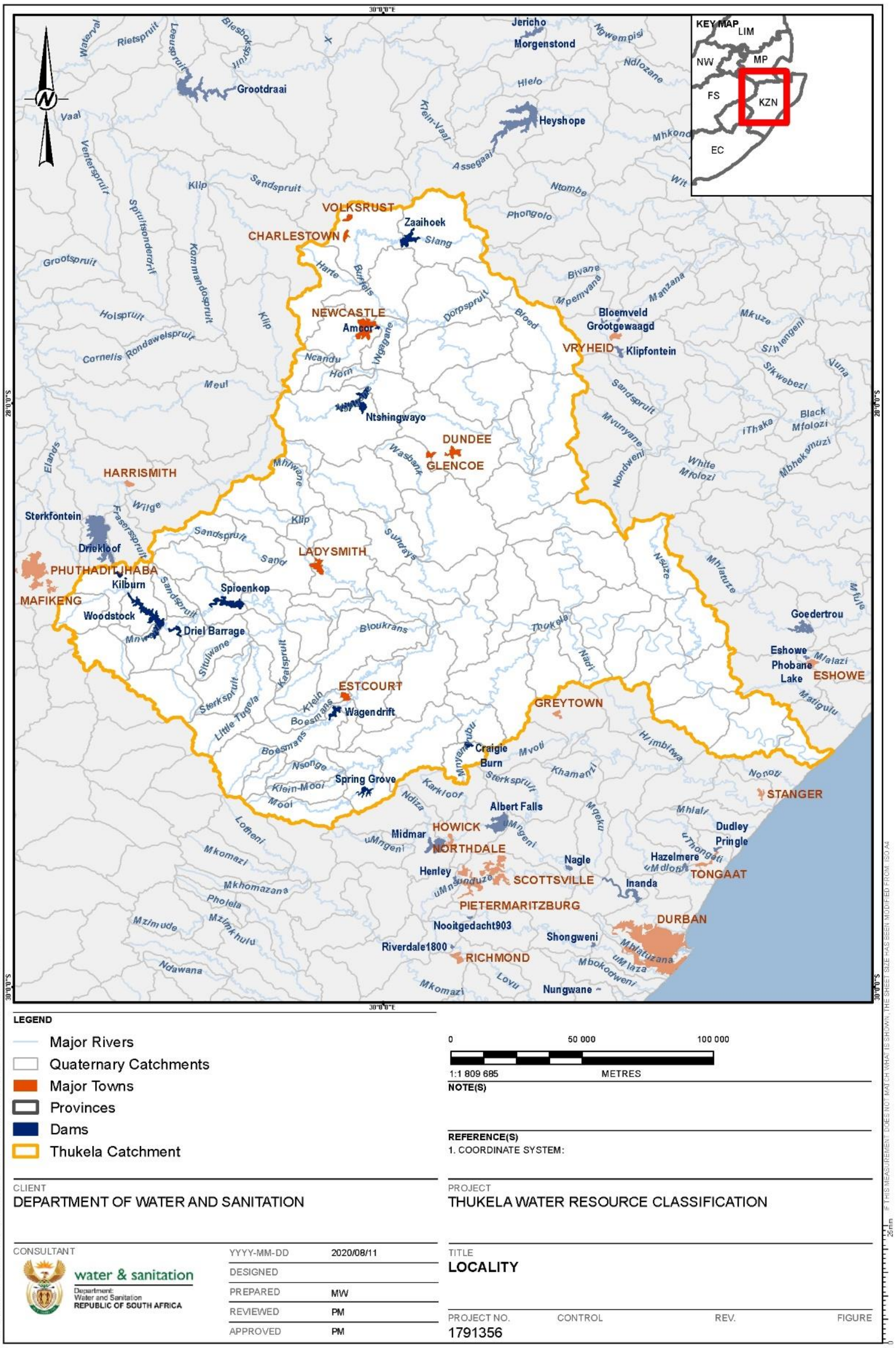

Figure 2: Thukela Catchment – Study Area

2 STATUS QUO: WATER RESOURCES AND SYSTEM ANALYSIS

2.1 Description of Water Resources

The Thukela River is one of the major surface water resources of South Africa, originating on the 3050 m high Mont-aux-Sources plateau in the Drakensberg Mountain Range along the border between Lesotho and the KwaZulu-Natal Province of South Africa. Its upper course lies within the Royal Natal National Park in the Northern Drakensberg. Due to the mountainous nature of the Thukela Catchment and its proximity to the Indian Ocean, the area experiences relatively high rainfall, ranging from in excess of 1500 mm in the west to 750 mm, to over 1000 mm at the coast. Due to the high rainfall, there is substantial runoff from the Thukela catchment. It is estimated that the Thukela River has the second highest Mean Annual Runoff (MAR) of 3799 million m^3/a, 9.9% of South Africa's total runoff after the Orange/ Gariep River (van Niekerk and Turpie, 2012).

The Thukela is a funnel shaped catchment with several tributaries which originate at the Drakensberg Mountains and flow together with the Thukela River, the primary river in the catchment, to discharge into the Indian Ocean on the eastern side of catchment.

The Thukela River rises above Bergville. Major tributaries flowing into the Thukela River from the north include:

- The Klip River, which passes through Ladysmith,
- The Sundays River, and
- The Buffalo River, which rises above Newcastle.

Major tributaries into the Thukela River from the south include:

- The Little Thukela River,
- The Bloukrans River,
- The Bushmans River, passing though Estcourt, and
- The Mooi River.

The lower Thukela River discharges *via* the Thukela Estuary, an open mouth estuary, into the Indian Ocean. The Thukela River Estuary lies midway between Durban and Richards Bay, 14 km to the south-east of the town of Mandini and 104 km from Durban.

In terms of hydrogeology, sedimentary rocks of the Karoo Supergroup occur throughout the catchment. Pre-Karoo formations have been altered significantly over various geological periods and thus represent isolated fractured aquifer zones and tilted fault blocks. These features play a significant role in the physical characteristics of the hydrogeological occurrences/ regimes in the catchment and groundwater flow. Basement rocks and younger unconsolidated sands (fluvial deposits *viz*. alluvial-primary aquifers) occur along major river channels and are present throughout the catchment, primarily in the centre reaches and along the coastline in the estuary.

Aquifers within the study area include weathered and fractured hard rock aquifer systems, and primary aquifers 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 (Dennis, 2009). Due to the catchment's highly variable climate signature and rainfall, groundwater recharge/ potential varies significantly.

The Thukela Catchment includes a number of protected wetland systems. A well-known priority wetland is the Wakkerstroom Vlei located in the northern portion of the catchment. A part of the uKhahlamba-Drakensberg Park Ramsar Site located within the Thukela catchment includes mountain catchment areas with wetlands associated with wilderness areas, nature reserves and state forests. This area forms the border between South Africa and the Kingdom of Lesotho and is an important mountain catchment in South Africa due to its high yield and excellent water quality. A number of systems, including valley bottom and floodplain systems, also occur along the headwaters and main stems of some of the river systems draining the broader Thukela catchment.

2.1.1 Catchment Boundaries

The Thukela River is the only river system making up the V hydrological drainage region comprising of the secondary drainage regions V1 to V7 (see Figure 3), 12 tertiary drainage areas and 88 quaternary catchments.

The Thukela catchment has been divided into four sub-areas based on watershed boundaries described in Table 1 and shown in Figure 4.

Table 1: Sub-catchment areas of the Thukela catchment

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 data

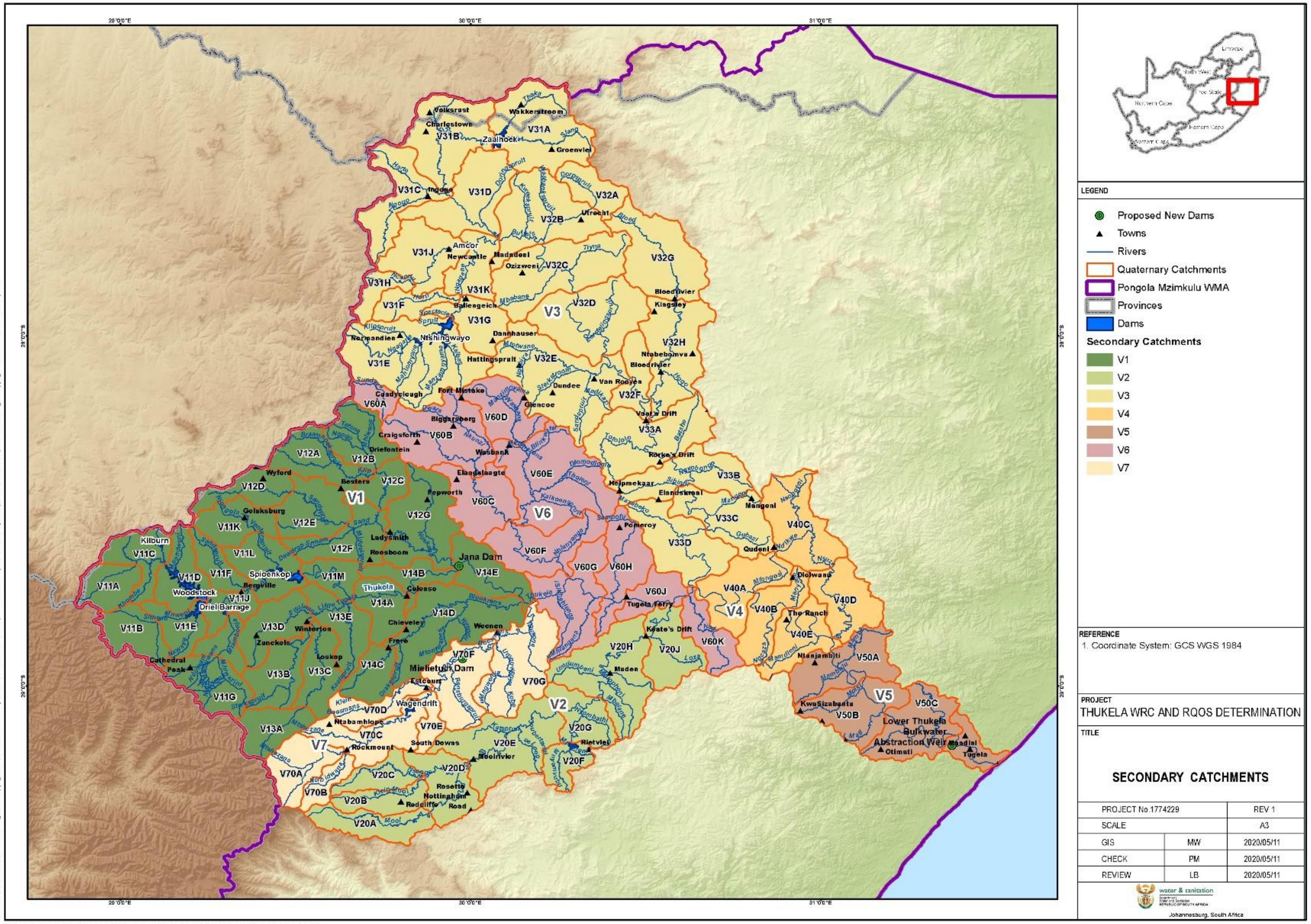

Figure 3: Secondary catchment area boundaries within the Thukela (V1 to V7)

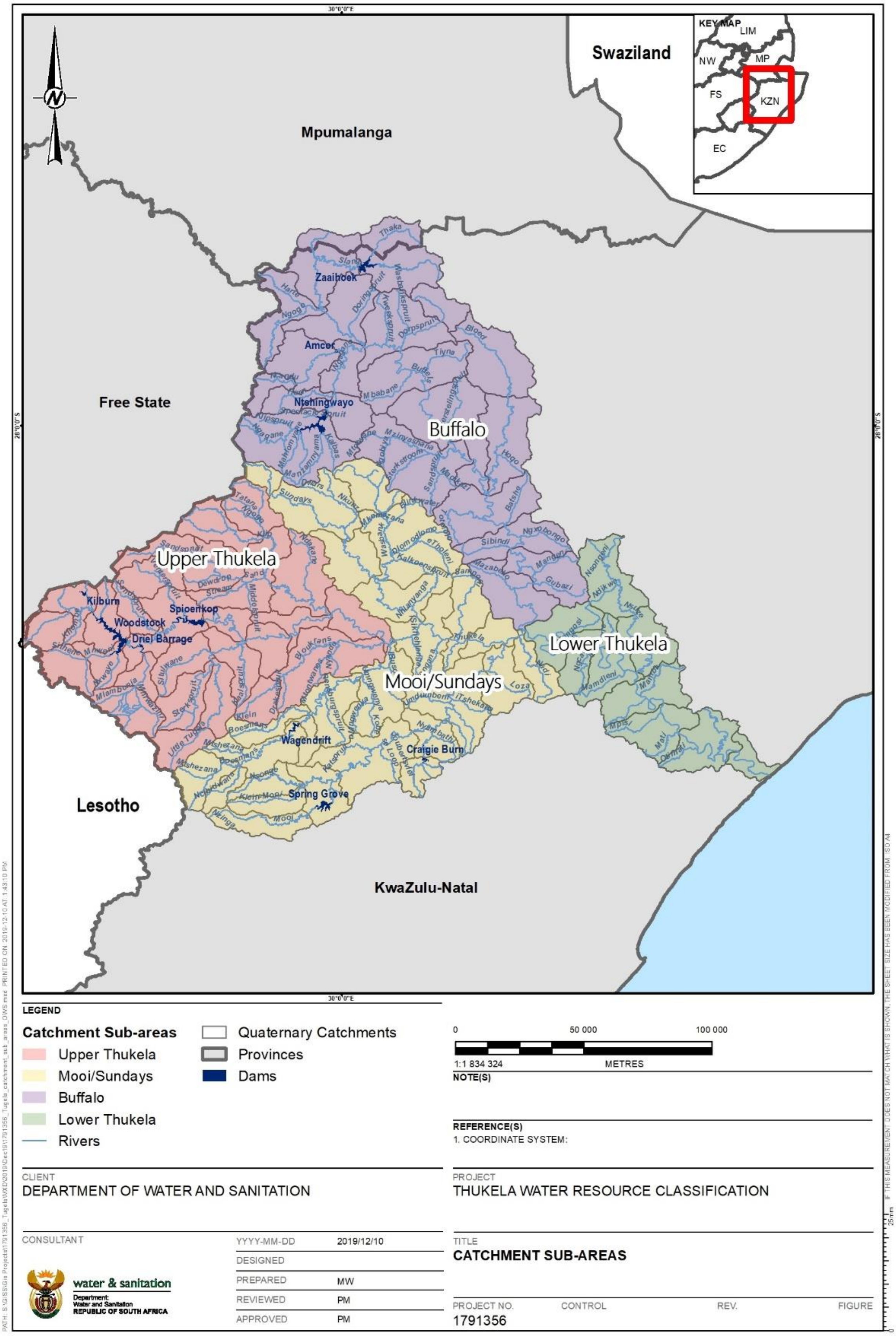

Figure 4: Major sub-systems of the Thukela catchment

2.1.2 Strategic Water Source Areas

Parts of the catchment area of the Thukela have been identified and delineated as strategic water source areas in South Africa (WRC, 2018).

Water source areas (or "Water Towers" as they are also referred to) are natural areas that provide disproportionate (*i.e*. relatively large) volumes of surface water and/or groundwater water per unit area, or which meet critical social, economic and environmental water requirements and provide water security. Strategic Water Source Areas (SWSAs) are a subset of water source areas that are considered of strategic significance for water security (WRC, 2018).

Surface-water SWSAs are found in areas with high rainfall and produce most of the runoff. They are found mainly along the eastern side of South Africa, particularly along the Drakensberg escarpment from the Eastern Cape though to Limpopo and are the source of most of the major river systems, such as the Thukela.

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.

In terms of WRC (2018), SWSAs have been identified and delineated if the area of land either:

(a) supplies a disproportionate amount of mean annual surface water runoff in relation to their size and are considered nationally important; or

(b) has a high groundwater recharge and are locations where the groundwater forms a nationally important resource; or

(c) meets both criteria (a) and (b).

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 (WRC, 2018), as indicated in Figure 5. 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.

While there is a strong requirement to protect SWSAs to ensure the sustained supply of high yields and water quality, there is currently no policy or legislation that specifically protects them. However, several legal measures do exist that may be applied to protect SWSAs.

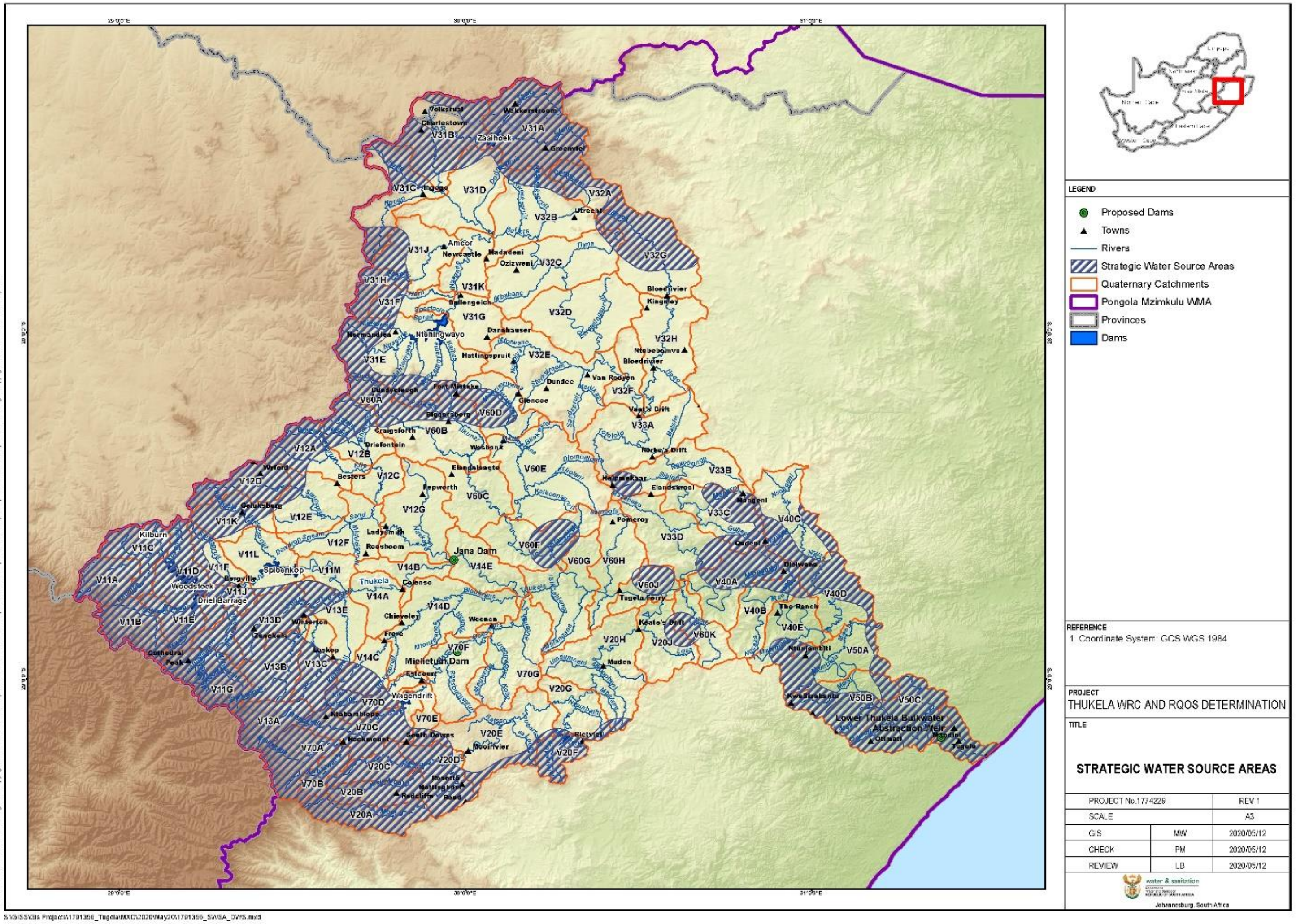

Figure 5: Strategic Water Source Areas delineated within the Thukela catchment

These include amongst others the (1) National Water Act (Act No. 36 of 1998), through the regulation of Section 21 water uses or Section 38, the declaration of controlled activities; (2) National Environmental Management Act (Act No. 107 of 1998), through Section 24 which prohibits or restricts granting of environmental authorisations for listed activities within identified geographic areas; (iii) National Environmental Management: Protected Areas Act (Act No. 57 of 2003) which provides for the declaration and management of protected areas in South Africa, (iv) Mountain Catchment Areas Act (Act No. 63 of 1970) which provide for the conservation, use, management and control of land situated in mountain catchment areas and (v) Environmental Impact Assessment Regulations and Listing Notices (GN R982, R983, R984 and R985 of 2014) that identify the activities for which environmental authorisation is required.

However, the National Water Act review process currently underway presents the opportunity to legislate the SWSAs. The inclusion of the SWSAs has been proposed as part of the National Water Bill being compiled (*personal communication, DWS Directorate Water Resource Classification, 2020*) which will ensure that the necessary legal framework is available to protect them.

This water resource classification and RQO determination process provides a parallel mechanism to afford the necessary protection to SWSAs within the Thukela catchment

2.1.3 Climate change aspects

The climate change related impacts in respect of rainfall for the Thukela catchment based on the DWS National Integrated Water Information System (NIWIS) data supplied by the DWS, are illustrated in Figure 6. The figures illustrate rainfall for the period 1975 – 2006 and predicted rainfall ranges for the period 2016 – 2045. The rainfall falls within the range of 632 mm to over 867 mm/ annum.

Figure 7 illustrates the percentage rainfall change as well as percentage streamflow change.

The percentage rainfall change ranges 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. The Upper Mooi River, Middle/ Lower Bushmans River, and the Escarpment rivers as well as the Thukela Mouth quaternary catchment, are expected to experience a 2% - 4% rainfall decrease. The Blood River catchment, Mooi River catchment and Lower Thukela catchments are expected to experience changes between -2% to an increase of 1 - 3% in V40C, V40E, V32F, V33A, V32H.

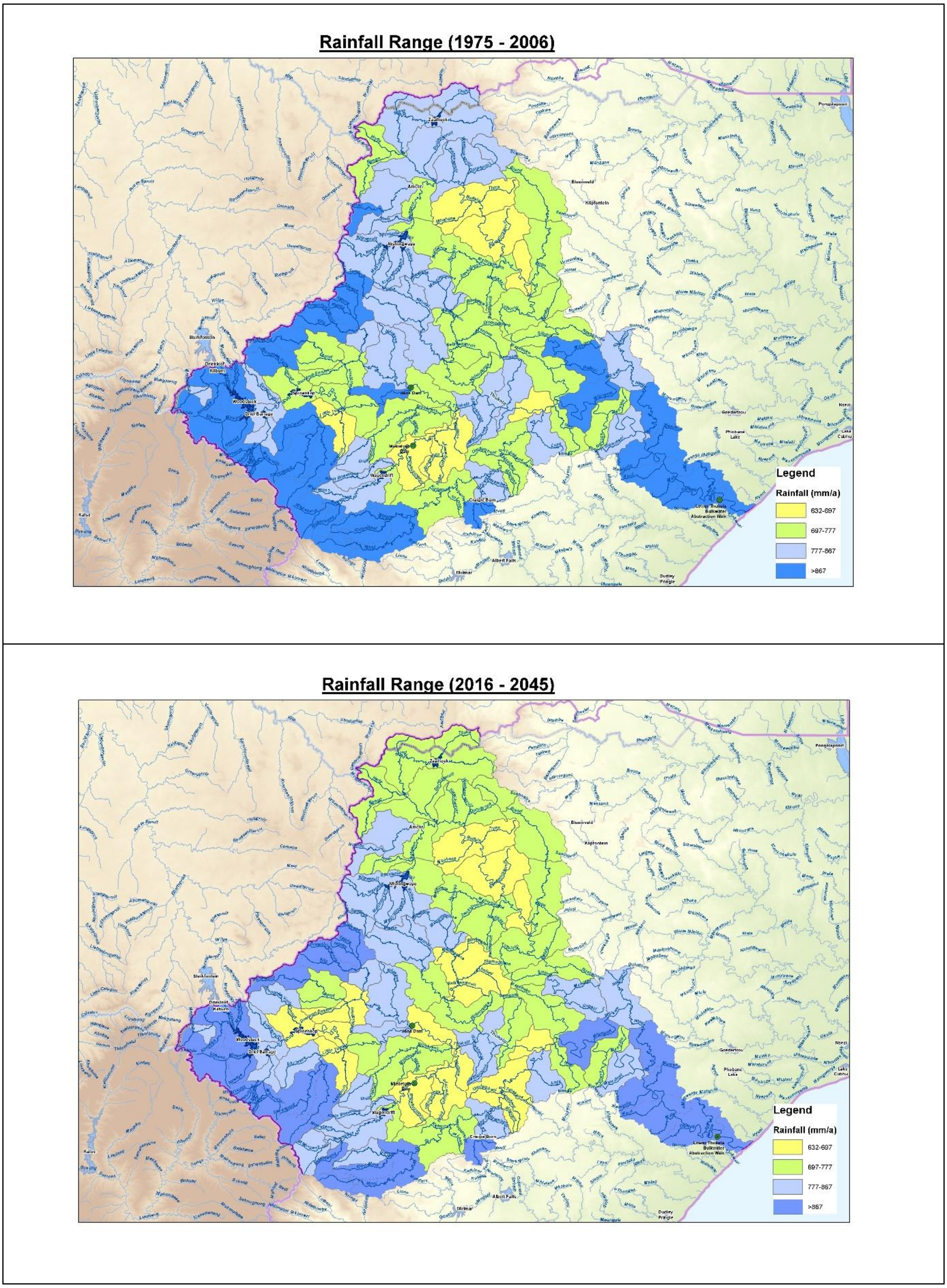

Figure 6: Climate change in respect of rainfall for 1975 – 2006 and predicted for 2016 to 2045 (DWS, NIWIS)

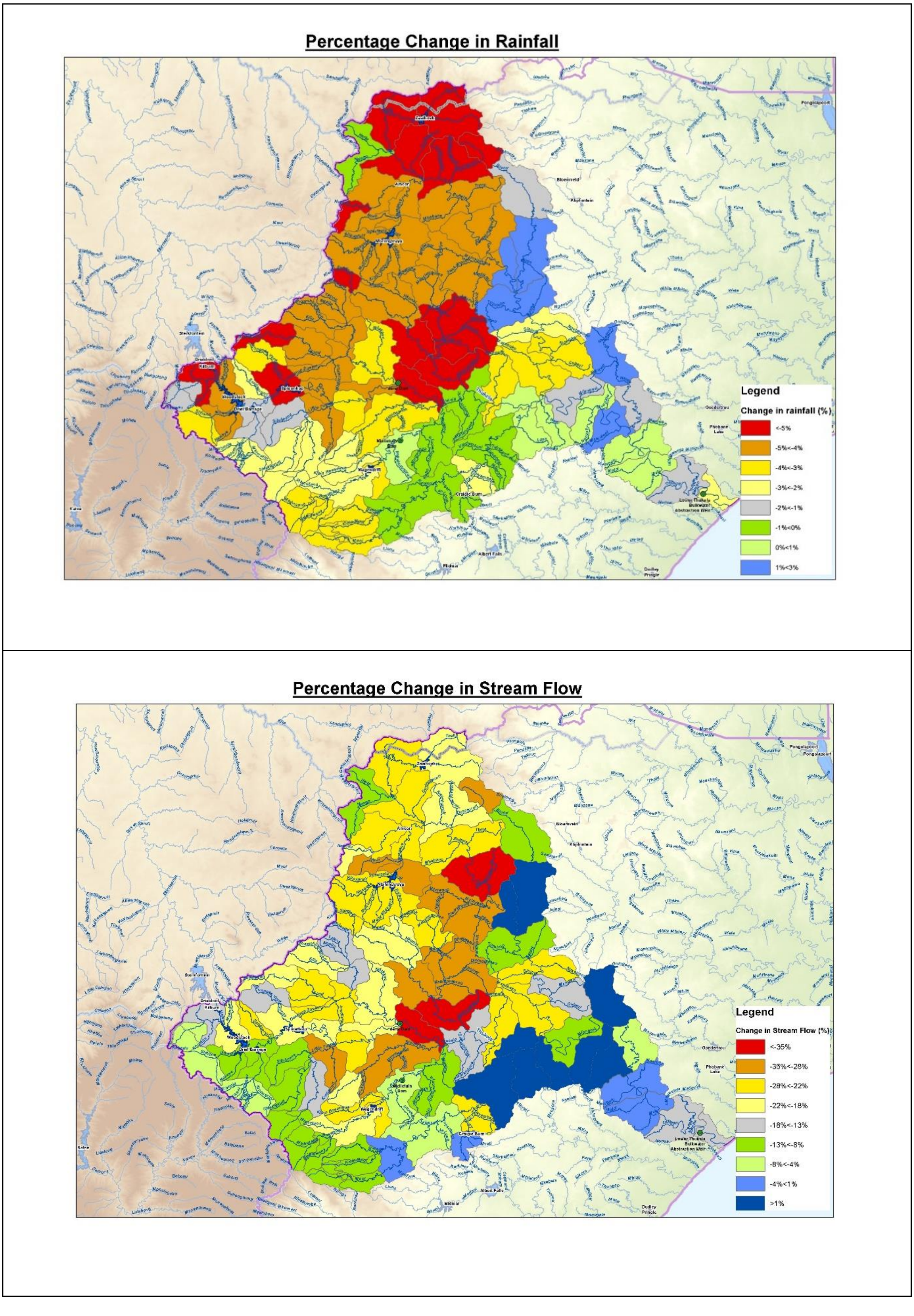

Figure 7: Percentage rainfall change and percentage streamflow change (DWS, NIWIS)

The changes in streamflow indicate a similar pattern throughout the Thukela Catchment with decreases of 28% - 35% expected 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 (Figure 8).

In 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). This analysis highlights the severe impact that climate change is having on the water resources of the Thukela catchment.

Percentage Evapotranspiration change

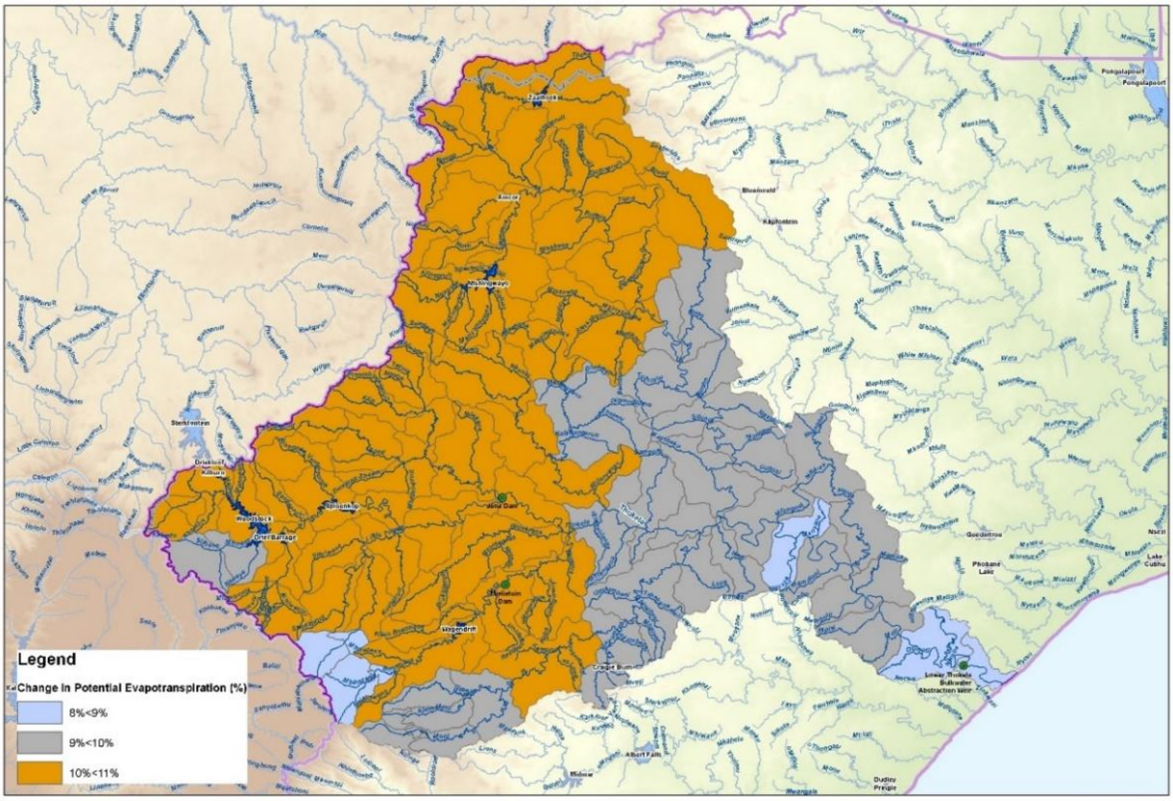

Figure 8: Percentage evapotranspiration change (DWS, NIWIS)

2.2 Description of Water Resource Systems and Analysis

2.2.1 Overview

The Thukela is a key catchment in South Africa, with the highest runoff in KwaZulu-Natal (KZN), estimated at 3799 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 Thukela River Catchment is strategically important catchment with a number of existing large water resources developments and plans for future developments. As such, the Thukela River Catchment features in the long-term plans of multiple neighbouring catchments. This includes the Integrated Vaal, the Richards Bay (Mhlathuze), and KZN Coastal Metropolitan Areas Reconciliation Strategies. However, the Thukela River Catchment does not have a single consolidated Reconciliation Strategy. While the DWS has attempted to steer these various strategies and associated studies in a co-ordinated way, with consideration of the various plans by the other catchment stakeholders, there is no consolidated document that captures all the proposed interventions and current catchment status. The DWS, and the Study Team thus thought it prudent that a planning scenario definition document be prepared early in the Classification process, to consolidate the various plans and information into a single source that can guide this study. This has been conducted and submitted to the DWS.

This status quo review builds on the scenario definition document and provides more information on the current scenario and status of the catchment from a water resources infrastructure development, water use and water balance perspective.

2.2.2 Surface Water Infrastructure

A number of large dams have been constructed associated with both water supply within the catchment, and water transfer to neighbouring catchments. These dams are listed in Table 2.

Table 2: Main 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
Craigieburn	Mooi	Myamvubu	Water supply and irrigation	22.5
Wagendrift	Boesmans	Bushmans	Water supply and irrigation	55.9

The total volume of minor dams (excluding the larger dams listed in Table 2), are presented in Table 3 for the Thukela catchment. The information is based on the latest information for the Mooi River catchment from the Update of the Mooi River Hydrology in 2018, and the Thukela Water Development Project Decision Support Phase (TWPDSP) study for the rest of the Thukela.

Table 3: Summary of minor dams in the catchment

Quaternary catchment	River Catchment	Total surface area of small dams (km^2)	Total capacity of small dams (million m^3)
V11H (U/S Spioenkop)	Upper Thukela River	6.21	22.9
V11A (U/S Woodstock)		3.82	14.1
V13A - E		9.77	36.2
V12A - F	Klip River	13.2	48.9
V12G, V14A, V14B, V14E	Upper and Middle Thukela River, Klip River	11.28	41.8
V11F	Upper Thukela River	2.54	9.4
V60A, V60B	Sundays River	11.28	41.8
V32E, V32F	Middle Buffalo	12.32	38.2
V32G, V32H, V33A, V33B	Blood River	4.93	15.3
V20A	Upper Mooi River	1.25	2.3
V20B		3.92	8.77
V20C		3.42	6.9
V20D		5.72	11.8
V20E		6.93	14.4
V20F	Lower Mooi River	1.86	3.07
V20G		0.45	1.05
V20H		0.8	2.04
V20J		0.16	0.3
Sub-total		**99.9**	**319.1**

* This is the coefficient in the standard storage volume to surface area equation.

The main existing water resources infrastructure associated with water transfers and bulk water supply schemes to users outside of the catchment are summarised in Table 4.

Table 4: Main Water transfer infrastructure

Scheme	Sub - catchment	Purpose	Capacity#	Operating rules*
Thukela Vaal Scheme	Upper Thukela	Water transfer and hydropower	20 m^3/s (1 700 ML/d)	To fill Sterkfontein Dam and support Vaal System.
Buffalo Vaal Scheme	Buffalo	Water transfer	2.16 m^3/s (186 ML/d)	To supply Majuba Power station and support Grootdraai Dam.
Mooi Mgeni Transfer Scheme (MMTS) (phase 1 and 2)	Mooi	Water transfer	4.5 m^3/s (388 ML/d)	To keep Midmar Full and support Mgeni.
Thukela to Mhlathuze scheme (also known as the Middledrift Transfer)	Lower Thukela	Water Transfer	1.0 m^3/s 2.0 m^3/s (86 ML/d)	Support Mhlathuze by pumping until Goedetrouw Dam > 60%
Lower Thukela Bulk Water Supply Scheme (LTBWSS) (phase 1)	Lower Thukela	Bulk Water supply	0.63 m^3/s (55 ML/d)	To supply users along North coast (KwaDukuza)

\# Capacities: The MMTS phase 1 capacity (from Mearns Weir) is 3.0 m^3/s. The MMTS Phase 2 capacity (from Spring Grove) is 4.5 m^3/s. The total MMTS transfer is limited by the receiving stream capacity of 4.5 m^3/s.

The Thukela to Mhlatuze installed capacity was 1.2 m^3/s. Water is however abstracted along the way for Middledrift and the net transfer is closer to 1 m^3/s. The current capacity of the Thukela to Mhlathuze transfer is being doubled by the DWS to ± 2 m^3/s.

The LTBWSS capacity is due to be upgraded to 110 ML/d in the near future through Phase 2.

* Operating rules: Thukela-Vaal pumping should continue until Bloemhof Dam is full to maximise support to Vaal. This has not occurred in recent years due to Eskom constraints.

The MMTS transfer has continued to operate with Midmar Dam spilling due to very low levels in dams downstream, *i.e*. Albert Falls.

The Phase 2 of the Lower Thukela is earmarked to supply areas to the north, possibly including King Chetswayo District Municipality.

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. The main domestic and industrial water users are listed in Table 5. The water requirements reflected will be updated as far as possible with recent data that is available.

Table 5: Bulk and industrial water users in the Thukela Catchment (million m³/annum)

Name (Demand – (Dem))	WRPM Channel	2001 Water[1] Requirement	2015 Water [2] Requirement	2016/2017 [3] Requirement	Water Requirements centres
Dem 1	19	1.47	1.61		Bergville, Emmaus, Carnation Industrial, Natal Parks
Dem 2	707	1.83	1.85		Rural, Jagersrust, Drakensville
Dem 3	38	5.87	7.06	11.3	Ladysmith
Dem 4	39	10.29	15.6	18.3	Ezhakeni, Pieters Industry
Dem 5	42	2.77	2.82		Driefontein, Roosboom, Matiwaneskop
Dem 6	33	1.49	1.74		Winterton, Loskop, V13 Tertiary Rural
Dem 7	35	1.78	2		Colenso, Nkanyezi, V14 Tertiary Rural
Dem 8	207	0.91	1.59	3.4**	Mooi River, Bruntville
Dem 9	205	0.03	0.05		Rosetta
Dem 10	105	27.21	31.45		Newcastle, Madadini & Oszweni, Rural
Dem 11A	110	1.4	2.16		Utrecht
Dem 11B	838	4.17	6.42		Dundee/Glencoe
Dem 12	116	2.46	2.54		Umzinyathi DC
Dem 13	126	27.75	28.36		Sappi, Mandini, Thukela, Sundumbili
Dem 14	85	10.29	10.75		Klipriver, Mining, Rural
Dem 15	64	0.44	0.44	1.1	Tugela Ferry
Dem 16	73	5.16	9.36	13.7	Estcourt, Wembizi, Craigtown
Dem 17	80	0.55	0.61		Weenen, Noodkamp
Dem 18	70	0.7	0.72		Kwadamini, Kwamazel, Sobabili
Dem 19	98	0.34	0.51		Wakkerstroom, Esizamelani
Dem 20	102	0.8	1.8		Volksrust, Charlestown, Vukhuzakhe
Dem 21	95	2.01	3.1		Durnacol/Dannhauser, Eskom, Siltec
Dem 22	828	7.94	9.18		Iscor Newcastle
Total		**117.66**	**141.72**		

[1] 2001 water requirements were based on actual water

[2] 2015 water requirements projected by 2003 Thukela Water Development Project Decision Support Phase (TWDPSP)
[3] 2016/17 water requirements where available are obtained from the Umgeni Water's Universal Access Plan (UAP) or Update of Hydrology of the Mooi Mgeni Study **

The volume of return flows of treated effluent discharged into the Thukela River and its tributaries are summarised in Table 6. These volumes will be updated with recent data from the municipalities where available.

Table 6: Return flows to the Thukela River

Name	Channel No.	2001 Flow [1] (million m³/a)	2015 Flow [2] (million m³/a)	Return flow Centre
Ret 3	37	4.17	5.01	Ladysmith
Ret 4	834	5.66	8.58	Ezhakeni, Pieters Industry
Ret 7	833	1.11	1.25	Colenso, Nkanyezi, V14 Tertiary Rural
Ret 8	304	0.8	1.39	Mooi River, Bruntville

Name	Channel No.	2001 Flow [1] (million m^3/a)	2015 Flow [2] (million m^3/a)	Return flow Centre
Ret 10	820	19.05	22.02	Newcastle, Madadini & Oszweni, Rural
Ret 11B	115	2	3.08	Dundee/Glencoe
Ret 13	836	25.53	26.09	Sappi, Mandini, Thukela, Sundumbili
Ret 14	837	4.01	4.19	Klipriver, Mining, Rural
Ret 15	840	0.11	0.11	Tugela Ferry
Ret 16	75	2.53	4.59	Estcourt, Wembizi, Craigtown
Ret 19	841	0.1	0.15	Wakkerstroom, Esizamelani
Ret 20	106	0.28	0.63	Volksrust, Charlestown, Vukhuzakhe
Ret 21	108	0.82	1.27	Durnacol/Dannhauser, Eskom, Siltec
Ret 22	92	3.02	3.49	Iscor Newcastle
Total		**69.2**	**81.9**	

[1] 2001 flow volumes based on 2003 TWPDSP study data
[2] 2015 flow volumes based on projected estimates from 2003 TWPDSP study

There is a significant amount of irrigation through the catchment. The irrigation volumes are summarised in Table 7. Information for the Mooi River catchment is available for 2017 as part of a more recent detailed hydrology update study. However, this is available for the rest of the catchment area.

Table 7: Irrigation volumes in the Thukela catchment

WRYM Number[(1)]	Tertiary Catchment	2001 Irrigation[1] (million m^3/a)	2015 Irrigation[2] (million m^3/a)	2017 Irrigation[3] Mooi catchment (million m^3/a)	File Name
710	V11	2.04	2.35		THDRIE.IRD
25	V11	3.47	4.02		THSKDS.IRD
17	V11	32.6	37.76		THSKOP_A.IRD
845	V11	6.21	7.19		THSKOP_B.IRD
705	V11	4.29	4.98		THWOOD.IRD
703	V11	1.92	2.22		TM02.IRD
20	V11	3.11	3.56		TM06_A.IRD
846	V11	6.61	7.58		TM06_B.IRD
40	V12	3.5	4.93		TM11A.IRD
43	V12	6.8	9.57		TM11B.IRD
32	V13	27.86	30.67		THLTUG.IRD
27	V13	3.34	3.68		TM08A.IRD
29	V13	9.04	9.96		TM08B.IRD
50	V14	3.83	5.08		KLIPA.IRD
48	V14	17.43	23.11		KLIPB.IRD
56	V14	1.61	2.13		TM12.IRD
208	V20	0.84	0.86	1.45	SPR00_MR.DIR
212	V20	0.34	0.34	1.43	SPR00_MR.MIR
209	V20	4.58	5.36	4.93	DAR00_MR.DIR
213	V20	3.89	4.55	2.70	DAR00_MR.MIR
235	V20	2.36	2.47	5.20	MLM00_MR.DIR

WRYM Number(1)	Tertiary Catchment	2001 Irrigation[1] (million m^3/a)	2015 Irrigation[2] (million m^3/a)	2017 Irrigation[3] Mooi catchment (million m^3/a)	File Name
237	V20	5.8	6.06	5.46	MLM00_MR.MIR
238	V20	2.13	2.33	1.44	MEM00_MR.DIR
271	V20	5.19	5.69	3.36	MEM00_MR.MIR
244	V20	2.13	2.37	2.49	UC_M_DIR.DEM
249	V20	1.56	1.6	0.33	CBM_2040.DEM
253	V20	7.92	8.08	6.72	MUM_2040.DEM
263	V20	6.15	6.54	2.19	KWM_2040.DEM
294	V20	2.84	3.03	2.78	MID00_MR.DIR
295	V20	2.89	3.09	2.02	SUT0_MR1.MIR
309	V20	2.89	3.09	3.39	SUT0_MR2.MIR
296	V20	1.71	1.83	5.94	SUT0_MR1.DIR
305	V20	1.71	1.83	1.52	SUT0_MR2.DIR
297	V20	4.81	5.14	4.52	MID00_MR.MIR
94	V31	1.98	2.52		CHELD.IRD
90	V31	7.86	8.7		TM24.IRD
97	V31	2.95	3.06		TM26.IRD
103	V31	8.17	10.17		ZAAID.IRD
109	V32	16.85	24.18		V3B.IRD
112	V32	1.88	2.72		V3_RORA.IRD
117	V32	2.79	4.07		V3_RORB.IRD
825	V33	7.95	11.46		RORKB.IRD
127	V50	9.08	14.7		MAND.IRD
124	V50	3.65	6.65		MHL_A.IRD
831	V50	6.54	11.94		MHL_B.IRD
63	V60	3.97	5.57		MUNGUB.IRD
86	V60	4.51	6.05		NON.IRD
61	V60	10.51	11.36		TM14B.IRD
59	V60	8.86	9.99		TM14_M.IRD
76	V70	12.27	16.04		LOCHS.IRD
81	V70	18.15	23.74		MNGWEN.IRD
71	V70	1.31	1.72		WAG.IRD
Total		**322.68**	**397.69**		

[1] 2001 irrigation volumes based on 2003 TWPDSP study data
[2] 2015 irrigation volumes based on projected estimate from 2003 TWPDSP study
[3] 2017 irrigation volumes based on updated areas from the Mooi-Mgeni Hydrology study

Stream flow reduction activities in the form of commercial forestry occur sporadically in the catchment. The stream flow reduction volumes are summarised in Table 8. Stream flow reduction also occurs as a result of alien invasive plants (AIP). Information is available for the Mooi River part of the Thukela catchment, and is included in the total stream flow reductions.

Table 8: Summary of stream flow reduction in the Thukela Catchment

Tertiary catchment	2001 Stream flow reduction (million m^3/a)	2015 Stream flow reduction (million m^3/a)	2017 Stream flow reduction Mooi catchment (million m^3/a)	File name
V11	1.42	2.14		TM049.AFF
V14	3.48	4.69		TM129.AFF
V20	1.66	1.99	3.74*	CRAIG.AFF
V20	1.14	1.34	7.16*	DAR.AFF
V20	0.35	0.39	5.08*	MEA.AFF
V20	0.1	0.15	1.72*	MIDD.AFF
V20	1.35	2.07	1.77*	MUDENA.AFF
V20	0.57	0.88	0.99*	MUDENB.AFF
V20	1.17	1.28	1.54*	SPR.AFF
V20	0.15	0.2	0.71*	SUT_A.AFF
V20	0.28	0.37	0.45*	SUT_B.AFF
V31	0.58	1.29		TM249.AFF
V31	1.41	3.14		TM259.AFF
V31	1.59	3.5		TM319.AFF
V32	2.4	4.4		TM279.AFF
V32	0.1	0.17		TM289_A.AFF
V32	2.24	4.09		TM289_B.AFF
V33	0.07	0.12		TM289_C.AFF
V40	0.95	1.02		TM329_A.AFF
V40	1.57	1.67		TM329_B.AFF
V50	2.6	2.77		TM30A.AFF
V70	3.23	4.24		TM139.AFF
V70	2.97	3.89		TM189.AFF
Total	**31.38**	**45.8**		

* The 2017 stream flow reductions are the result of both commercial afforestation and alien invasive plants

2.2.3 Sub-Systems Water Availability

The main sub-systems in the Thukela Catchment are the:

- Upper Thukela
- Mooi-Sundays
- Buffalo
- Lower Thukela

These are shown graphically in Figure 4. During the scenario analyses, the water resources model will be run to develop an understanding of water supply potential for current and future development levels and quantify the balance between ecological protection with water supply. As the model is still in the process of being updated with the latest water use information and IUA definitions, it is not possible to report on water balances at this stage. Preliminary estimates of water supply potential and the water balance in the catchment has been drawn from the Thukela Water Development Project Decision Support Phase (TWPDSP) Study. This is summarised per sub-system in the following sections, to provide a high-level perspective of water availability in the catchment.

2.2.3.1 Upper Thukela

The projected water requirements together with the potential for these to be supplied are summarised in Table 9, for the Upper Thukela.

The main changes from this projected situation is the increase of water requirements from Spioenkop Dam for the Ladysmith area.

Table 9: Projected water supply potential for 2015 for Upper Thukela (from TWPDSP)

	Volumes as per 2015 projection (million m^3/a)		
Sector	**Requirement**	**Supply**	**Percentage Supply**
Irrigation	158.8	121.0	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%**

2.2.3.2 Mooi-Sundays

The projected water requirements together with the potential for these to be supplied are summarised in Table 10, for the Mooi-Sundays.

Table 10: Projected water supply potential for 2015 for Mooi-Sundays (from TWPDSP)

	Volumes as per 2015 projection (million m^3/a)		
Sector	**Requirement**	**Supply**	**Percentage Supply**
Irrigation	138.7	115.7	83%
Afforestation	16.8	16.5	98%
Rural / Urban / Industrial	23.1	20.5	89%
Transfer	142.0	112.2	79%
Total	**320.6**	**264.9**	**83%**

The main changes from this projected situation is the increase of water requirements for the Estcourt area from those projected. The Spring Grove Dam was included in this scenario.

2.2.3.3 Buffalo System

The projected water requirements together with the potential for these to be supplied are summarised in Table 11, for the Buffalo.

The main changes from this projected situation is the increase of water use in the Buffalo from those projected, including increased abstractions at Tayside. The water abstracted at Tayside is for supply to Glencoe and Dundee and is the main source of water for these towns after the use of their smaller local dams.

Table 11: Projected water supply potential for 2015 for Buffalo (from TWPDSP)

	Volumes as per 2015 projection (million m^3/a)		
Sector	**Requirement**	**Supply**	**Percentage Supply**
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%**

2.2.3.4 Lower Thukela

The projected water requirements together with the potential for these to be supplied are summarised in Table 12, for the Lower Thukela.

Table 12: Projected water supply potential for 2015 for Lower Thukela (from TWPDSP)

	Volumes as per 2015 projection (million m^3/a)		
Sector	**Requirement**	**Supply**	**Percentage Supply**
Irrigation	33.3	33.3	100%
Afforestation	5.5	5.5	100%
Rural / Urban / Industrial	58.0	58.0	100%
Transfer	37.9	37.9	100%
Total	**134.6**	**134.6**	**100%**

The main changes from this projected situation is the implementation of the Phase 1 of the Lower Thukela Bulk Water Supply Scheme, which increases abstractions by around 55 ML/d. The transfer to the Mhlathuze was included.

2.2.3.5 Preliminary Ecological Water Requirements

The overall impacts of the preliminary EWR flows from the TWPDSP Study on water requirements are summarised in Table 13. These impacts were based on the final EWR scenarios from the study in 2003. Some revision to these EWR flows is likely to occur and various scenarios will be tested, so these should be considered as useful information to provide a feel for the possible impacts. Additionally, the water requirements have increased from 2005 and thus the impact could also be higher.

Table 13: Estimates of the likely impact of the implementation of EWRs in the Thukela catchment on water supply

Subsystem	Reduction in 2005 requirements (without EWR)				Allowable requirements with EWRs as a % of the supply without EWR			
	Urban		Irrigation		Urban		Irrigation	
	Shortfall	% Supply	Shortfall	% Supply	Shortfall	% Supply	Shortfall	% Supply
Mooi	0	100%	6.49	89%	0	100%	17.25	68%
Little Thukela	0	100%	31	27%	0.32	80%	7.37	35%
Bushmans	0	100%	0	100%	0	100%	0	100%
Sundays	1.06	90%	18.1	40%	1.56	83%	0	100%
Buffalo	0.3	99%	14.88	75%	0	100%	0	100%
Upper Thukela (1)	2.45	95%	52.72	75%	3.83	91%	21.44	87%
Lower Thukela (1)	2.75	98%	74.09	79%	4.93	97%	38.69	86%

(1) Includes the "allowable" requirement from upstream sub-systems

Similarly, the impact on water transfers was also estimated, as well as the impacts on the projected surplus at the bottom of each catchment. These are summarised in Table 14 and Table 15. The surplus suggested in Table 15, are theoretical volumes available at the bottom of each sub-system and there may be surpluses in a catchment where upstream users need to be curtailed. This could be the result of incremental flows entering the sub-system below the upstream users. The Internal Strategic Perspective (ISP), also completed by the DWAF in late 2003 noted lower surplus as a result of higher water requirements. The surpluses reported in the system will be reduced as a result of greater water use in the system, e.g. the Lower Thukela BWSS, and greater use by all sectors. The Thukela is reportedly already fully allocated, although actual use is lower than the full allocation amounts.

These realities will be tested in more detail through the use of a water resource model and various development scenarios as part of this classification study and process.

Table 14: Estimates of possible impacts of EWR on water transfer volumes

Sub-system	Transfer Scheme	Transfer without EWR (million m^3/a)	Transfer with EWR (million m^3/a)	Reduction in transfer (million m^3/a)	Reduction in transfer (%)
Mooi	Mooi-Mgeni	52.1	40.9	11.2	21%
Buffalo	Buffalo-Vaal	43.8	43.8	0	0%

Sub-system	Transfer Scheme	Transfer without EWR (million m^3/a)	Transfer with EWR (million m^3/a)	Reduction in transfer (million m^3/a)	Reduction in transfer (%)
Upper	Thukela	533.8	490.5	43.3	8%
Lower	Thukela-Mhlathuze	37.9	37.9	0	0%
Lower	Thukela – North Coast (1)	13.2	13.2	0	0%

(1)This was the supply potential for the old Fairbreeze licence which has been stated for the LTBWSS as a substitute.

Table 15: Previously estimated impact on surplus available at the bottom of catchments as of 2003

Sub-system	Surplus without EWR (million m^3/a)	Surplus with EWR implemented (3) (million m^3/a)	Reduction in Surplus (million m^3/a)	Reduction in Surplus (%)
Mooi (1)	24.25	29.02	-4.77	-20%
Little Thukela	0	0	0	0%
Bushmans(2)	69.43	75.61	-6.18	-9%
Sundays	3.79	1.84	1.95	51%
Buffalo	92.68	55.23	37.45	40%
Upper Thukela	241.32	154.45	86.87	36%
Lower Thukela	362.52	205.08	157.44	43%

(1) These are theoretical surpluses that will have been reduced due to greater use in the catchment since 2003

(2) The theoretical increase in the Bushmans catchment was due to scenario selection for EWR 5 and 6 and will need to be resolved in this study.

(3) These are theoretical surpluses that will have been reduced due to greater use in the catchment since 2003.

3 STATUS QUO SOCIO-ECONOMICS AND ECOSYSTEM SERVICES

The Thukela catchment is situated in central KwaZulu-Natal forming the drainage basin for the Thukela, Buffalo and Sundays Rivers. The catchment is bordered by the Upper Vaal to the west, Usuthu to Mhlatuze to the east, and Mvoti to Umzimkulu catchment to the south. Relatively undeveloped, the largest cities include Newcastle, Ladysmith, Dundee, Utrecht, Volksrust and Estcourt illustrated in Figure 2 in Section 1.

The size of the catchment is approximately 29 000 km^2 with 75% representing natural untransformed land. Approximately 20% has been transformed to agricultural and 6% human settlement land uses (Figure 9).

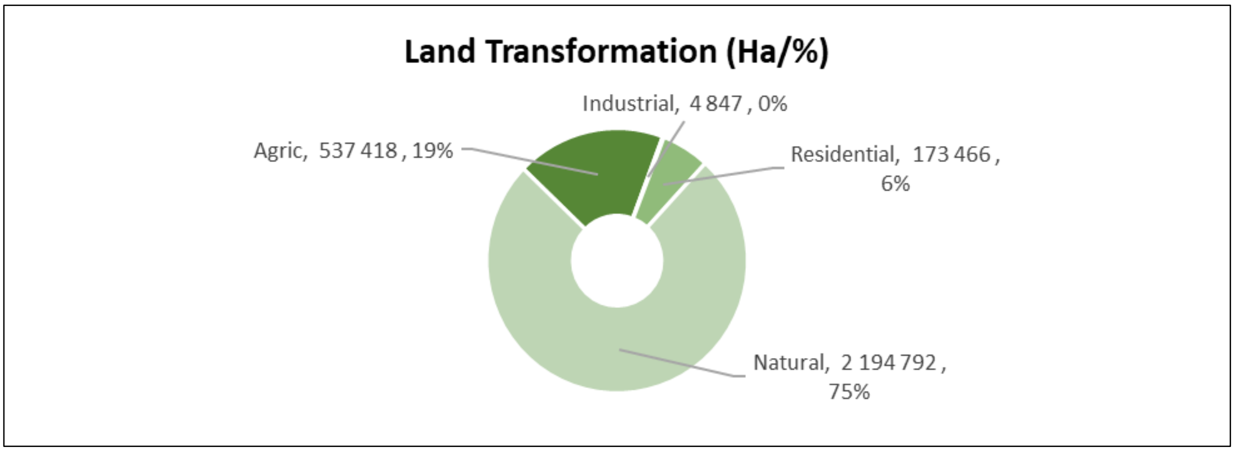

Figure 9: Land transformation extent in the Thukela Catchment

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 spatial breakdown of local municipalities is shown in Figure 10. A relatively large proportion of land ownership is traditional and therefore includes a large rural population comprised of traditional homelands characteristic of subsistence livelihoods (Figure 11). A variety of large dams and impoundments support the local economy but also provide water tranfers into neighbouring catchments. Water transfers include the Thukela-Vaal, Zaaihoek, Mooi to Mgeni, Thukela to Mhlatuze and Lower Thukela transfer schemes.

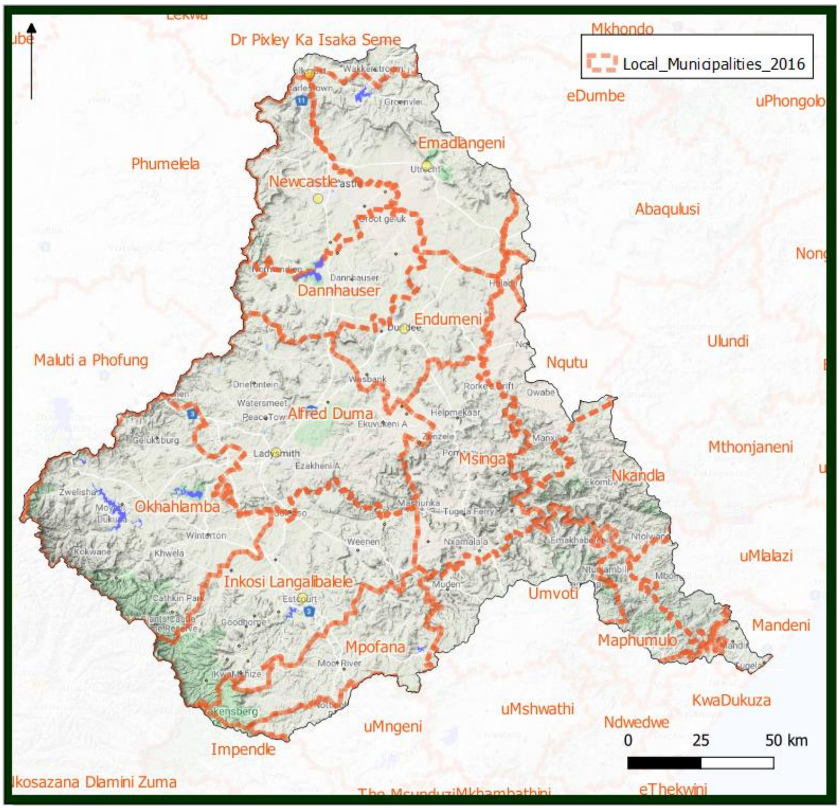

Figure 10: Locality of local municipalities in the Thukela Catchment (Municipal IDPs)

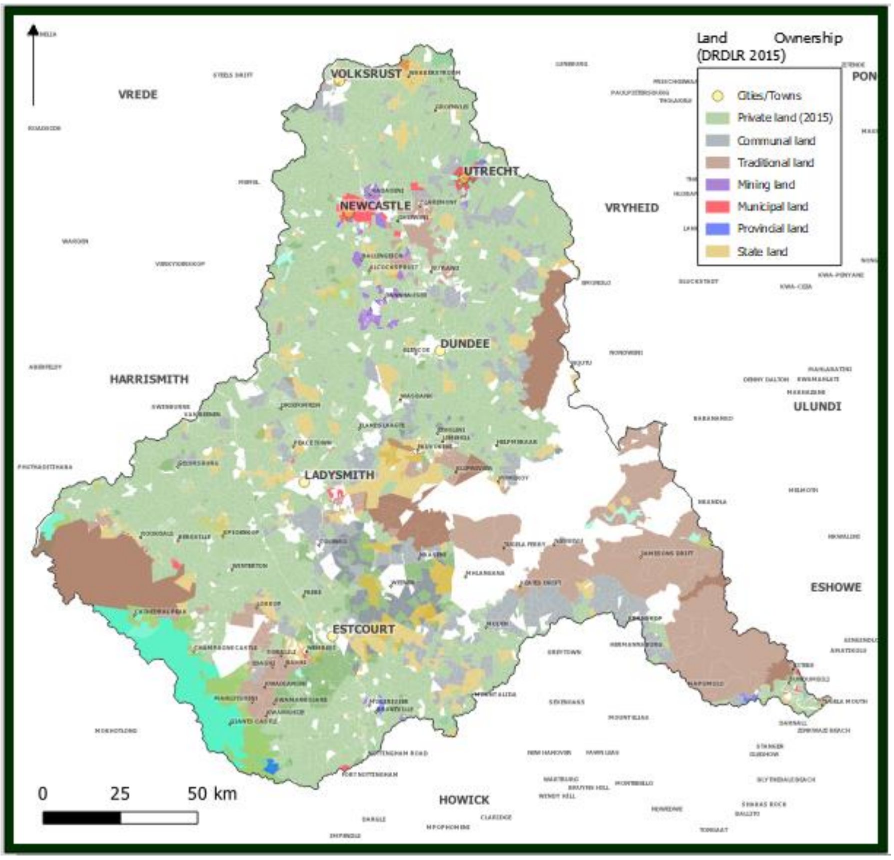

Figure 11: Land ownership in the Thukela Catchment (DRDLR 2015)

3.1 Demographics and Socio-Economic Profile

The Thukela Catchment has a total population of approximately 1 848 001 with approximately 414 321 households. The population density is higher in the upper and western regions of the catchment and tends to be in the areas around the towns (Figure 12). The predominant language spoken in the catchment is IsiZulu (84%), followed by English (4%) and Afrikaans (2%).

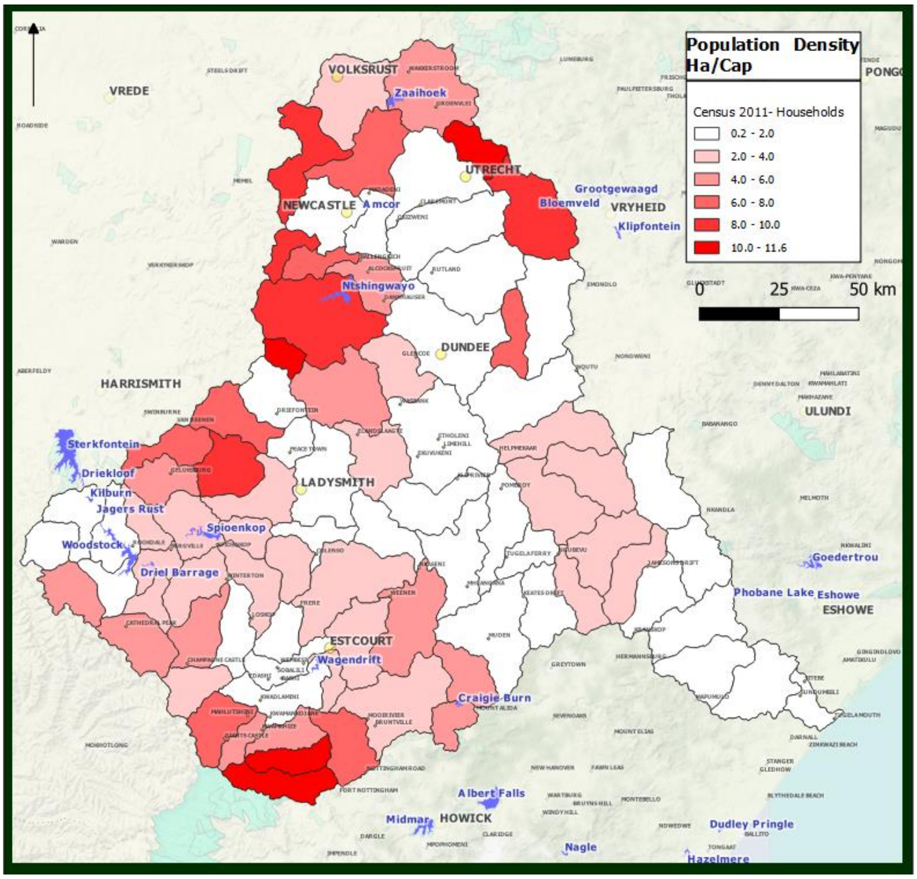

Figure 12: Population Density in the Thukela Catchment

The 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. In the catchment as a whole there are as many as 20% of the residents that are relying on the rivers, streams and dams as their primary source of water, with 45% of the total population have limited or no access to piped water services (Stats SA, Census, 2011) (Figure 13).

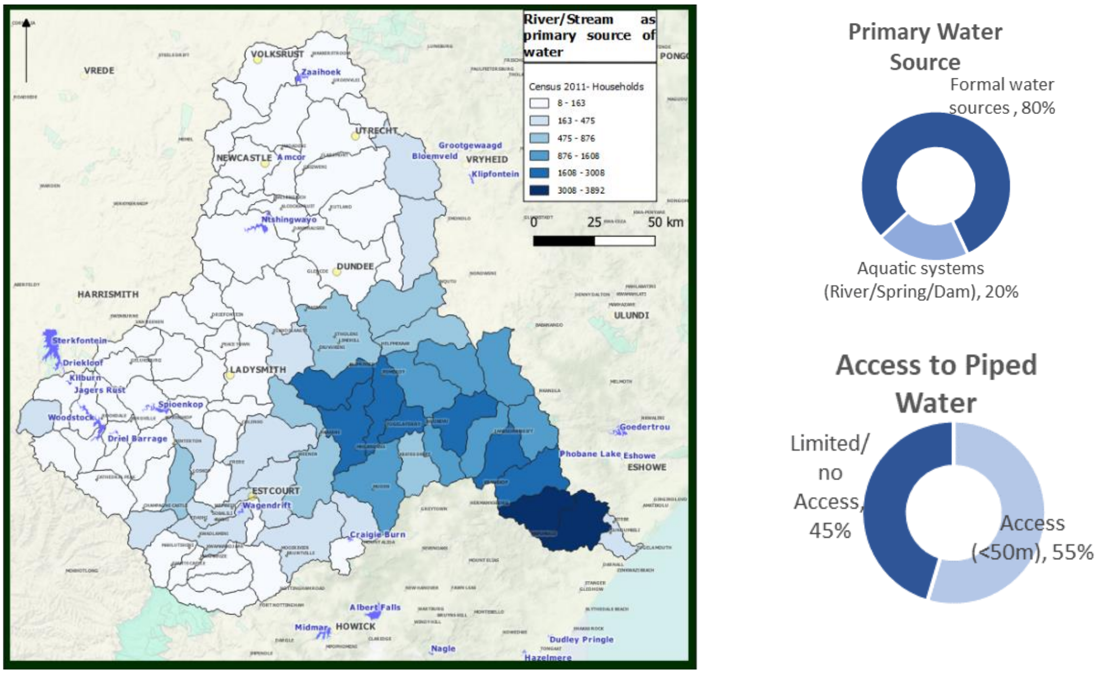

Figure 13: Reliance on rivers, streams, and dams (impoundments) as primary source of water in the Thukela catchment (Stats SA, Census 2011)

Employment within the Thukela catchment varies and more than half of the population within the catchment are without employment, particularly within the rural communities. The economically active residents in the catchment represent 48% of the catchment population and 73% are employed in the formal sector. Employment, particularly within the formal sector tends to be concentrated around the larger cities or towns within the catchment (Figure 14 and Figure 15).

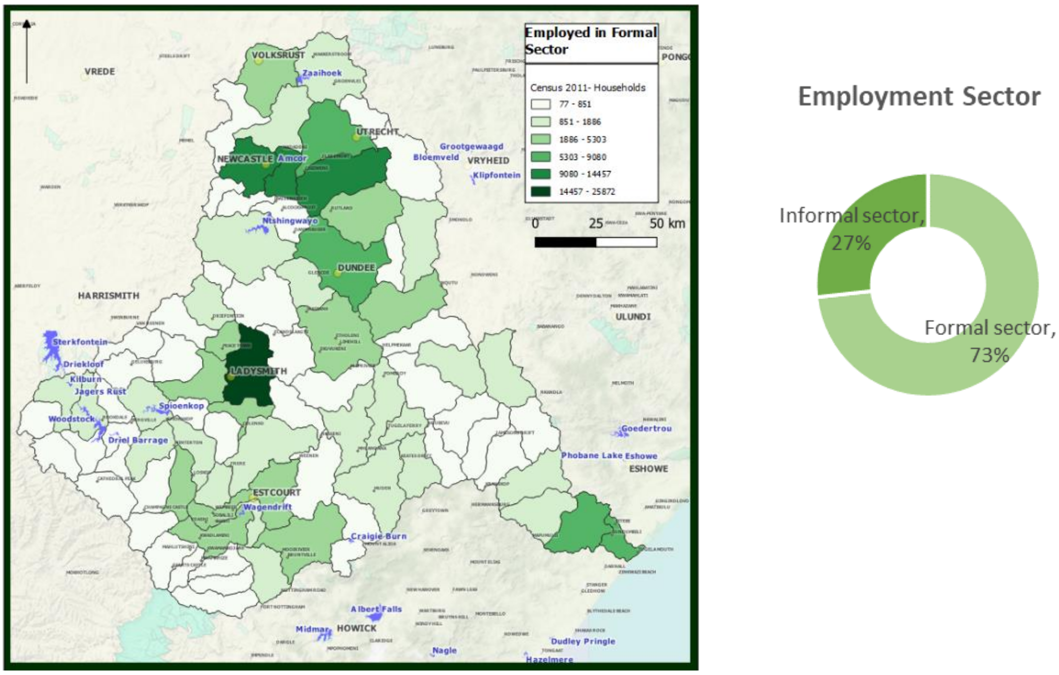

Figure 14: Employment in the formal sector in the Thukela catchment

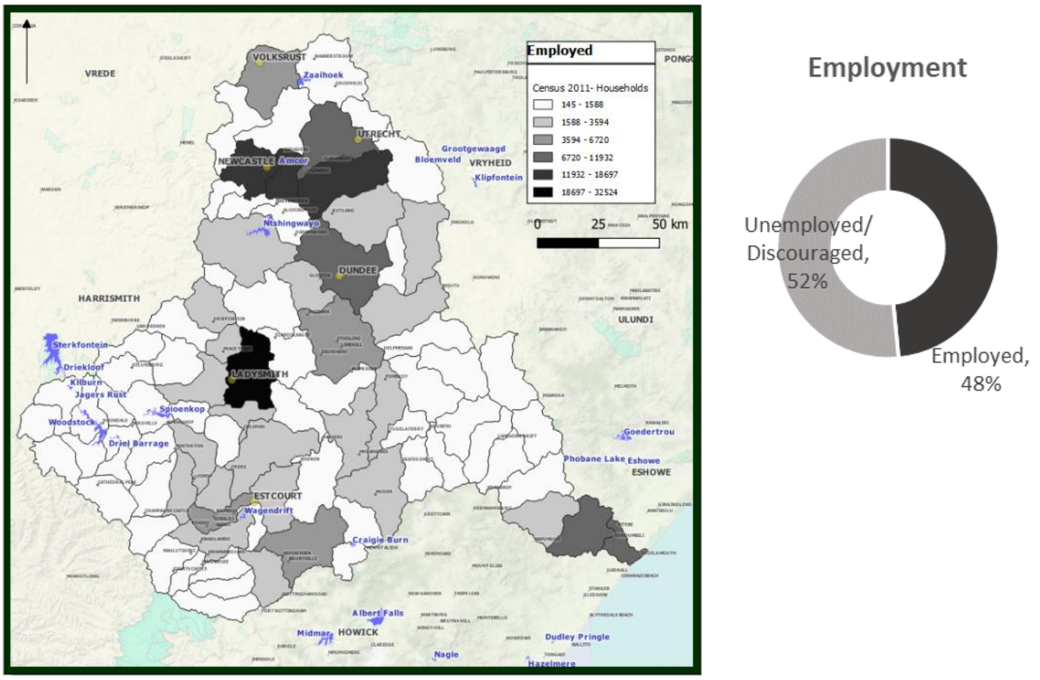

Figure 15: Number of households that are employed (StatsSA - Census 2011)

3.2 Economic Sectors

The province of KwaZulu-Natal contributed approximately R746 billion to the GDP of South Africa in 2017. This represented around 16% of the national figure, second only to Gauteng with a 34% contribution.

No official published data exists that measures the economic size of the Thukela water management area, however, initial estimates made as part of this study shows that the WMA contributed around 8% (+-4%) of the KZN GDP or between 1.5% (+-0.5%) of the national GDP. In Rand terms, this would be approximately R54 billion per year (Table 16).

Table 16: Estimated GDP and Salaries of Thukela catchment

Rands	Minimum estimate (Rand)	Maximum estimate (Rand)
Gross Domestic Product	27 460 000 000	80 546 000 000
Compensation to Employees	13 841 000 000	40 597 000 000

The bulk of the area's employment (28%) is in community services, including education and other government projects. The primary land use within the broader region appears to be subsistence agriculture and grazing. A significant proportion of the rural settlements which rely on subsistence farming also collect their water from surface sources, such as rivers, streams, and dams, making them particularly vulnerable to changes in these water sources.

The second highest employment sector, at 20% of the region's total, is agriculture. A few key areas, mostly concentrated in the western portion of the region, exhibit high intensity agriculture. This is characterised by dryland annual crop cultivation and some high intensity pivot irrigation. Sugar cane is also cultivated towards the lower reaches of the basin.

Manufacturing, mainly of textiles and clothing, accounts for approximately 19% of the region's employment figures. Several commercial and industrial hubs are centred around the towns of Ladysmith, Newcastle and Estcourt, but these localities are mostly exceptions to the rest of the area. The iSithebe industrial zone at the foot of the Thukela represents the region's manufacturing hub, accounting for a significant proportion of the regions manufacturing capacity.

Some scattered coal mining and quarrying operations exist, employing only around 1% of the catchment's formally employed workforce. This number is largely accounted for by the coal mines of Platberg Collieries in Thukela District Municipality.

Tourism exhibits potential in the region, with several of the local municipalities noting their intention to enhance this sector in their local economies.

Overall, the Thukela basin is not intensively exploited through high intensity water resource usage. Table 17 demonstrates the major sources of income in the catchment.

Table 17: Sources of income in the Thukela water catchment area (Stats SA, 2011)

Economic sector	Estimated 2019 number of people employed in the formal sector	Percentage of employment per sector %
Household services	22 275	12%
Agriculture	36 738	20%
Mining	1 488	1%
Manufacturing	36 180	19%
Electricity	1 535	1%
Construction	4 371	2%
Trade	14 509	8%
Transportation	6 743	4%
Finance	10 928	6%
Community services	51 247	28%

3.3 Ecological Infrastructure

Key water resources include various 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 (Figure 16).

Significant wetland systems include those found in the upper catchments such as those at Wakkerstroom, Groenvlei, upper Blood river, Ntshingwayo Dam, the foothills of the Drakensberg escarpment and the Thukela mouth (Figure 16).

Large dam and impoundments include the Zaaihoek Dam (in the north), Ntshingwayo Dam in the Newcastle region, Woodstock and Spioenkop Dam in the west and Spring Grove and Craigie Burn Dam in the south (Figure 16).

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 (Figure 16).

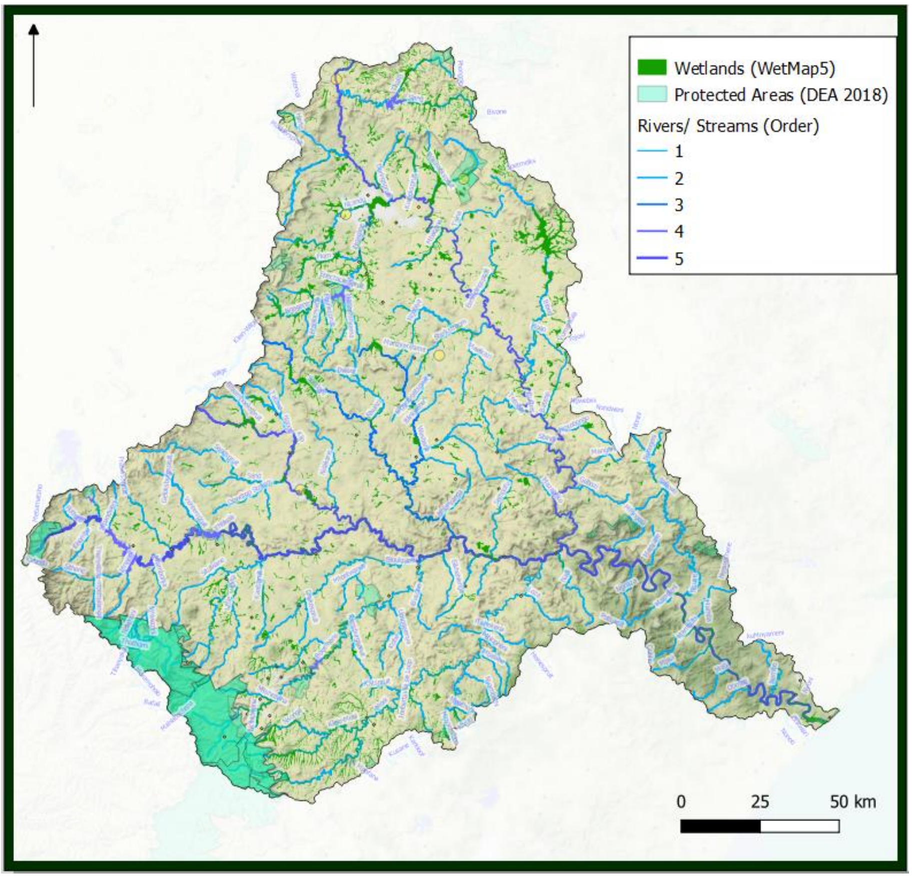

Figure 16: Locality of ecological infrastructure within the Thukela Catchment

3.4 Ecosystem Service Sensitivity

Ecosystem Service Sensitivity areas are identified at a high level through two general ways:

1) Knowledge of benefits received through ecological infrastructure, and
2) Inferring the flow of ecosystem services through the spatial relationship of potential beneficiaries and ecological infrastructure.

General categories of ecosystem services are utilised to define sensitivity and include provisioning, regulating and cultural services. Additionally, due to the nature of the catchment classification process, the water provisioning service is highlighted to be included in the sensitivity analysis.

Key ecosystem services in the Thukela catchment are preliminarily identified as the following (Figure 17):

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 as major wetlands and the Thukela Mouth estuary. Provisioning services (other than water) will play a larger role in rural livelihoods. Regulating services will provide overarching benefits to the wider economy.

Cultural services as indicated by the distribution of protected areas, tourism and community demographics.

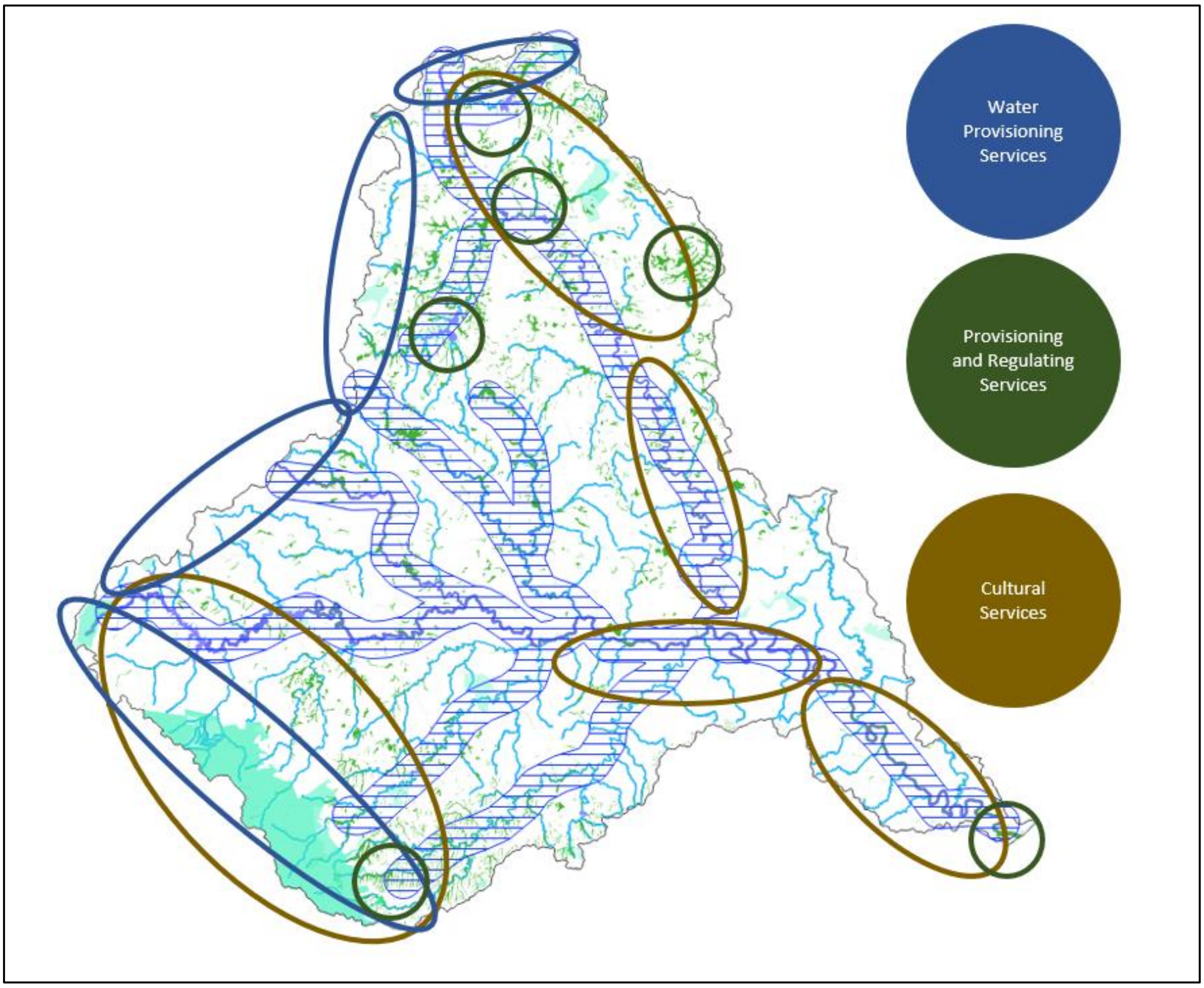

Figure 17: Ecosystem Service Sensitivity Areas in the Thukela Catchment

3.5 Socio Economic Zones

Socio-Economic Zones (SEZ) are defined as zones of relatively homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems. In other words, areas that represent a relatively similar mix of social wellbeing and economic drivers for the purposes of providing input into the IUA delineation process.

The SEZ's were categorised through the regional classification of the catchment in terms of economic activities, social demographics and wellbeing and ecological features.

The process included three steps (Figure 18):

- Step 1: Land Use Assessment

A land cover classification process was conducted that allowed for the understanding of physical features in the catchment. Physical features included natural features such as rivers, wetlands, catchments, ridges and mountains but also transformed land associated with land uses such as mining, agriculture and towns and settlements (urban and rural).

- Step 2: Economic Assessment

The economic assessment allowed for an understanding of the key economic drivers within each region. Each municipality within the catchment was investigated and profiled in terms of economic sectors. This process assisted in understanding the presence and variability of economic drivers across the catchment.

- Step 3: Social Assessment

The social assessment allowed for an understanding the demographic characteristics across the catchment. Census data by ward was used to investigate the general level of wellbeing of resident populations in terms of access to services (as a proxy for development), primary source of water, employment, population density, employment, income, and education.

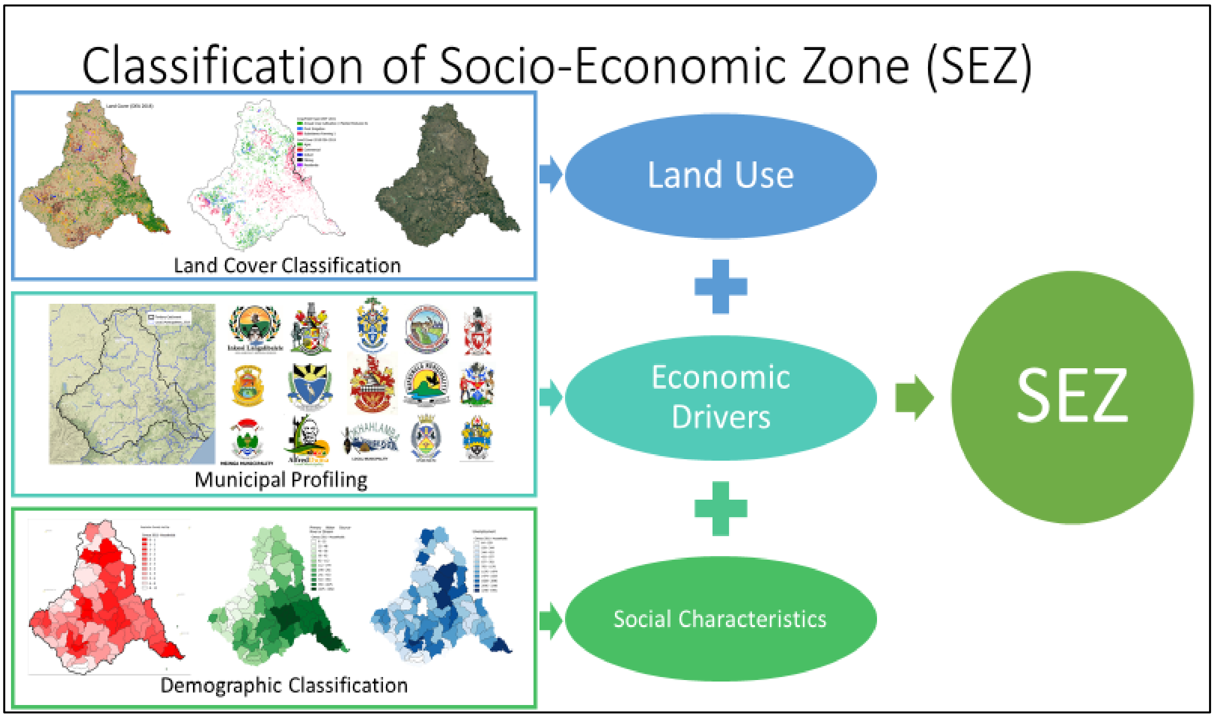

Figure 18: Schematic representation of Socio-Economic Zone delineation process

The catchment was delineated into 4 SEZ's including and defined as the following (Figure 19):

<u>The Mixed-Use Zone</u> represents relatively high intensity land uses including mining and industrial manufacturing but also agriculture (irrigated, commercial and subsistence) and tourism. The zone represents the highest population densities and access to services (flushing toilets and piped water access).

<u>Agricultural Zone</u> represents less intensive land use mostly cantered around agricultural land use (high prevalence of irrigation and commercial farming but also subsistence). Populations are less dense and slightly less access to services than mixed zone

<u>The Rural Zone</u> represents a rural region with distinctly low levels of development with no significant formal economic drivers. Key sources of livelihood are subsistence agriculture and tourism. The region has the lowest densities with a low proportion having access to services

(Sanitation and piped water). The region has the highest proportion of residents relying directly on rivers and streams as the primary source of water.

Commercial Development Zone is characterised by coastal sugarcane plantations, the Industrial Development Zone (IDZ) in Mandini and tourism. Populations in the zone have relatively high access to services and infrastructure

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

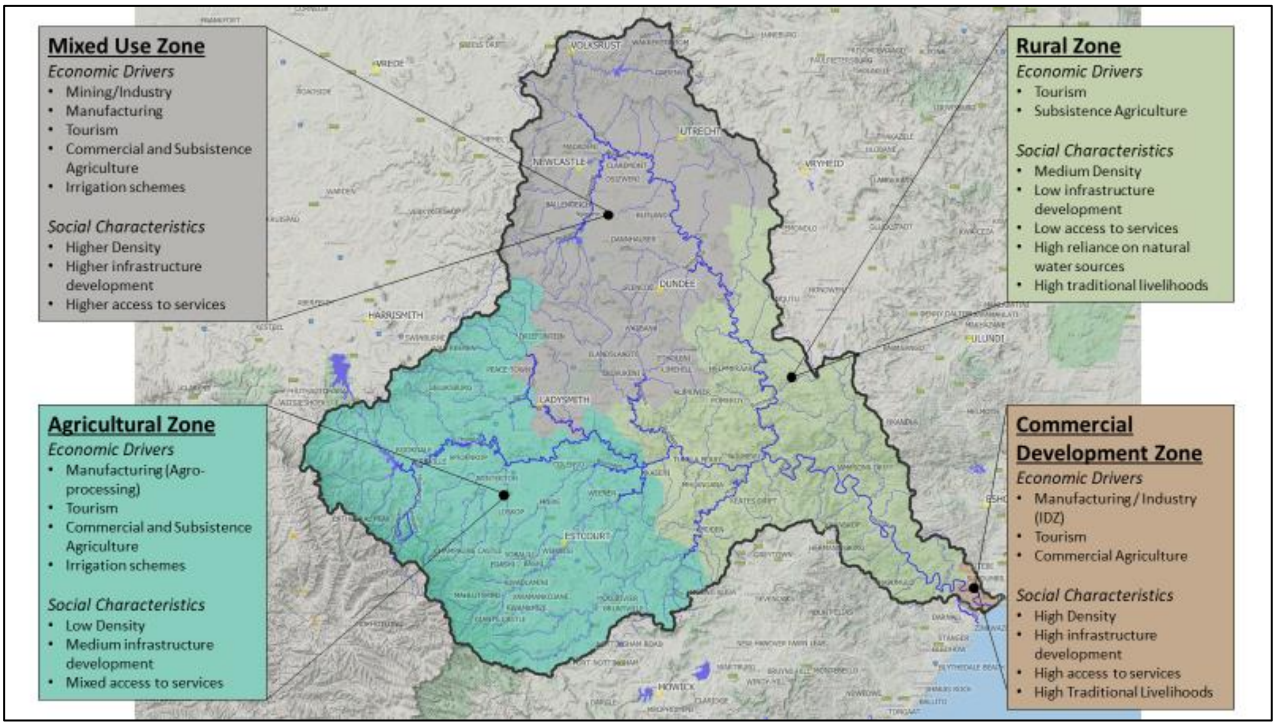

Figure 19: Socio-Economic Zones within the Thukela Catchment as per the IUA delineation process

4 STATUS QUO RIVERS

4.1 Description

Table 18 presents the mainstem rivers with associated tributaries within the Thukela Catchment that comprise the network of significant rivers identified for classification and associated RQO development. Significant rivers may be important from a use perspective or ecological perspective due to expected change in their condition in response to water quantity or water quality variation. Each of the rivers within the network has been characterised in the following sections to determine how they are to 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 is 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.

Table 18: 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 River	Nadi, Mfongosi, Ngcaza, Manyane, Mamdleni, Nsuze and tributaries
V50	V50A-V50D		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

4.2 RIVER CHARACTERISATION

The status of the rivers within the Thukela Catchment have been characterised based on their eco-regions, geomorphological zonation, present ecological state, ecological importance and sensitivity (EIS) and hydrological character. This characterisation has provided a basis to the IUA delineation.

4.2.1 Eco-regions

Eco-regional classification allows for the grouping of rivers according to similarities. The available information has been used to delineate eco-region boundaries at a broad scale for South Africa. Eco-regions derived from terrain and vegetation, with altitude, rainfall, runoff variability, air temperature, geology and soil were delineated and thirty-one Level I Eco-regions were identified for South Africa (Kleynhans *et al*., 2005). The next level, Level II, which used the same attributes but included more detail at a finer resolution was defined in 2007 (Kleynhans *et al*., 2007).

While eco-regions descriptions tend to be based on physical and vegetation attributes, the assumption is that the biota within an eco-region are likely to be similar.

The eco-regions that are found to occur in the Thukela Catchment described in Table 19 (Kleynhans *et al*., 2005, DWA, 2008) are illustrated in Figure 20.

Table 19: Eco-regions that characterise the Thukela Catchment

Eco-region	Level II	Distribution in catchment	Description
11: Highveld	11.02	Northern portion of quaternaries V31A; V31B – Wakkerstroom wetland, Zaaihoek Dam and area of Volkrust.	This eco-region (high lying region) is characterized by plains with low to moderate relief, Moderately undulating plains and pans, and moist sandy highveld grasslands. The altitude ranges between 1300masl and 1900masl. Rainfall is concentrated in early to mid-summer, with a MAP of 500 to 800mm.Mean annual air temperatures are between 12°C and 18°C.
14: North Eastern Uplands	14; 01; 14.02; 14.04; 14.06; 14.05; 14.07; 14.08	Dominates the catchment area - Buffalo, Sundays, Klip, Thukela River; lower Bushmans, Lower Mooi	This region is very diverse with lowlands, hills and mountains with moderate and high relief, as well as closed hills and mountains with moderate and high relief, being the defining characteristics. Grassland and Bushveld types, mainly Natal Central Bushveld and Valley Thicket characterize the vegetation. The altitude ranges between 100masl and 1500masl. Rainfall is concentrated in early to late summer, with a MAP of 600 to 1000mm. Mean annual air temperatures range between 14°C to >22°C.

Eco-region	Level II	Distribution in catchment	Description
15: Eastern Escarpment Mountains	15.03; 15.04; 15.05; 15.06; 15.07	Much of the escarpment area. Source of the Thukela, Buffalo and Mooi rivers.	High lying region characterized by closed hills, mountains with moderate and high relief with prominent escarpments towards the east. The vegetation consists of a range of grassland types with Afro Mountain and Alti Mountain Grassland being the defining types. The altitude ranges between 1100masl and 3100masl. Rainfall is concentrated in mid-summer, with a MAP of 500 to 1000mm. Mean annual air temperatures range between 8°C to 16°C.
16: South Eastern Uplands	16.01; 16.03	Upper catchment of Mooi River and major portion of headwater catchments of quaternaries V50A and V50B.	This eco-region is characterized Closed Hills, Mountains; moderate and high relief. Lowlands, Hills and Mountains; moderate and high relief terrains. Vegetation types include moist Upland Grassland, North-eastern Mountain Grassland, Sub-arid Thorn Bushveld, Afromontane Forest, Short Misbelt Grassland, Valley Thicket, Coast-Hinterland Bushveld, Moist Upland Grassland, Alti Mountain Grassland. The altitude ranges between 300masl and 1900masl. Rainfall is concentrated in mid-summer, with a MAP of 600 to 800mm. Mean annual air temperatures range between 12°C to 18°C.
17: North Eastern Coastal Belt	17.01; 17.02	Thukela Estuary and portion of headwater catchments of quaternaries V50B and V50C.	A diversity of terrain types occur in this region with closed hills and mountains with plain and a low to moderate relief being the most definitive. Vegetation types include Valley Thicket, Sand Forest, Afromontane Forest and Coastal Forest. Altitude varies from sea level to 900masl. Rainfall is concentrated over summer, with a MAP of 600 to 800mm. Mean annual air temperatures range between 16°C to 22°C.

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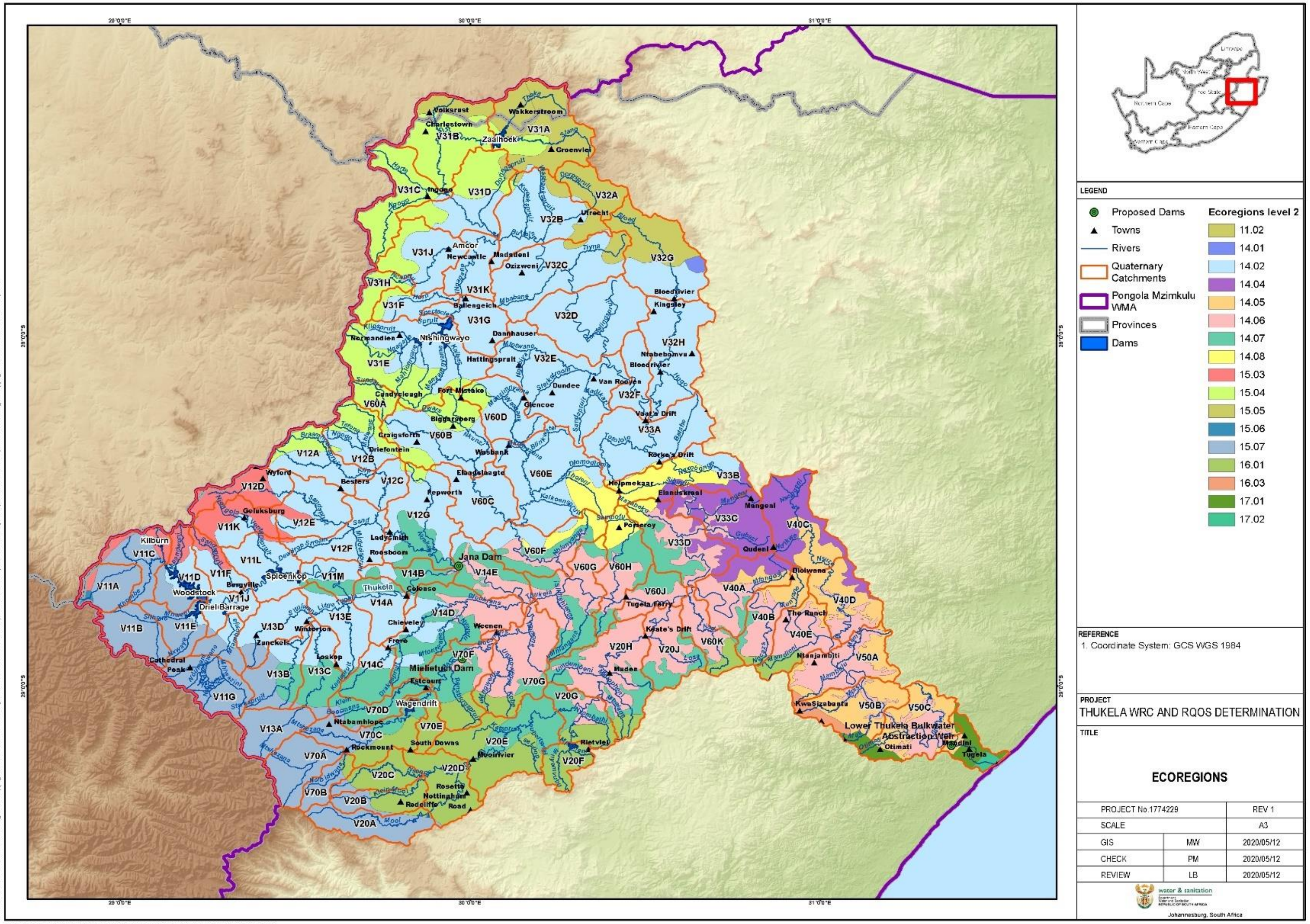

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Figure 20: Eco-regions in the Thukela

4.2.2 Geomorphology

Geomorphology provides a basis of classification for the purpose of describing the physical habitat of riparian and aquatic ecosystems, as it encompasses the physical processes which have shaped the river channel. Rivers and streams change naturally along their lengths with respect to temperature, depth, current speed, substratum, turbidity and chemical composition. The longitudinal physical and chemical changes can be used to classify the reaches of rivers. Rowntree and Wadeson (1999) have developed a zonal classification system for Southern African rivers modified from Noble and Hemens (1978).

The concept of river zonation recognises the longitudinal changes in river characteristics associated with the river long profile. In a graded system there is a natural progression from mountain stream through foothill stream to lowland river. On the basis of channel features ten geomorphological zone classes have been defined and are described in Table 20. The zones are areas within a catchment which can be considered as homogenous with respect to flood runoff and sediment production.

Table 20: Geomorphological zonation of South African river channels (Adapted from Rowntree and Wadeson, 1999) (DWS 2007b)

Zone class	Zone	Gradient class	Characteristic Features
S	Source Zone	Not specified	Low gradient, upland plateau, or upland basin able to store water. Spongy or peat hydromorphic soils
A	Mountain Headwater Stream	>0.1	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order. Reach types include bedrock fall and cascades.
B	Mountain Stream	0.04 – 0.099	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool.
C	Transitional	0.02 – 0.039	Moderately steep stream dominated by bedrock or boulder. Reach types include plane-bed, pool-rapid or pool-riffle. Confined or semi-confined valley floor with limited floodplain development.
D	Upper Foothills	0.005 – 0.019	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plane-bed, pool-riffle, or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow floodplain of sand, gravel or cobble often present.
Dr	Rejuvenated bedrock cascades	>0.02	Moderate to steep gradient, confined channel (gorge) resulting from uplift in the middle to lower

Zone class	Zone	Gradient class	Characteristic Features
			reaches of the long profile, limited lateral development of alluvial features, reach types include bedrock fall, cascades and pool-rapid.
E	Lower Foothills	0.001 – 0.005	Lower gradient mixed bed alluvial channel with sand and gravel dominating the bed, locally may be bedrock controlled. Reach types typically include pool-riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Floodplain often present.
F	Lowland River	0.0001 – 0.0009	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is an increased silt content in bed or banks.
Er	Rejuvenated Foothills	0.001 – 0.02	Steepened section within middle reaches of the river caused by uplift, often within or downstream of gorge; characteristics similar to foothills (gravel/cobble bed rivers with pool-riffle/ pool-rapid morphology) but of a higher order. A compound channel is often present with an active channel contained within a macro-channel activated only during infrequent flood events. A limited flood- plain may be present between the active and macro-channel.

The geomorphological zones that occur in the Thukela catchment and their extent are listed below and shown in Figure 21. 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%
- Class F: Lowland River - 9.34%

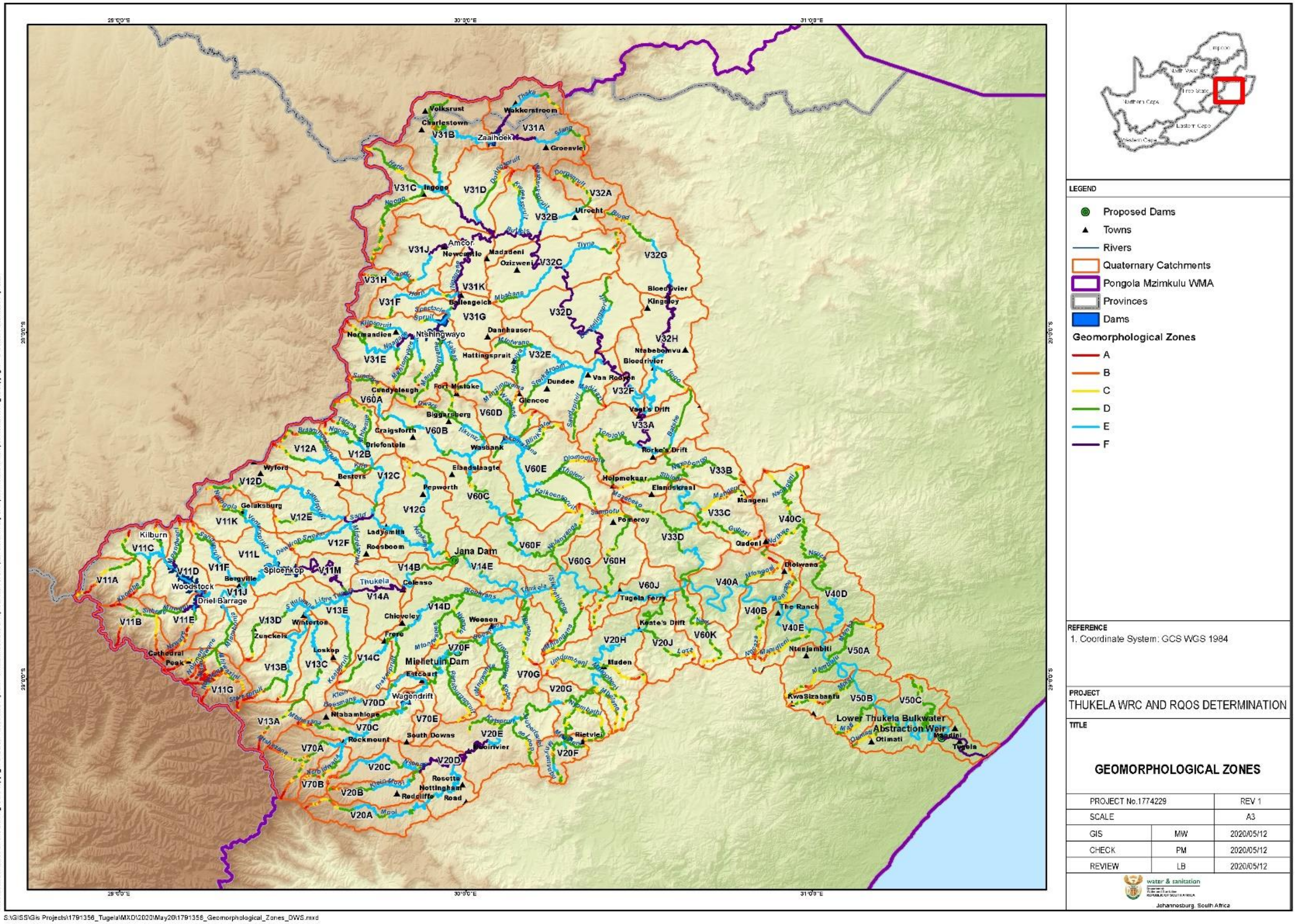


Figure 21: Geomorphological zones in the Thukela

4.2.3 Present Ecological Status

Present Ecological State (PES) represents how the ecological condition of a river has been modified from its natural (reference) conditions. The measure is based on water quality variables, biotic indicators and habitat information that has been collected. Results are classified on a 6-point scale, from Category A (Largely Natural) to Category F (Critically Modified).

The PES of a river is expressed in terms of various components, *i.e.* drivers (physico-chemical variables, geomorphology and hydrology) and biological responses (fish, riparian vegetation and aquatic macroinvertebrates), as well as in terms of an integrated state, the EcoStatus. Different processes are followed for each component to assign a category ranging from an A to an F category (Table 21). Ecological evaluation against the expected reference conditions, followed by integration of the categories of each component, provides a description of the Ecological Status or EcoStatus of a river. The EcoStatus can thus be defined as the total of the features and characteristics of the river (instream and riparian zones) that influence its ability to support an appropriate natural vegetation and animal life. This ability relates directly to the capacity of the system to provide a variety of goods and services (Modified from Kleynhans and Louw, 2007).

Table 21: Description of the Ecological categories

Ecological Category	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

The PES is a very broad qualitative assessment of both the instream and riparian components of a river. In 2013, the DWS published a national database of the PES/EIS of Sub-quaternary (SQ) river reaches throughout the country that was based on a modified desktop level eco-classification. A combination of expert knowledge and available information on the sub-quaternary reach levels were used to derive the Desktop Present Ecological State (PES). This PES/EIS database was used as the basis of the surface water maps to represent the ecological state component. The final modelled information in the front-end model for each primary catchment is available from the Directorate: Resource Quality Information Services (D: RQIS), DWS. Information was extracted in a 'master spreadsheet' for each primary catchment that incorporates the PES/EIS results. The objective of the PES/EIS is to provide desktop level information on ecological issues as it relates to the protection and management of river reaches. The PES results for the Thukela catchment are presented in the sub-sections to follow.

The Thukela catchment includes 285 SQ river reaches. Figure 22 presents the PES as an ecological category for the 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 in catchment, *i.e.* in a 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). More detail on the PES per secondary catchment is provided in the following sections. The driver of the PES ecological category is indicated for rivers in a C category or below, *i.e.* if not in a natural (A) or largely natural state (B). In terms of the driver descriptors, flow impact refers to modification of stream flow, water quality refers to physico-chemical modifications to the river reach and non-flow impact refers to instream habitat and/or riparian/wetland continuity and zone modifications.

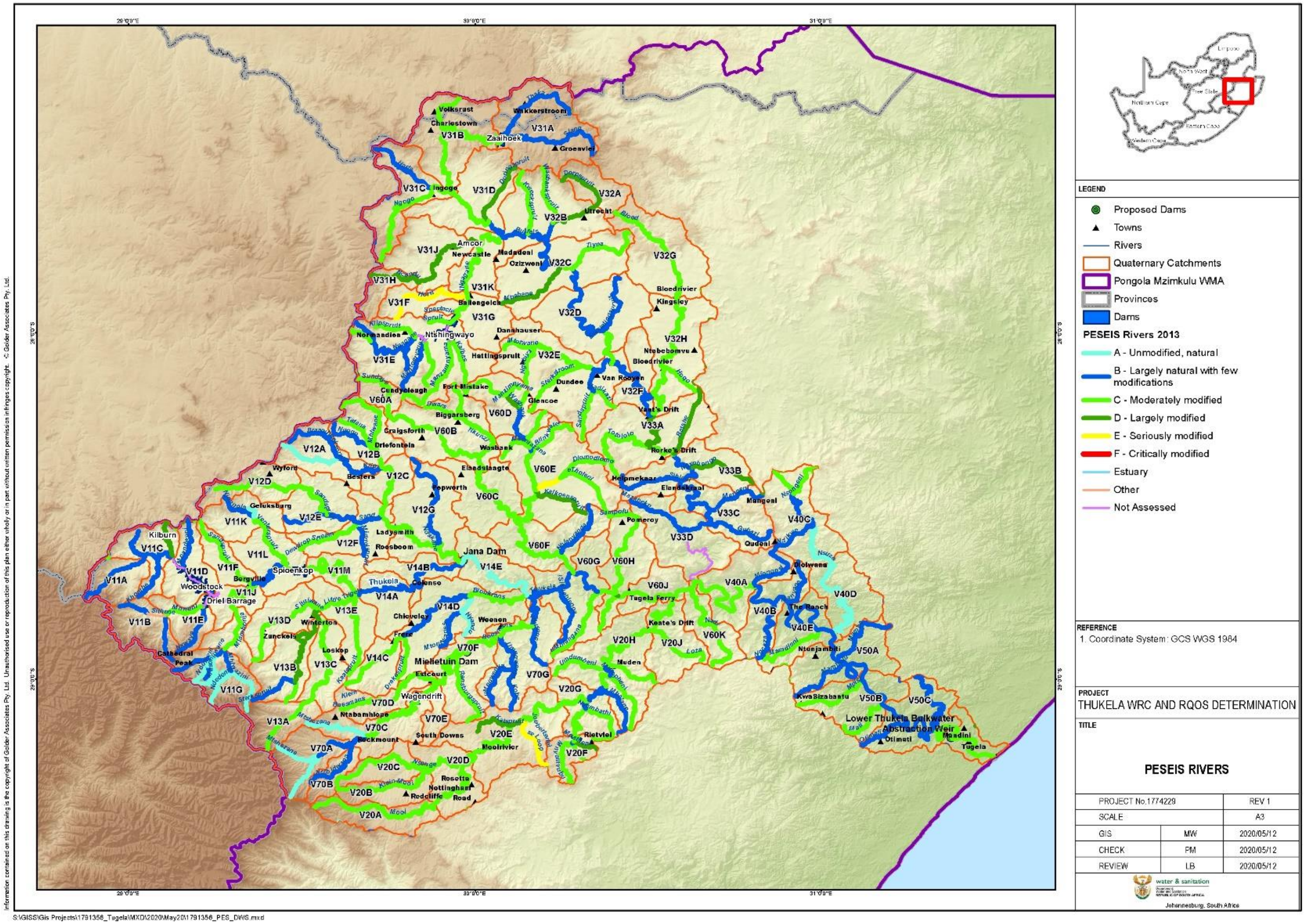


Figure 22: PES categorisation of the rivers in the Thukela catchment

4.2.3.1 V1 - Upper Thukela River

The V1 secondary catchment includes the Upper Thukela River to the confluence with the Bloukrans River. The rivers in the sub-catchment are in a good ecological condition, falling within an A, B or C PES ecological category, with the exception of the lower reaches of the Sterkspruit and its confluence with the Little Thukela and the Majajeni tributary, which are the only D category river reaches (Table 22).

This is due to flow and water quality impacts related irrigation, dams, land use and erosion. The catchment includes the headwaters of the Thukela and many of its tributaries which are in a pristine, close to natural state, located within the uKhahlamba Drakensberg National Park. The protected status of the area and location within the mountainous terrain limits the impacts on these headwater systems. The catchment includes Spioenkop, and Woodstock Dams and Driel Barrage which impact on the flow of the upper Thukela River and result in habitat modifications.

Table 22: PES and condition or PES Drivers for V1 – Upper Thukela River

Sub-quaternary (SQ)	River	PES	Condition or PES Driver (if below a B category)
V11A-03277	Thukela	B	Largely natural, marginal impact
V11B-03410	Sithene	B	Largely natural, marginal impact
V11B-03470	Thonyelana-mpumalanga	B	Largely natural, marginal impact
V11C-03181	Majaneni	D	Flow and non-flow significant
V11C-03196	Thukela	B	Largely natural, marginal impact
V11C-03203	Putterill	B	Largely natural, marginal impact
V11C-03261	Thukela	B	Largely natural, marginal impact
V11C-03285	Khombe	B	Largely natural, marginal impact
V11D-03170	Mpandweni	B	Largely natural, marginal impact
V11D-03275	Thukela	not assessed	*Woodstock Dam*
V11D-03302	Thukela	not assessed	*Woodstock Dam*
V11E-03400	Mnweni	C	Water quality and non-flow
V11E-03407	Mnweni	not assessed	*Woodstock Dam*
V11E-03446	Nxwaye	B	Largely natural, marginal impact
V11F-03182	Sandspruit	C	Flow and non-flow
V11G-03572	Mlambonja	B	Largely natural, marginal impact
V11G-03576	Mlambonja	B	Largely natural, marginal impact
V11G-03579	Mlambonja	A	Natural/close to natural
V11G-03582	Mhlwazini	B	Largely natural, marginal impact
V11G-03603	Masongwane	A	Natural/close to natural
V11G-03615	Ndumeni	A	Natural/close to natural
V11G-03631	Ndumeni	A	Natural/close to natural
V11G-03635	Un-named tributary	B	Largely natural, marginal impact
V11G-03643	Un-named tributary	A	Natural/close to natural
V11G-03645	Mhlwazini	A	Natural/close to natural
V11G-03647	Mhlwazini	A	Natural/close to natural
V11G-03650	Un-named tributary	A	Natural/close to natural
V11G-03652	Un-named tributary	A	Natural/close to natural
V11G-03656	Un-named tributary	A	Natural/close to natural
V11G-03644	Masongwane	A	Natural/close to natural
V11G-03657	Ndedema	A	Natural/close to natural
V11G-03658	Un-named tributary	A	Natural/close to natural
V11G-03659	Un-named tributary	A	Natural/close to natural
V11G-03660	Masongwane	A	Natural/close to natural
V11G-03663	Un-named tributary	A	Natural/close to natural
V11G-03665	Un-named tributary	A	Natural/close to natural
V11G-03667	Un-named tributary	A	Natural/close to natural
V11G-03668	Un-named tributary	A	Natural/close to natural
V11G-03669	Un-named tributary	A	Natural/close to natural
V11G-03672	Un-named tributary	A	Natural/close to natural
V11G-03676	Un-named tributary	A	Natural/close to natural
V11G-03677	Un-named tributary	A	Natural/close to natural
V11G-03678	Ndedema	A	Natural/close to natural
V11G-03683	Un-named tributary	A	Natural/close to natural

Sub-quaternary (SQ)	River	PES	Condition or PES Driver (if below a B category)
V11G-03684	Un-named tributary	A	Natural/close to natural
V11G-03687	Un-named tributary	A	Natural/close to natural
V11G-03693	Un-named tributary	A	Natural/close to natural
V11G-03695	Un-named tributary	A	Natural/close to natural
V11G-03697	Un-named tributary	A	Natural/close to natural
V11G-03698	Un-named tributary	A	Natural/close to natural
V11G-03702	Un-named tributary	A	Natural/close to natural
V11G-03703	Un-named tributary	A	Natural/close to natural
V11G-03706	Ndedema	A	Natural/close to natural
V11G-03709	Un-named tributary	A	Natural/close to natural
V11G-03710	Thuthumi	A	Natural/close to natural
V11G-03715	Ndedema	A	Natural/close to natural
V11G-03725	Ndedema	A	Natural/close to natural
V11H-03422	Mlambonja	C	Flow, water quality, non-flow
V11J-03381	Thukela	C	Flow and non-flow
V11J-03382	Thukela	not assessed	*Driel Barrage*
V11K-03106	Geluksburgspruit	A	Natural/close to natural
V11K-03119	Njongola	B	Largely natural, marginal impact
V11L-03141	Venterspruit	C	Water quality, non-flow, primarily flow
V11L-03301	Thukela	B	Largely natural, marginal impact
V11M-03280	Thukela	C	Flow, water quality, non-flow
V12A-02922	Braamhoekspruit	B	Largely natural, marginal impact
V12A-02962	Klip	A	Natural/close to natural
V12A-03003	Klip	B	Largely natural, marginal impact
V12B-02860	Mhlwane	C	Flow, water quality, non-flow
V12B-02895	Tatana	C	Water quality, non-flow
V12B-02932	Ngogo	B	Largely natural, marginal impact
V12B-02972	Ngogo	C	Flow, water quality, non-flow
V12B-02990	Ngogo	C	Water quality, non-flow
V12C-03021	Klip	C	Flow, water quality, non-flow
V12D-02987	Sandspruit	C	Non-flow
V12E-03122	Sand	B	Largely natural, marginal impact
V12E-03171	Un-named tributary	B	Largely natural, marginal impact
V12F-03115	Sand	B	Largely natural, marginal impact
V12F-03209	Dewdrop Stream	C	Flow and non-flow
V12F-03212	Un-named tributary	A	Natural/close to natural
V12F-03215	Middelspruit	B	Largely natural, marginal impact
V12G-03029	Ndakane	B	Largely natural, marginal impact
V12G-03125	Klip	C	Water quality, non-flow
V12G-03256	Klip	C	Flow, non-flow, primarily water quality
V13B-03497	Sterkspruit	D	Flow, water quality, non-flow
V13B-03689	Sterkspruit	B	Largely natural, marginal impact
V13B-03722	Un-named tributary	C	Flow and non-flow
V13C-03495	Little Thukela	C	Flow and non-flow
V13D-03379	Situlwane	C	Flow, water quality, non-flow
V13D-03464	Little Thukela	D	Flow and non-flow
V13E-03362	Little Thukela	C	Water quality, primarily flow
V13E-03423	Little Thukela	C	Water quality, flow
V13E-03435	Kaalspruit	C	Flow, water quality, non-flow
V14B-03296	Thukela	B	Largely natural, marginal impact
V14C-03537	Bloukrans	C	Water quality, non-flow
V14D-03374	Bloukrans	B	Largely natural, marginal impact
V14D-03383	Bloukrans	C	Flow, water quality, non-flow
V14D-03439	Nyandu	A	Natural/close to natural
V14D-03481	Mtontwanes	B	Largely natural, marginal impact
V14D-03488	Nyandu	A	Natural/close to natural
V14D-03555	Drakespruit	C	Flow and non-flow
V14E-03233	Thukela	A	Natural/close to natural
V14E-03352	Thukela	B	Largely natural, marginal impact

4.2.3.2 V2 – Mooi River

Secondary catchment V2 comprises the Mooi River with its tributaries the Klein-Mooi, Nsonge, Katspruit, Joubertsvlei, Mnyamvubu, Mbalane, Mhlopheni, Umdumbeni, iTshekana and the Loza. A large percentage of the rivers (63%) are in a C category PES, indicating basic ecosystem functions are still predominantly unchanged. However, flow impacts and changes to the instream habitat and biota are responsible for the predominantly modified systems. The lower reach of the Mnyamvubu tributary and Mbalane tributary and the stretch of reach of Mooi River between their confluences, is largely natural, with a B category PES. The Joubertsvlei se Loop in quaternary V20E of the sub-catchment is the only seriously modified tributary (E ecological category) (Table 23).

The PES is due to serious flow and habitat modifications due to a number of instream dams, and impacts associated with irrigation, forestry, and erosion.

Table 23: PES and condition or PES Driver for V2 – Mooi River

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V20A-04023	Mooi	C	Water quality, non-flow, primarily flow
V20B-04034	Klein-Mooi	C	Water quality, non-flow, primarily flow
V20C-03919	Nsonge	C	water quality, significantly flow
V20D-03934	Klein-Mooi	C	Water quality, non-flow, flow
V20E-03742	Mooi	C	Water quality, non-flow, primarily flow
V20E-03833	Katspruit	D	Flow and non-flow
V20E-03849	Mooi	D	Flow and non-flow
V20E-03881	Joubertsvlei se Loop	E	Flow and non-flow
V20E-03884	Mooi	C	Flow and water quality
V20F-03931	Mnyamvubu	C	Flow and non-flow
V20F-03945	Mnyamvubu	B	Largely natural, marginal impact
V20F-03952	Mpatheni	D	Flow and non-flow
V20F-03955	Rietvleispruit	C	Flow and non-flow
V20G-03780	Mooi	B	Largely natural, marginal impact
V20G-03830	Mnyamvubu	B	Largely natural, marginal impact
V20G-03850	Nyambathi	C	Flow and non-flow
V20G-03853	Mnyamvubu	C	Flow and non-flow
V20H-03500	Mooi	C	Water quality, non-flow, primarily flow
V20H-03584	Umdumbeni	C	Non-flow
V20H-03670	iTshekana	C	Non-flow
V20H-03696	Mooi	B	Largely natural, marginal impact
V20H-03716	Mooi	B	Largely natural, marginal impact
V20H-03739	Mooi	C	Flow and non-flow
V20H-03750	Mhlopheni	C	Flow and non-flow
V20H-03785	Mbalane	B	Largely natural, marginal impact
V20J-03467	Mooi	C	Non-flow
V20J-03566	Loza	C	Non-flow

4.2.3.3 V3 – Buffalo River

The Buffalo River catchment, the largest secondary catchment of the Thukela comprising a third of the total surface catchment area (9803 km^2), is represented by largely natural, moderately modified and largely modified river system in terms of PES ecological condition. The sub-catchment is the most impacted within the Thukela, as it includes a number of tributaries in a D ecological condition, including the Doringspruit, Ncandu, Dorpspruit, Mbabane, Batshe, Nxobongo, Ngagane and a short reach of the Buffalo River within quat V33A. The ecological status is driven largely by flow modifications (instream dams), non-flow (modifications to habitat) and water quality (irrigation, sedimentation, development around mining and major towns). The Horn River within the Ngagane catchment is the only river in the catchment in an E ecological condition (seriously modified). This is water quality, flow and non-flow driven as a result of coal mining impacts, river diversions and instream dams in the area. The Doringspruit has similar impacts that drives its D ecological condition (Table 24).

The major towns within the sub-catchment include Volkrust, Newcastle, Wakkerstroom, Utrecht, Madadeni, Dannhauser, Normandien, Bloedrivier, Glencoe, Dundee, Van Rooyen

Vant's Drift and Rorke' Drift. These areas due to the level of development in the urban areas, settlements, mining, industrial and agricultural sectors, as well as the presence of dams and transfers have influenced the ecological condition of the river systems, driving the C and D PES ecological categories. The largely natural systems (B PES category reaches) form the headwater systems or are reaches with limited land use or development.

Table 24: PES and condition or PES Driver for V3 – Buffalo River

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V31A-02254	Thaka	B	Largely natural, marginal impact
V31A-02319	Slang	B	Largely natural, marginal impact
V31B-02277	Buffels	C	Flow, water quality, primarily non-flow
V31B-02290	Slang	C	Non-flow, primarily flow
V31B-02341	Buffels	C	Flow, primarily non-flow
V31C-02354	Harte	B	Largely natural, marginal impact
V31C-02417	Ngogo	C	Non-flow, primarily flow
V31C-02448	Ngogo	C	Non-flow
V31D-02370	Buffels	C	Non-flow and flow
V31D-02387	Doringspruit	D	Non-flow, significantly flow
V31D-02492	Buffels	B	Largely natural, marginal impact
V31E-02647	Klipspruit	C	Non-flow and flow
V31E-02648	Spectacle Spruit	C	Flow, primarily non-flow
V31E-02653	Un-named tributary	B	Largely natural, marginal impact
V31E-02663	Ngagane	C	Non-flow and flow
V31E-02665	Ngagane	not assessed	*Reach in Chelmsford Dam*
V31E-02666	Ngagane	not assessed	*Reach in Chelmsford Dam*
V31E-02668	Ngagane	not assessed	*Reach in Chelmsford Dam*
V31E-02686	Manzamnyama	not assessed	*Reach in Chelmsford Dam*
V31E-02703	Ngagane	B	Largely natural, marginal impact
V31E-02708	Ngagane	B	Largely natural, marginal impact
V31E-02714	Fouriespruit	not assessed	*Reach in Chelmsford Dam*
V31E-02730	Mahlomyane	B	Largely natural, marginal impact
V31E-02731	Kalbas	C	Flow, non-flow, primarily water quality
V31E-02732	Fouriespruit	C	Flow, primarily non-flow
V31E-02733	Manzamnyama	C	Non-flow and flow
V31E-02747	Un-named tributary	B	Largely natural, marginal impact
V31F-02600	Horn	E	Water quality, significantly non-flow
V31G-02618	Ngagane	C	Non-flow and flow
V31J-02487	Ncandu	D	Water Quality and non-flow
V31K-02516	iNgagane	C	Water quality, non-flow, primarily flow
V31K-02541	iNgagane	C	flow, significantly water quality
V32A-02398	Dorpspruit	D	Water Quality and non-flow
V32B-02409	Wasbankspruit	C	Water Quality and non-flow
V32B-02414	Kweekspruit	C	Non-flow
V32B-02457	Buffels	B	Largely natural, marginal impact
V32B-02499	Dorpspruit	B	Largely natural, marginal impact
V32B-02515	Buffels	B	Largely natural, marginal impact
V32C-02526	Tiyna	C	Non-flow
V32C-02533	Buffels	B	Largely natural, marginal impact
V32C-02570	Buffels	C	Non-flow and flow
V32C-02580	Mbabane	D	Water quality, significantly non-flow
V32D-02575	Buffels	B	Largely natural, marginal impact
V32D-02592	Eerstelingspruit	B	Largely natural, marginal impact
V32D-02699	Buffels	C	Non-flow and flow
V32E-02660	Mzinyashana	C	Flow, non-flow, primarily water quality
V32E-02713	Mtotwane	C	Non-flow and flow
V32E-02750	Ngobiya	C	Non-flow and flow
V32E-02769	Mzinyashana	C	Flow, water quality, non-flow
V32E-02785	Sandspruit	B	Largely natural, marginal impact
V32E-02810	Sterkstroom	C	Flow, water quality, non-flow
V32E-02831	Sandspruit	B	Largely natural, marginal impact
V32E-02871	Madikazi	C	Non-flow
V32E-02877	Sandspruit	C	Flow, non-flow, primarily water quality
V32F-02707	Buffels	B	Largely natural, marginal impact
V32G-02465	Bloed	C	Non-flow, water quality, primarily flow
V32H-02816	Hoqo	C	Non-flow
V32H-02834	Bloed	C	Water quality, primarily flow

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V33A-02876	Batshe	D	Water quality, flow, primarily non-flow
V33A-02899	Buffels	D	flow, significantly non-flow
V33A-02950	Totololo	C	Non-flow and flow
V33A-03017	Buffels	C	Non-flow and flow
V33B-03002	Ngxobongo	D	Non-flow
V33B-03024	Buffels	B	Largely natural, marginal impact
V33B-03062	Sibindi	B	Largely natural, marginal impact
V33B-03090	Buffels	B	Largely natural, marginal impact
V33C-03114	Buffels	B	Largely natural, marginal impact
V33C-03137	Mangeni	B	Largely natural, marginal impact
V33C-03211	Buffels	B	Largely natural, marginal impact
V33C-03213	Gubazi	B	Largely natural, marginal impact
V33D-03147	Mazabeko	B	Largely natural, marginal impact
V33D-03206	Buffels	B	Largely natural, marginal impact
V33D-03260	Buffels	not assessed	

4.2.3.4 V4 and V5 – Lower Thukela River

The Lower Thukela secondary sub-catchment is for the most part in a very good ecological condition, with 74% of the river systems in a largely natural to natural state (A and B PES ecological categories) (Table 25).

The catchment area is sparsely populated, with limited development, with the exception of the lowest reach of the Thukela River in quaternary V50D. The moderately modified rivers (C category) are driven predominantly by habitat modifications and flow modifications (weirs). The lower Thukela River upstream of the Thukela Estuary (V50D), includes the town of Mandini, the Sappi Paper Mill as well as the Umgeni Water Bulk Water Transfer, all of which drive the C PES category in this reach.

Table 25: PES and condition or PES Driver for V4 and V5 – Lower Thukela River

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V40A-03318	Mfongosi	B	Largely natural, marginal impact
V40A-03384	Thukela	C	Flow and non-flow
V40B-03370	Manyane	B	Largely natural, marginal impact
V40B-03429	Thukela	B	Largely natural, marginal impact
V40B-03438	Thukela	B	Largely natural, marginal impact
V40B-03505	Ngcaza	B	Largely natural, marginal impact
V40C-03088	Nsongeni	C	Non-flow
V40C-03099	Nsuze	C	Non-flow
V40C-03159	Nsuze	B	Largely natural, marginal impact
V40C-03253	Ndikwe	B	Largely natural, marginal impact
V40D-03249	Nsuze	A	Natural/close to natural
V40E-03457	Thukela	B	Largely natural, marginal impact
V40E-03556	Thukela	B	Largely natural, marginal impact
V40E-03563	Mamdleni	C	Non-flow
V50A-03552	Mamba	B	Largely natural, marginal impact
V50A-03602	Thukela	B	Largely natural, marginal impact
V50A-03616	Thukela	B	Largely natural, marginal impact
V50A-03680	Mambulu	B	Largely natural, marginal impact
V50A-03707	Thukela	B	Largely natural, marginal impact
V50B-03786	Thukela	B	Largely natural, marginal impact
V50B-03796	Mpisi	C	Non-flow
V50B-03859	Mati	C	Non-flow
V50C-03788	Nembe	B	Largely natural, marginal impact
V50C-03860	Thukela	B	Largely natural, marginal impact
V50C-03882	Thukela	B	Largely natural, marginal impact
V50C-03920	Otimati	B	Largely natural, marginal impact
V50D-03903	Thukela	C	Non-flow, water quality, flow

4.2.3.5 V6 – Sundays and Middle Thukela Rivers

The V6 secondary catchment includes the Sunday and middle Thukela Rivers. The ecological condition of this sub-catchment is largely, moderately modified, with most river systems with a PES of a C ecological category (Table 26). Land use, wetland modifications and instream dams (flow and non-flow) are largely drivers of ecological condition. In some reaches water quality impacts related to mining, irrigation, communities/ towns, and other land uses drive the C category PES. The D ecological condition of the Wasbank River in quaternary V60D is driven by poor water quality due to mining; of the Kalkoenspruit and Wasbank (V60E) by serious instream habitat and wetland continuity modifications impacted by sand mining, cultivation, erosion, and of the Thukela (V60H) due to serious riparian-wetland zone modification due to extensive cultivation in the floodplain. The PES of the only seriously modified river, the eTholeni, is driven by non-flow impacts of instream habitat wetland modification associated with urban development, loss of riparian zones, sand mining, erosion and over grazing.

Table 26: PES and condition or PES Driver for V6 – Sundays and Middle Thukela Rivers

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V60B-02826	Sundays	C	Non-flow and flow (primarily)
V60B-02845	Nkunzi	C	Flow, non-flow and water quality
V60B-02883	Nkunzi	C	Flow, non-flow, significantly water quality
V60B-02884	Dwars	C	Non-flow and flow
V60C-03031	Sundays	C	Flow, non-flow and water quality
V60D-02827	Manzimnyama	C	Non-flow, water quality, primarily flow
V60D-02830	Wasbank	C	Water quality and primarily non-flow
V60D-02867	Uithoekspruit	C	Water quality and primarily non-flow
V60D-02868	Wasbank	D	Water quality and non-flow
V60D-02898	Wasbank	B	Largely natural, marginal impact
V60D-02920	Biggersgatspruit	C	Flow, non-flow, primarily water quality
V60E-02936	Blinkwater	C	Water quality and primarily non-flow
V60E-02955	Wasbank	C	Flow, non-flow and water quality
V60E-02975	Mkomazana	C	Water quality and non-flow
V60E-02979	Dlomodlomo	C	Non-flow and flow
V60E-03013	eTholeni	E	Water quality, significantly non-flow
V60E-03016	Wasbank	B	Largely natural, marginal impact
V60E-03025	Wasbank	C	Water quality and non-flow
V60E-03077	eTholeni	C	Non-flow and flow
V60E-03117	Wasbank	C	Non-flow, water quality, flow
V60E-03134	Wasbank	D	Water quality, significantly non-flow
V60E-03139	Kalkoenspruit	D	Flow and significantly non-flow
V60F-03177	Nhlanyanga	B	Largely natural, marginal impact
V60F-03210	Sundays	C	Non-flow
V60F-03308	Sundays	C	Non-flow and flow
V60G-03247	Thukela	B	Largely natural, marginal impact
V60G-03348	Thukela	B	Largely natural, marginal impact
V60G-03372	Thukela	B	Largely natural, marginal impact
V60G-03385	Thukela	C	Water quality, significantly non-flow
V60G-03425	iSikhehlenga	B	Largely natural, marginal impact
V60G-03436	uMhlangana	C	Water quality and non-flow
V60H-03167	Sampofu	C	Water quality and non-flow
V60H-03431	Thukela	D	Water quality, significantly non-flow
V60H-03461	Un-named tributary	C	Non-flow
V60J-03343	Thukela	C	Non-flow and flow
V60J-03395	Thukela	C	Flow, water quality, primarily non-flow
V60K-03419	Thukela	C	Non-flow and flow
V60K-03443	Nadi	C	Non-flow

4.2.3.6 V7 – Bushmans River

The PES of the rivers within the Bushmans River secondary catchment are in a good ecological condition. A number of rivers are in a largely natural to natural state (A and B PES ecological category) (Table 27).

The rivers in these quaternaries 70A, 70B and the Mtshezana tributary are pristine and lie within the protected area of the uKhahlamba Drakensberg National Park. The B PES category tributaries within V70G are of high ecological importance and are minimally impacted by any anthropogenic activity in the area. The river systems with a PES of a C ecological category are driven by flow and non-flow modifications and water quality impacts due to cultivation in riparian zones, instream dams, weirs, sewage pollution (failing infrastructure and non-compliant effluent), the activities and development associated with the town of Estcourt, sand mining and irrigation.

Table 27: PES and condition or PES Driver for V7 – Bushmans River

Sub-quat	River	PES	Condition or PES Driver (if below a B category)
V70A-03876	Bushmans	B	Largely natural, marginal impact
V70A-03925	Mtshezana	A	Natural/close to natural
V70A-03966	Bushmans	A	Natural/close to natural
V70B-03927	Ncibidwana	B	Largely natural, marginal impact
V70C-03745	Bushmans	C	Largely non flow impact and flow, water quality
V70C-03822	Mtshezana	A	Natural/close to natural
V70C-03900	Bushmans	B	Largely natural, marginal impact
V70D-03699	Klein Bushmans	C	Non flow impact and flow, primarily water quality
V70F-03548	Bushmans	C	Mainly flow, non-flow and water quality
V70F-03623	Bushmans	C	Non flow impact, flow and water quality
V70F-03636	Rensburgspruit	C	Largely non flow impact and flow, water quality
V70G-03440	Bushmans	B	Largely natural, marginal impact
V70G-03515	Bushmans	C	Non flow impact, flow and water quality
V70G-03543	iBusone	B	Largely natural, marginal impact
V70G-03565	Umngwenya	B	Largely natural, marginal impact
V70G-03679	uMngwenya	B	Largely natural, marginal impact
V70G-03688	Kobe	B	Largely natural, marginal impact

4.2.3.7 Conclusion

The sub-quaternary reaches of similar PES and/or of similar reasons for the PES related to land use and impacts have formed a basis for the IUA delineation as areas of homogenous PES and impacts are more suited to be managed together.

4.2.4 EWR Site information

The Thukela preliminary Reserve included 17 Ecological Water Requirement (EWR) sites, nine in the upper Thukela Catchment and tributaries and eight sites in the Lower Thukela Catchment. A number of rapid Reserve determinations were undertaken between 2002 and 2005. However, no reports were available for these studies. Rapid assessments were undertaken for the Ngagane, Horn, Ncandu and Ncone rivers in 2013 and for the Mooi River just upstream of the existing comprehensive site, Thukela_10, in V20E during 2019. An intermediate assessment was undertaken during 2017 for the lower Thukela River at Thukela_16, and two additional sites just downstream of the new abstraction weir in quaternary catchment V50D.

The sites and level of assessments are listed in Table 28 and shown in Figure 23.

Table 28: EWR sites and Rapid assessments undertaken in the Thukela Catchment

Name/ Identification	River	Quaternary catchment	Level	Year
Thukela_1, Bergville	Thukela	V11J	Comprehensive	2003
Thukela_2, Skietdrift	Thukela	V11M	Comprehensive	2003
Thukela_3, Klein Thukela	Little Thukela	V13E	Comprehensive	2003
Thukela_4A, Zingela	Thukela	V14E	Comprehensive	2003
Thukela_4B, Thukela Estates	Thukela	V14E	Comprehensive	2003
Thukela_10, Caravan Park	Mooi	V20E	Comprehensive	2003
Thukela_11, Mooi Falls	Mooi	V20E	Comprehensive	2003
Thukela_12, Gracelands	Mooi	V20H	Comprehensive	2003
Thukela_13, Upper Buffalo	Buffalo	V32F	Comprehensive	2003
Thukela_14, Lower Buffalo	Buffalo	V33C	Comprehensive	2003
Thukela_15, Jameson's Drift	Thukela	V40E	Comprehensive	2003
Thukela_16, Mandini	Thukela	V50C	Comprehensive; revised in 2017 with an intermediate assessment	2003
Thukela_7, Upper Sundays	Sundays	V60C	Comprehensive	2003
Thukela_8, Lower Sundays	Sundays	V60F	Comprehensive	2003
Thukela_9, Tugela Ferry	Thukela	V60J	Comprehensive	2003
Thukela_5, Weenen NR	Bushmans	V70F	Comprehensive	2003
Thukela_6, Darkest Africa	Bushmans	V70G	Comprehensive	2003
Thu_EWR17	Thukela	V50D	Intermediate	2017
Thu_EWR18	Thukela	V50D	Intermediate	2017
V11C	Khombe	V11C	Rapid III	2005
V11D	Mpandweni	V11D	Rapid III	2005
EWR2, Venterspruit	Venterspruit	V11K	Rapid III	2005
EWR3, Klipspruit	Klipspruit	V12A	Rapid	tbc
V12A	Braamhoekspruit	V12A	Rapid III	2005
Klein Thukela	Little Thukela	V13C	Rapid III	2002
V20A	Mooi	V20A	Rapid III	2002

Name/ Identification	River	Quaternary catchment	Level	Year
EWR4	Hlatikhulu	V20C	Rapid III	2005
EWR_Mooi_N3	Mooi	V20D	Rapid III	2012, 2019
V31E, May13_EWR1	Ngagane	V31E	Rapid I	2013
V31F, May13_EWR2	Horn	V31F	Rapid III	2013
V31H	Ncandu	V31H	Rapid III	2005
V31K, May13_EWR3	Ngagane	V31K	Rapid III	2013
Kno_up	Knockbrex	V31K	Rapid II	2017
Kno_down	Knockbrex	V31K	Rapid II	2017
Ncone	Ncone	V32H	Rapid III	2012
EMAN2	eMandeni Stream	V50D	Rapid III	2017

The EWR information obtained from the preliminary Reserve determination and the additional EWR assessments undertaken during this study will be used to quantify, extrapolate and finalise the EWRs for all the selected nodes within the delineated IUAs and subsequently develop the rule curves, summary tables and time series for the scenario analysis. The delineation of the IUAs requires that there be at least one EWR site/hydrological node at the outlet of the catchment to assess the attainment of proposed water resource class through the flow and ecological specifications set. This will be achieved in terms of the delineated IUAs.

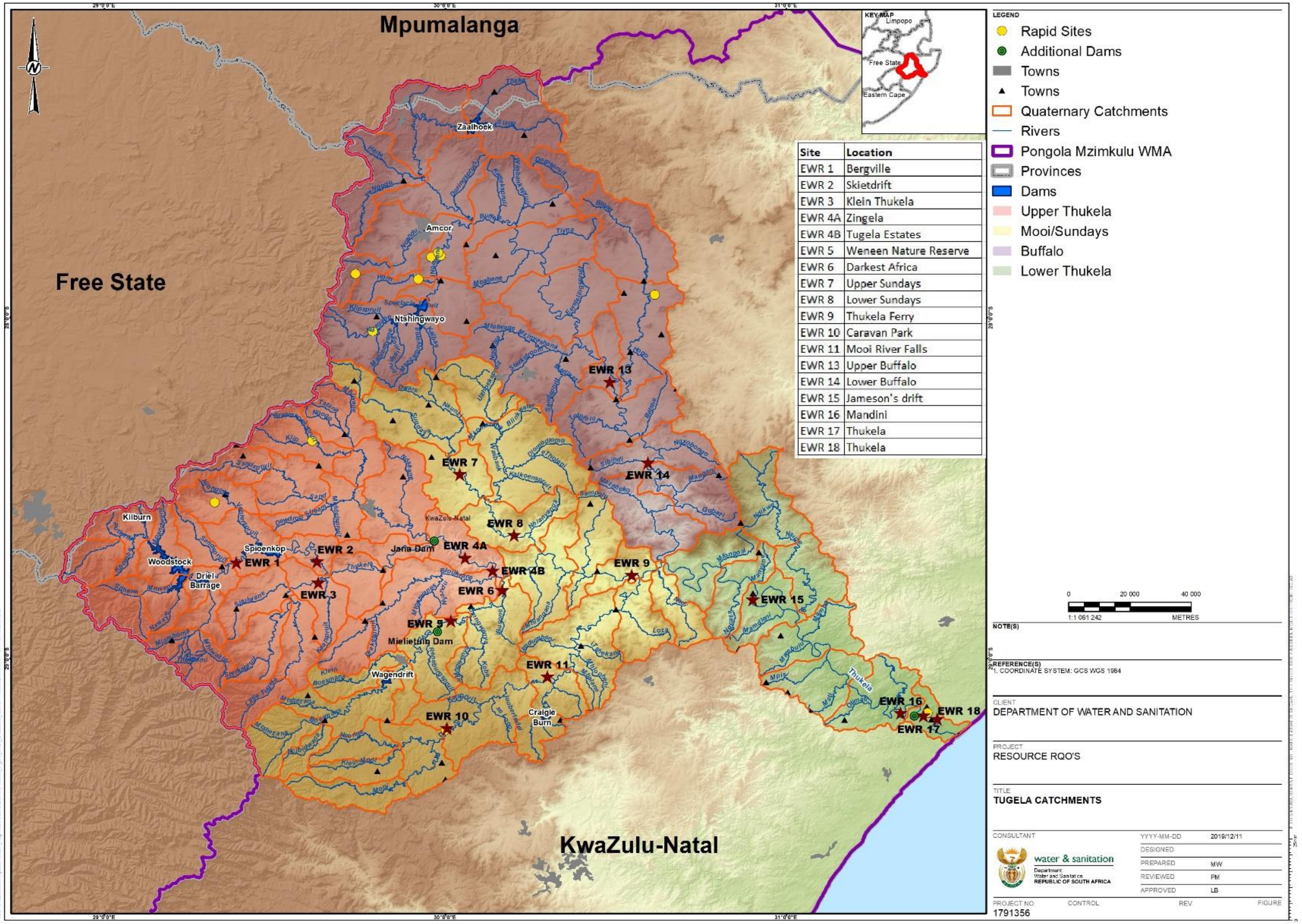


Figure 23: Location of EWR sites and Rapid assessments undertaken in the Thukela Catchment

4.2.5 Hydrological Character

Hydrological Index values determined by Hughes and Hannart (2003) are used to characterise hydrological variability at a quaternary catchment level throughout South Africa. The hydrological index is based on an input time series of natural monthly flow volumes using a combination of monthly coefficients of variation (CV) and an index of baseflow contribution to total flow (BFI) (Table 29). Higher values imply rivers with variable and unreliable flow regimes. The CV Index is based on the sum of the average coefficient of variation for the three main wet season months and the three main dry season months.

Table 29: Hydrological Index

Class	Coefficient of Variation Index	Hydrological character
Class 1	CV_Index 1-4	Perennial
Class 2	CV_Index 5	Seasonal
Class 3	CV_Index 6-9	Ephemeral

The Thukela River and all its tributaries are perennial rivers (CV_ Index for all rivers ranging from 1 to 4).

4.2.6 Protected Areas

The Thukela catchment includes a number of protected conservation areas (approximately 35) (Figure 24) of high biodiversity, cultural heritage, water and landscape importance. The uKhahlamba-Drakensberg Park is the most prominent conservation area in the catchment area, designated as 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 are also found in the catchment.

Other protected areas include the Royal National Park, and Weenen and the Nkandla Nature Reserves (V40D). The Qudeni (V40A), Hlatikulu (V40A), Normandien (V31H) and Ncandu (V31F) Reserves are small and do not have major rivers flowing through them. 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.

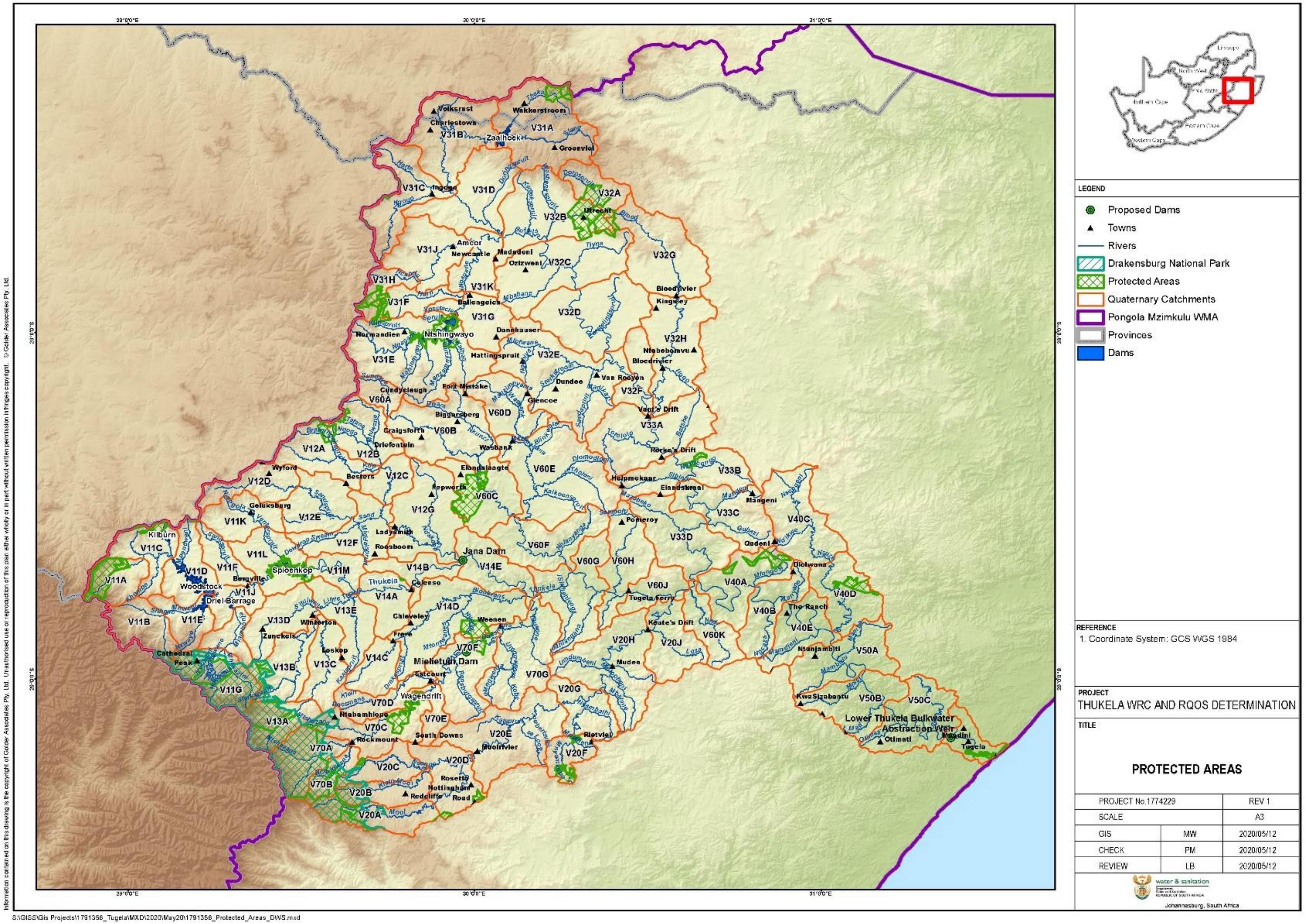


Figure 24: Designated Protected Areas within the Thukela catchment

5 STATUS QUO GROUNDWATER

5.1 Overview

The hydrogeological characteristics of the Thukela Catchment is mainly driven by the presence of a wide range of geological formations present, *i.e.* 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.

Topographically, the Thukela Catchment, being the 2nd largest river system [in terms of flow discharge] in South Africa, varies significantly due to the erosion features mainly formed by the different geological formations, *i.e*. high gradient terrains in the more competent (harder) basalt/sandstone formations and low gradients underlain by less competent (shales and mudrocks).

Several gorges have been incised in the bedrock formations and flat lying Karoo Sills in the catchment have developed into several mesa-like features. As an example, the Thukela River cuts through the Thukela Gorge (Clarens Sandstone Formation) at the foot of the escarpment (~1500 mamsl), runs through the Ladysmith Basin (Ecca Group shales/sandstones at ~1,050 mamsl)and follows a narrow and deep channel below Colenso (Emakwenzi Formation – Beaufort Group at ~750 mamsl). At Jameson’s Drift (Pre-Karoo Basement rocks [e.g. amphibolites] at ~300 mamsl), it enters the wide open Thukela Trough (Pre-Karoo gneiss overlain by Natal Group sandstone <250 mamsl) and then the coastal plain (Cenozoic sediments underlain by Dwyka Group Tillites at <100 mamsl).

Although the Karoo/Post-Karoo (viz. Phanerozoic Eon: < 545 Ma) structural geological features are limited to Karoo Dolerite sills/dikes/sheets, the pre-Karoo structural geological features are mainly the result of the late Proterozoic (1,600 to 1,000 Ma) Namaqua-Natal metamorphic events. Several large lineaments, i.e. faults/shear zones, are present in the basement rock formations running in a west-east direction across the catchment. These features played a significant role on the landscape development of the catchment – several of the large river channels have developed on these features. The lower sections of the Upper Thukela River, the Bloukrans River and the Mfongosi River follows the same west-east running fault zone, named the Thukela Fault Zone. Reactivation of the Thukela Fault during the Gondwana Land Break Up (80 to 126 Ma), has resulted in lateral movement of the Karoo Formations along this fault zone. The role of the Thukela Fault Zone has on groundwater occurrences seems to be insignificant, or not specifically investigated in the past.

Groundwater quality in the WMA is classified as good to ideal, however, anthropogenic developments in the since the 1900’s unavoidably had a significant impact on water quality. One example is the acid mine drainages from redundant coal mine workings in the Buffalo River catchment. An aspect that should be acknowledge especially in the central and eastern part of the catchment, is the poorer “natural” water quality status due to the initial marine/lake

Karoo sedimentary conditions (*i.e.* a paleo saline environment). These salts are still embedded in the micro-rock matrix and released during erosional/decomposition processes.

5.2 Description

The majority of land is used for agriculture, with relatively large areas of grassland. In the southern and eastern parts of the catchment, small amount of forestry occurs. Agriculture practices includes (i) sugar cane farming towards the coastal regions and around Weenen (both dry land/irrigated), (ii) vegetables and nuts, (iii) citrus farming on the coast near Mandini. Inland, large areas of beef and dairy pastures are present. The majority of irrigation uses sprinkler irrigation systems, but centre-pivot irrigation is also used in the western areas (especially around the Thukela River – DWAF, 2009).

The surface water drainage systems consist of several sub-catchment units, *viz*.:

- Upper Thukela (northwestern highlands area – basalt, sandstone[1] & mudstone, shale plus Karoo Dolerite intrusions);
- Mooi-Boesmans-Bloukrans (southwestern-southern boundary area – basalt, sandstone and mudstone, shale plus Karoo Dolerite intrusions);
- Sundays (upper central area – sandstone & mudstone, coal & shale, shale plus Karoo Dolerite intrusions);
- Buffalo (northern-eastern boundary area of Thukela catchment – sandstone & mudrock, coal & shale, shale, diamictite & mudrock plus Karoo Dolerite intrusions); and
- Lower Thukela ("panhandle" towards ocean – shale, sandstone & coal & shale, shale, diamictite & mudrock, arenite & shale[2], gneiss & schist[3], Basement Gneiss, and Cenozoic sediments (quaternary catchment V50D).

The natural vegetation types of the Thukela River catchments follow a similar pattern to the geology. The simplified vegetation types prevailing within the bulk of the Thukela catchment are as follows (DWAF, 2009):

- Western (Drakensberg Escarpment) and northern boundary: highland sourveld changing to southern tall grassveld (west to east and north to south);
- Central area: grassveld, changing to valley bushveld (west to east) and Natal sour sandveld (north to south); and
- Coastal area: coastal forest.

Land use is primarily related to limited forestry developments, agricultural practices (stock farming, cash crop irrigations, game farming and sugar cane plantations). A low proportion of the catchment is natural and consists mostly of grassland and bushland, with some forest. Approximately 1-2% of the catchment is urban, comprising mostly residential, industrial and

[1] Also referenced as "arenites" – all course to medium grained clastic rocks (sandstones, siltstones and conglomerates) representing water bearing zones/aquifers.
[2] Part of the Natal Group (Natal [TMG] sandstones.
[3] Part of the Natal Sector, Namaqua-Natal Metamorphic Province (~1.1 Ga)

commercial development, as well as mines and quarries. This is mainly associated with the towns of Estcourt, Ladysmith, Dundee and Newcastle, situated in the upper catchment.

A number of other commodities such as sand and dolerite mining/quarrying and historic coal mining are found in the Vryheid Formation (the Ecca Group coal seams). The coal mines, scattered over the northern parts of the Thukela River Catchment (the Sundays and Buffalo sub-catchments) are all redundant, however, rewatering (*i.e*. flooding) of these mines poses a serious problem with decanting acid rock drainage which finds its way to the surface water systems. Dennis & Dennis (DWAF, 2009) stated that most of the older mines were never rehabilitated adequately and produce acid rock drainage decant that enters the surface water resources around Newcastle impacting the Buffalo and Ngagane Rivers.

In terms of groundwater-surface water interaction, two aspects need to be highlighted:

- River-alluvium aquifers; and
- Wetlands.

These will be discussed in more detail below. It is, however, important to note 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, *i.e*. surface water source and wetland biomes..

A detailed description of the soil conditions is provided in the Reserve determination assessment by DWAF (2009). The physical characteristics of the soil is an important aspect in terms of groundwater recharge – one of the important characteristics is the interconnected pores spaces, *i.e*. a factor of soil permeability and describes the rate at which water (and air) move from shallow to deeper soil horizons. Soil permeability is also influenced by soil matrix, *i.e.* how soil particles are sorted and clumped together. Soils vary in their contents of clay (very fine particles), silt (fine particles), sand (medium-sized particles), and gravel (coarse to very coarse particles). The proportion of the different sizes and types of mineral particles determines the soil texture. Loam soils are comprised of roughly equal mixtures of clay, sand silt and humus, which are the best soils for growing most crops (DWAF, 2009). The following soil types occur in the Thukela Catchment:

- Drakensberg Escarpment (western boundary): Moderate to deep clays on steep slopes;
- Drakensberg Escarpment (northern boundary): Moderate to deep sandy loams on undulating terrain;
- Central area: Moderate to deep clays on undulating terrain and moderate to deep clayey loams on steep slopes and undulating terrain; and
- Coastal belt: moderate to deep clayey loams, sandy loams on undulating terrain, and unconsolidated sand.

5.2.1 Geology

The rock formation present in the Thukela Catchment varies significantly over the geological time; rock formations are mainly from the Phanerozoic Eon (*viz*. Karoo and younger) as well as formations formed/metamorphosed during the Pre-Cambrian Period (*viz*. >545 Ma). The spread of the different formations, as well as secondary geological features, *i.e*. dykes, sills and associated lineaments (shear zones and faults) are illustrated in Figure 25. The different rock formations in the Thukela catchment are summarized as follows:

Pre-Karoo Rocks and Secondary Geological Features (pan-handle area of catchment)**:**

- Barberton Sequence (various types of Basement Rocks, but mostly gneissic) – Swazian (**Z**);
- Namaqua-Natal (Metamorphic) Province Group (shear-zoned meta-arenaceous rocks) – Namaquan (**N**); and
- Various degree of faulting/shearing present (~1,000 Ma).

Natal Group (formerly correlated with the Table Mountain Group – pan-handle area of WMA) (Arenaceous rocks (course to very coarse grained, arkostic) with interbedded mudrock and conglomerate units – Ordovician (**O**) – Silurian (**S**);

Karoo Supergroup (various sedimentary depositional phases from deep marine, fluvial/lacustrine to aeolian/playa environments):

- Diamictite and mudrock – Carboniferous – Permian Tillite (C-Pd);
- Argillaceous rocks (shales, clay(stones), mudrock & siltstone, and minor arenites) – Permian (P); and
- Arenaceous rocks (sandstone (arenites)), feldsphatic sandstone/arkose, and mudrock) – Triassic (T_R).

Karoo Igneous Sequence:

- Karoo Dolerite intrusive dolerite (dykes, sills and saucer-like sheets) – Jurassic (J); and
- Volcanic Sequence: overlying massive extrusive volcanic rocks (continental basalt flows) – Jurassic (J).

Undifferentiated (younger) coastal and coastal plain deposits – Tertiary-Quaternary (T-Q);

- Consisting of unconsolidated to semi-consolidated sand, calcrete, aeolianite and conglomerate, etc.

River Channel Alluvium (young Quaternary unconsolidated clay, sand, conglomeratic horizons) – Quaternary (Q).

The study area is mostly underlain by the Karoo Supergroup and is either sub-horizontal or has a very gentle inland dip to the west, and a minor eastern coastal and coastal hinterland portion, wherein the structure comprises numerous south-easterly or seaward tilted fault blocks. These fault blocks play an important role in groundwater flow. In the low-standing east central portion of the basin, extending east to within about 20 km of the coast - 'Basement' rocks are exposed, comprising granite-gneiss, schists and amphibolites. Younger unconsolidated sands are limited to the coastal area and riverbeds.

Three Late Triassic/Early Jurassic Formations, *i.e*. Molteno (course sandstones/mudrocks with limited coal seams: bedload-dominated rivers), Elliot (mudrock/fine-to-medium sandstone: "red-bed" fluvial deposits), and Clarens (fine-grained aeolian sand with playa-lake deposits: desert, sedimentary conditions) are present in the western highlands. Erosion relics of these formations give way to the extraordinary escarpment related topographic patterns in the upstream reaches of the Thukela, Mooi and Bushmans rivers. The erosional features in the Thukela Gorge, with the extraordinary water features is an excellent example of the landscape sculptured by the Karoo rock formations.

The Karoo sedimentary sequence was finally capped by continental flood basalts deposits (*i.e*. volcanic sequence) representing the Drakensburg Group consisting of "*stacked lava flows*". As a result of the Karoo flood basalt extrusions, an underlying network of intrusive Karoo dolerite dykes, sills and saucer-shaped sheets formed. These features play a significant role on groundwater occurrences and potential.

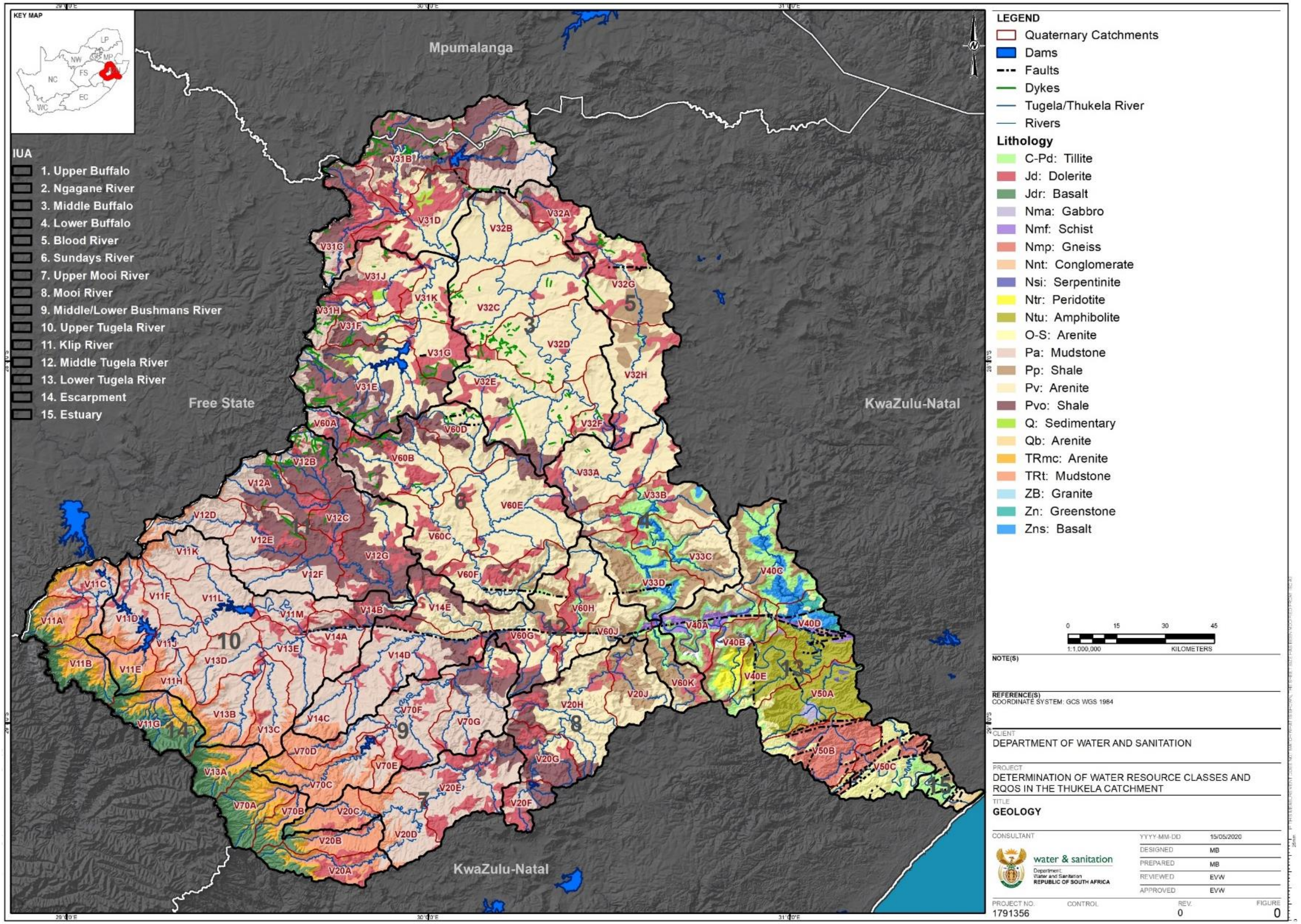


Figure 25: Geology of the Thukela catchment

5.2.2 Hydrogeology, Aquifer Types and Vulnerability

The sediments of the Karoo Supergroup and the Karoo Igneous event represent the main aquifer systems in the catchment. The rock formations are mainly of (i) a claystone/mudrock (argillaceous) and (ii) sandstone/arenite (arenaceous) nature, however, secondary features (i.e. dolerite contact zone/fault planes) play an important role on the presence to productive water bearing zones. Secondly, weathering of the shallower (~45 to 65 m) of the mudrock/sandstone horizons produce good aquifer systems given frequent replenishment of the aquifer storage volume (*viz*. annual rainfall recharge).

Aquifers within the study area include:

- 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 are as follows (not mapped on the larger scale maps):

- Dolerite Contact Zone [hard rock] aquifers present where the Karoo Dolerite intrusions occur. Due to the pre-intrusion fracturing formed by the intrusive sources, and the resulting contact metamorphism, high permeable zones develop at/along dolerite/host rock contact zones in the cases of dolerite dykes (vertical), sills (oblique/horizontal) or sheets (massive fracture systems). Although the storativity of the features are limited, the permeability allows groundwater flux over large distances (<1 km).

- 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.

The hydrogeology map of the Thukela Catchment is illustrated in Figure 26. The map shows the coloured ranges for (i) aquifer types and (ii) borehole yield class (in median $\ell \cdot s^{-1}$) (also indicated in Figure 27).

Except in the coastal area around the estuary, aquifers in the Thukela River Catchment are classified as minor aquifers, (<1.0 ℓ·s-1), 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.

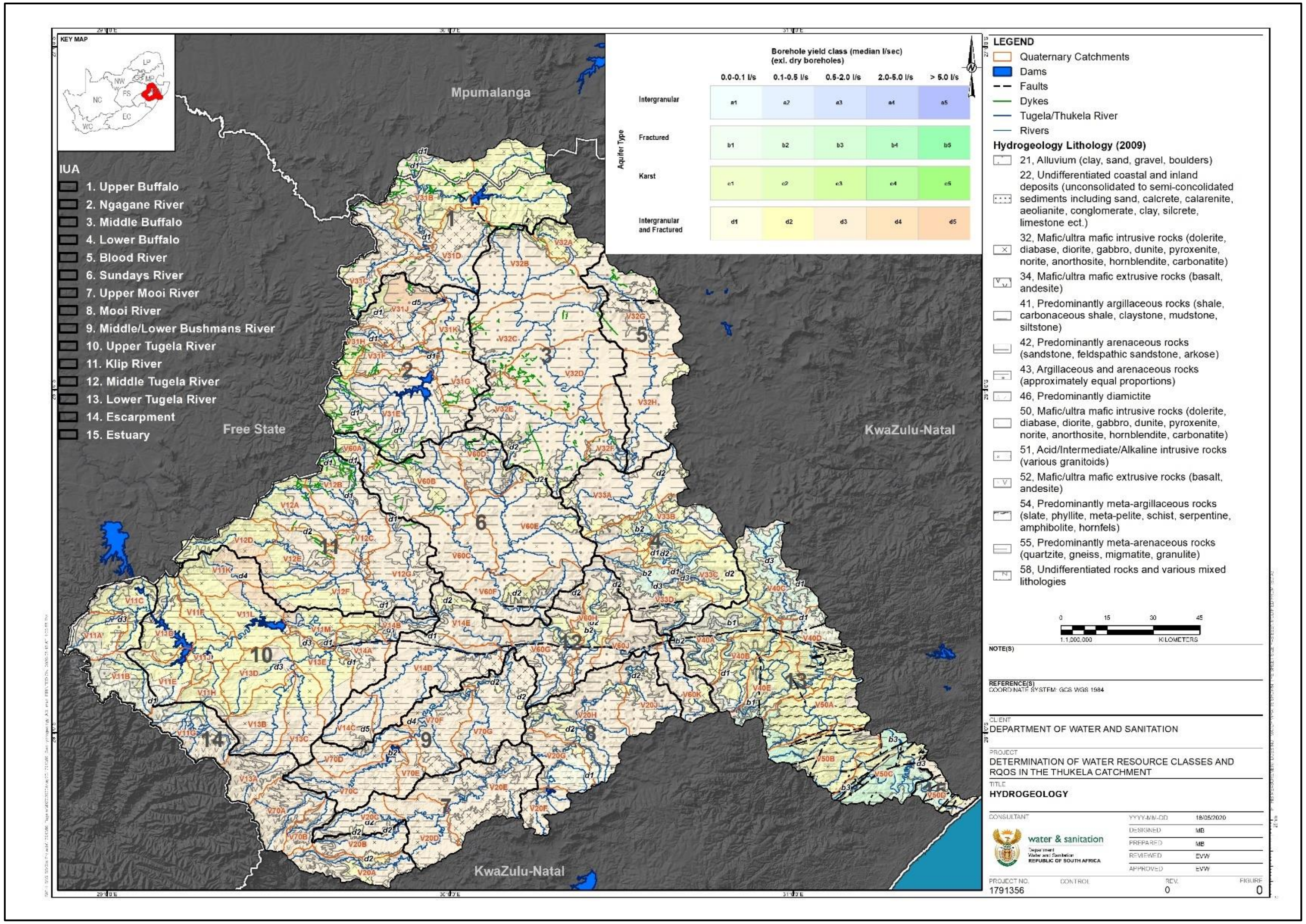


Figure 26: Hydrogeology Map of the Thukela catchment

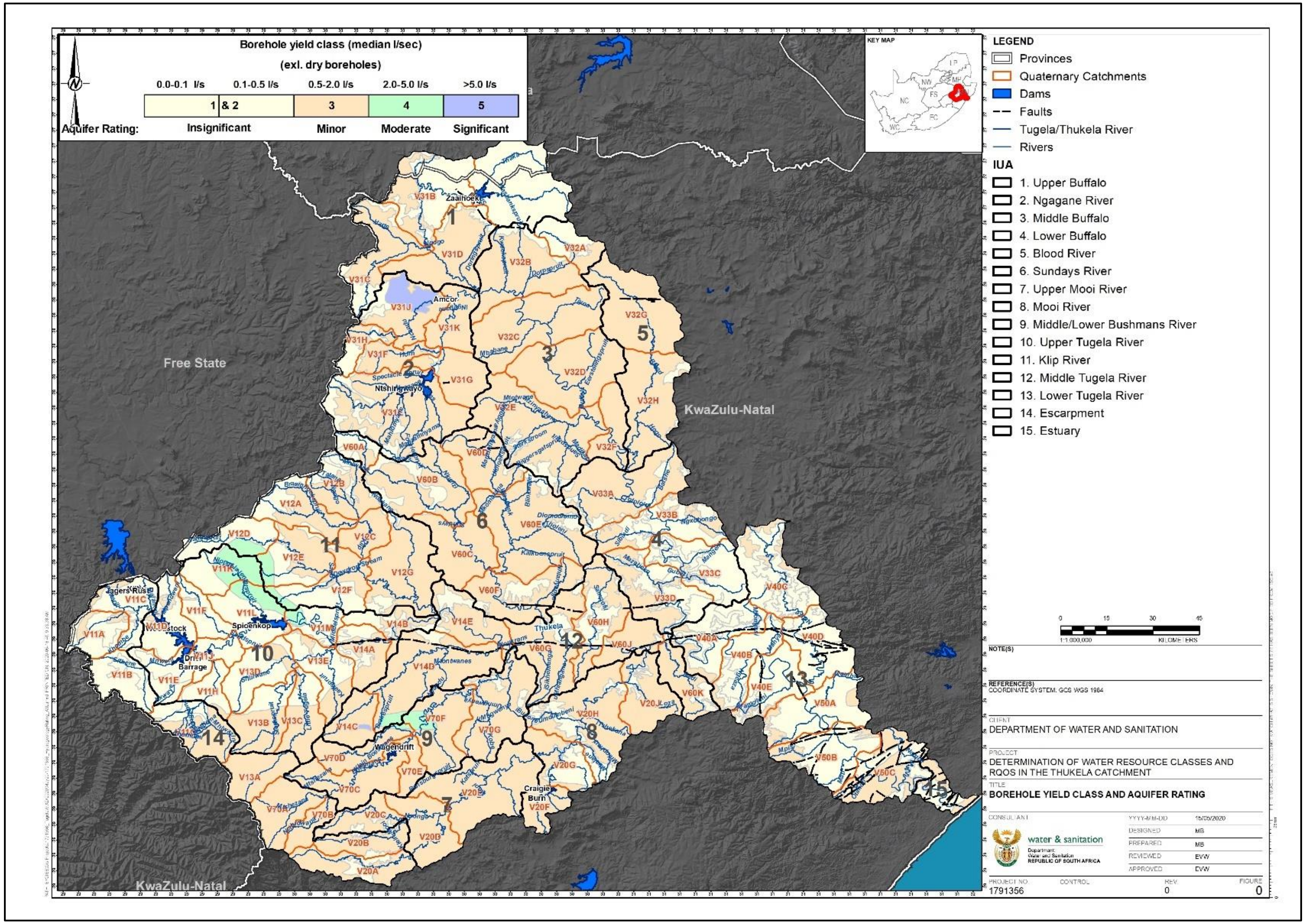


Figure 27: Borehole yield classes in the Thukela catchment

In DWAF (Dennis & Dennis (2009) it is noted that Parsons and Conrad (1998) classify the aquifers in the study area as minor aquifers. The DWAF (2009) Reserve determination study compiled an aquifer vulnerability and land use assessment based on the DRASTIC approach (based on water levels, slope of area, recharge, soil media, aquifer media and vadose zone). Aquifer vulnerability is estimated as a percentage (%) and is linked with a three-tier classification of land use (*i.e.* low-moderate-high). Each of the 23 groundwater resource units have been assessed using this approach and aquifer vulnerability varies between 38% and 66% – indicating a low to moderate vulnerability index with respect to anthropogenic impacts.

For the current study, only the water level depths (metres below ground level) and the recharge (rainfall depths) are regarded as time related variables. Both variables have not changed significantly since 2009 in the Thukela catchment. Specific quaternary catchments identified where water levels have dropped due to extraordinary abstraction and/or impacted by recent “below-average” annual precipitation. Land use remains as defined by the 2009 Reserve determination study – except those areas indicated by the KZN-Regional Office as potential “affected” areas. Land use has probably increased (significantly) due to rural residential developments, *i.e.* the distribution in the uThukela District Municipality (DWS, 2018). This development will have significant impacts on the water resource classification and resource quality objectives.

5.3 Status

The last detailed assessment of the groundwater conditions in the Thukela Catchment was undertaken in 2009 by the Institute for Groundwater Studies, University of the Free State as a groundwater Reserve determination. This study is regarded as a “High level assessment” with respect to certain attributes of the groundwater resource directed measures principle, however, poor data coverage, for example accurate borehole test pumping results, were scarce and could, therefore, not verify this study as (for example) a Comprehensive Reserve Determination level.

5.3.1 Recharge

Groundwater recharge for the “High level assessment” was based on numerous methods by the IGS research team of which the following represents the most trusted/applicable ones*, i.e*.:

- Chloride Mass Balance (as percentage of mean annual precipitation);
- Geological Recharge Estimates (recharge percentages per specific lithologies (i.e. formation type); and
- Qualified Guess (Based on land cover and soil types)

Average recharge values vary between ~15 and 45 $mm \cdot a^{-1}$, or between 1 and 6% of MAP based on the geological formations present in the catchment. The bulk (~85%) of the catchment consists of Beaufort Group (arenite and mudstone) and Ecca Group (shales, arenite, coal, and shale) with recharge figures of ~3% of MAP (~750 mm) =~25 $mm \cdot a^{-1}$.

5.3.2 Water levels

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, with one each in Klip River, Upper Thukela River, Middle Thukela River, Middle/Lower Bushmans River where there is 1, historic dataset – not relevant), and Mooi River.

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 (Figure 28).

Long-term, and post-2009 water level time series data from the catchment are illustrated in Figure 29 and Figure 30. Water level trends are of the same order/pattern as the pre-2009 period shown in Figure 28, however there is a clear water table recession that 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).

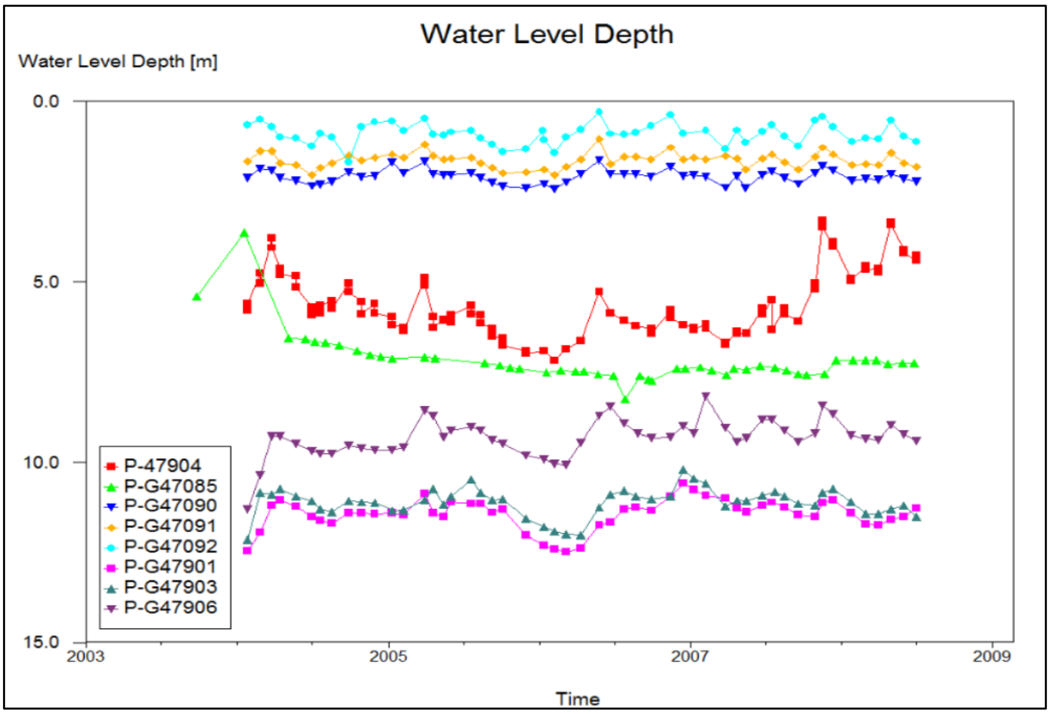


Figure 28: Pre-2009 groundwater levels (mbgl) in Thukela Catchment

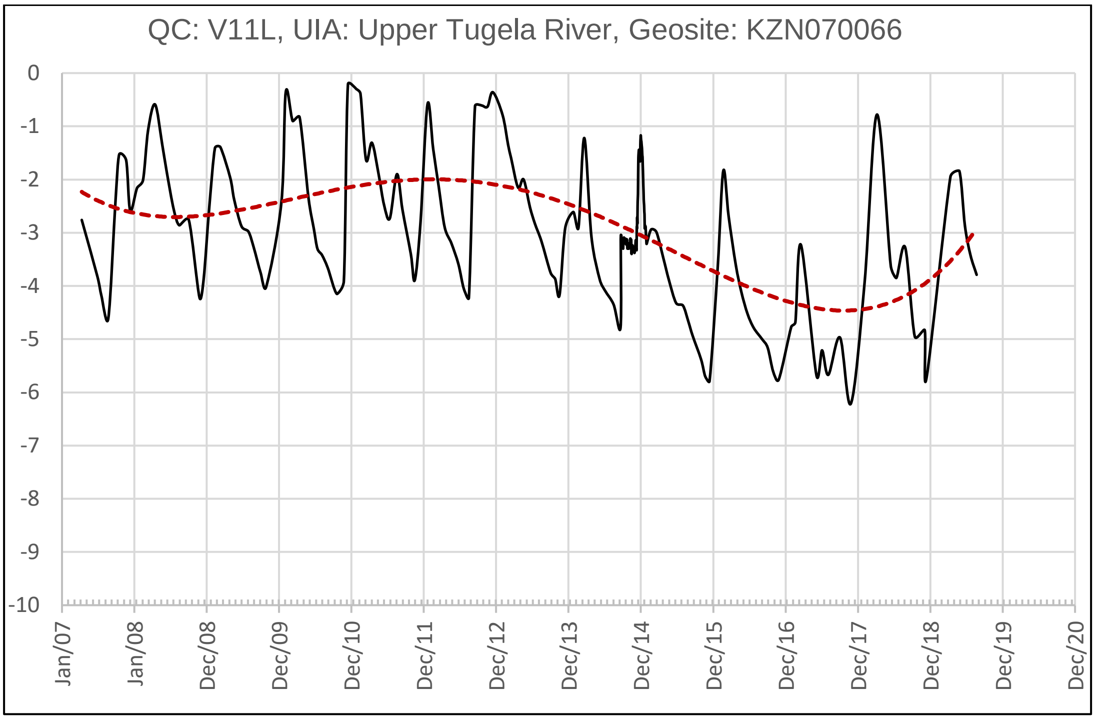


Figure 29: Groundwater levels (mbgl) in Thukela Catchment (with trend line added)

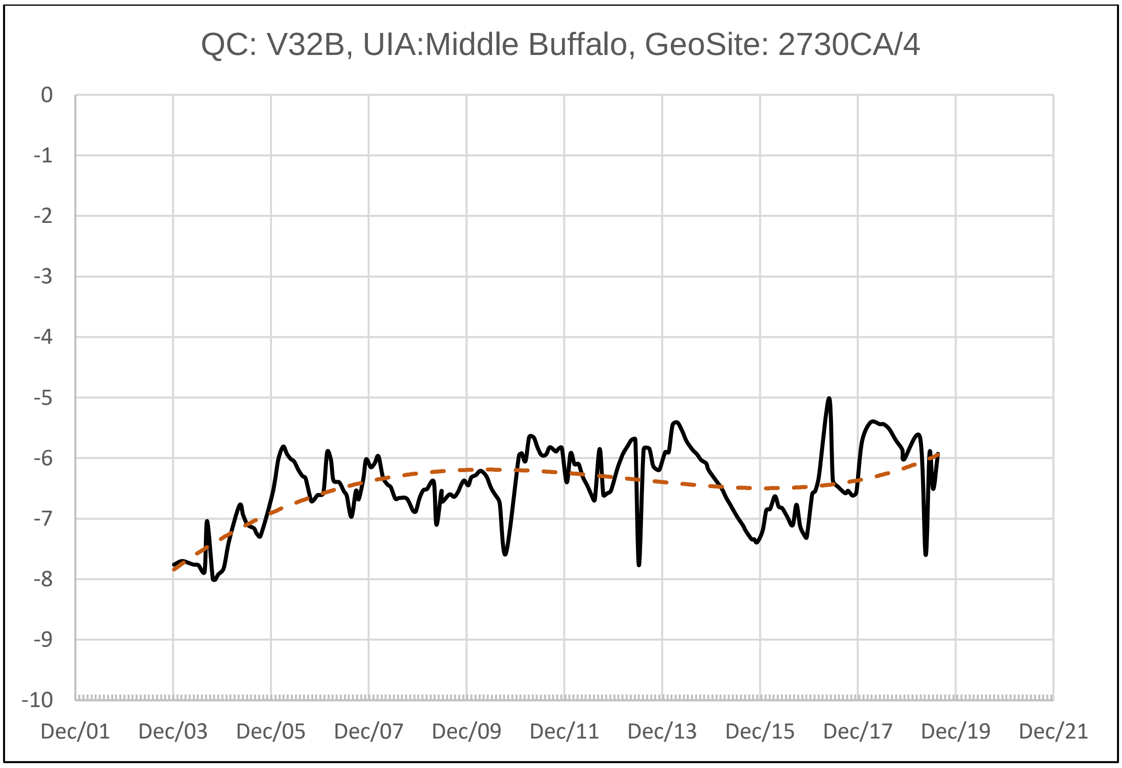


Figure 30: Groundwater level (mbgl) in Thukela Catchment (with trend line added)

5.3.3 Contribution to baseflow

Detailed study of the baseflow and groundwater component of the baseflow discharges was conducted during the 2009 groundwater Reserve determination study. In our opinion the baseflow mechanism has not changed significantly in the Thukela catchments, and the 2009 baseflow values are still regarded as applicable. Only areas where significant land use changes, i.e. wherever deforestation has occurred, will an increase in baseflow result – a land use assessment will be conducted using timeseries satellite to verify land use changes in quaternary catchments. For the long-term, the baseflow figures provided in the 2009 Reserve determination are regarded as a high-level assessment of groundwater contribution to baseflow – the Herold Method was applied, and correlated with Pitman, Hughes, and Van Tonder (DWS, 2009). A survey of the wetland areas in the catchment will be conducted and those wetlands with a clear hydraulic connection to a local groundwater source(s) will be identified. Where information on water quality and groundwater elevations are available, dependence on groundwater will be assessed as well as considering abstraction of groundwater for domestic use or other supplies. Where information on water quality and groundwater elevations are available, dependence on groundwater will be assessed as well as limited on development, i.e. abstraction of groundwater for supplies. There are many important wetlands in the Thukela catchment. They are concentrated in three areas:

- the upper Buffalo Catchment (Wakkerstroom Vlei, Groenvlei and the Blood River Vlei),
- the upper Mooi/Bushmans Catchment and
- the upper Myamvubu Catchment upstream of Craigie Burn Dam.

There are several smaller vleis in the upper catchment of the Slang River. Boschoffsvlei is near Utrecht. Well-known vleis in the upper Mooi River Catchment are the Hlatikulu, Stillerust Vlei and the Highmoor Vlei. More detail is provided in Section 6.

5.3.4 Groundwater use

Groundwater use data (WARMS data) was obtained, however, it is limited and does not appear to provide a current situation for the Thukela Catchment. The latest WARMS dataset indicates a total catchment volume of ~3.6 $Mm^3 \cdot a^{-1}$ of which 2.59 $Mm^3 \cdot a^{-1}$ was registered from 2009 onwards for groundwater abstractions (registered in WARMS) which is a fraction of the groundwater use figure presented in the 2009 assessment (433 $Mm^3 \cdot a$-1, DWAF, 2009). The latter volume, however, included areas under irrigation and plantations – done on a high-level assessment approach (DWAF, 2009). A similar approach undertaken by the 2009 groundwater Reserve team will be followed, *i.e.* using an annual factor (~5% annual increase) to increase the groundwater use figures since 2009. It is estimated that the total groundwater use (volume abstracted) will be in the order of 5.4 $Mm^3 \cdot a^{-1}$, excluding the large irrigation and plantations. Thus, the total (2020) estimation for groundwater use will be in the order of 435 $Mm^3 \cdot a^{-1}$ (with 0% increase of the plantations areas[4]).

5.3.5 Groundwater quality

The groundwater quality (in electrical conductance (EC) [at 25°C]) is illustrated in Figure 31. A large part of the catchment has groundwater with a low (0-70 $mS \cdot m^{-1}$) with a moderate (70-300 $mS \cdot m^{-1}$) in the following groundwater resource units (IUAs):

- 3 (Middle Buffalo);

[4] approach to be considered by the project study team.

- 8 (Mooi River);
- 11 (Klip River);
- 12 (Middle Thukela); and
- 13 (Lower Thukela.

Groundwater quality of a small area in the lower Mooi River sub-catchment (mainly in the centre of quaternary catchment V20H) is classified as having a high EC-value, *i.e.* >300 $mS \cdot m^{-1}$. This is probably a “hot spot” related to anthropogenic reason as no relation between the higher EC-values and geology/hydrogeology could be found – the area does not have a significant high population as well (i.e. wastewater pollution).

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 (Figure 31). The Total Dissolved Solid (TDS) content of the groundwater is generally in the range 90 to 200 mg/l, but it can exceed 500 mg/l in the lower rainfall portions of the catchment (DWAF, 2007).

The hydrochemistry characteristics of the groundwater is a $CaMg\text{-}HCO^3$ character and found in the western part of the catchment along the escarpment. These chemical characteristics are typical of younger groundwater near the recharge area. Towards the east, groundwater quality deteriorates in the direction of flow and assumes a more dominant N-Cl character.

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, it is localised. In addition to potential groundwater contamination in urban and industrial areas (from waste and sewage disposal, underground storage tanks and chemical spills.), a number of potential sources of groundwater contamination exist in the study area. These include (DWA, 2007):

- Mines (acid mine drainage and closed mine decants in the Sundays and Buffalo Catchments
- Agriculture (irrigation return flow, fertilizers and pesticides, feedlots)
- Rural communities (sanitation and informal waste sites)
- Sporadic non-compliance of effluent discharge occurs in Estcourt, Newcastle and Mandini
- Domestic discharge into Wakkerstroom Vlei
- The discharge of effluent from paper mills
- Industrial spills in the Newcastle area.

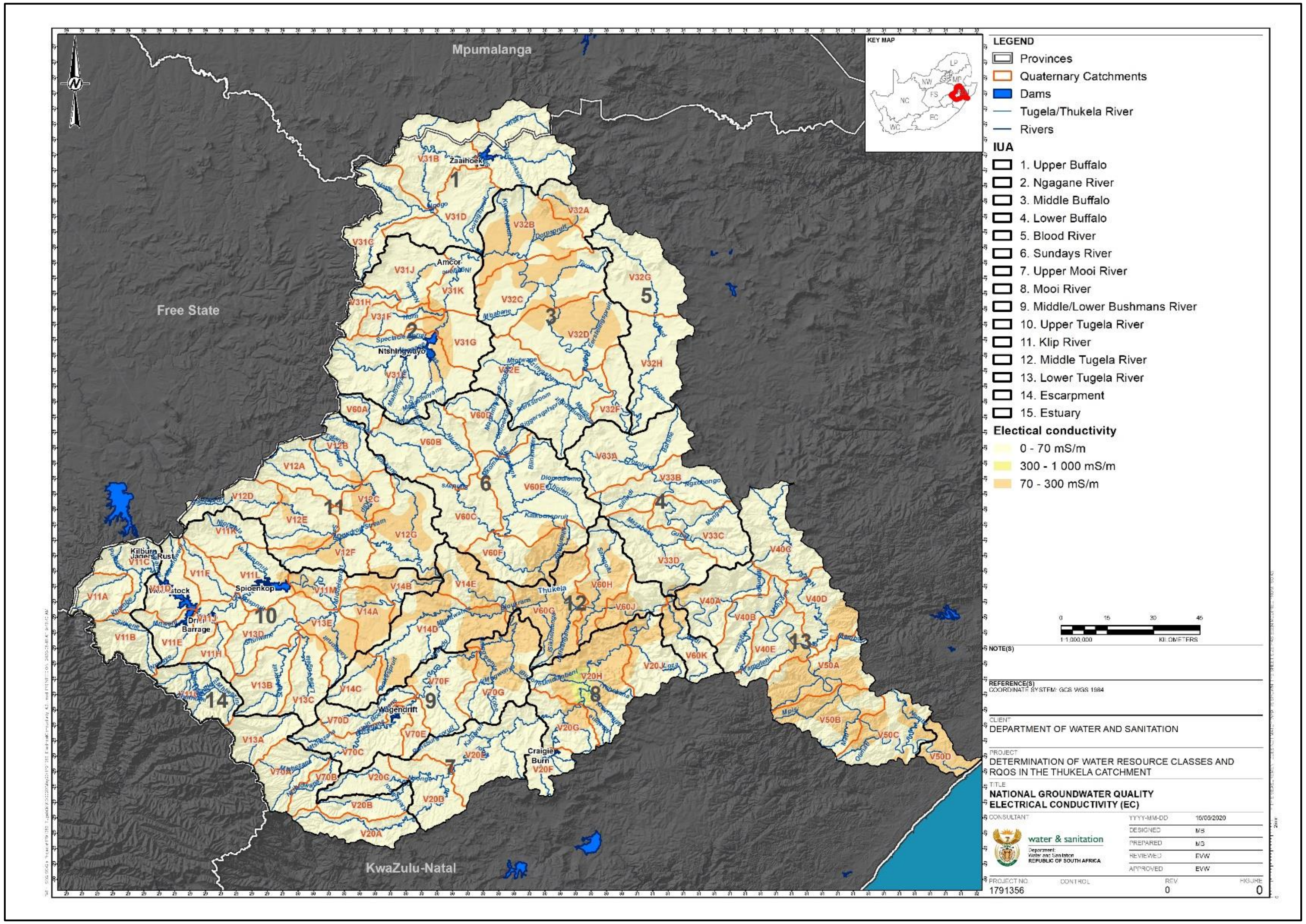


Figure 31: Groundwater quality in the Thukela Catchment

5.4 Groundwater Resource Units

5.4.1 Delineation

There are 88 quaternary catchments within the Thukela Catchment, making groundwater resource units (GRUs) delineation a complex process. The GRU delineations conducted for the 2009 groundwater Reserve determination study recognised the fact that a surface water Reserve has already been completed for the catchment. The groundwater Reserve, therefore, took these results into account, and the surface water IUAs will therefore also be taken into account when considering groundwater.

5.4.2 Previous hydrogeological delineations

The first step in the delineation process was to divide the study area into four sub-catchments, namely the Upper Thukela, Buffalo, Mooi/Sundays and Lower Thukela catchments. Each area is then divided into smaller and in most cases quaternary catchments. Other aspects taken into consideration are:

- Geology
- Climate
- Topography and geomorphology
- Recharge
- Groundwater levels and flow directions
- Groundwater quality
- Groundwater use (and stress)
- Groundwater-dependent ecosystems.

In total, 23 groundwater resource units were delineated, numbered RU A to RU Y. The characteristics of each GRU included the following attributes (much related to associated hydrological conditions of the resource units of which the groundwater recharge was probably the most important attribute of them all):

- Terrain conditions – mountainous area, and quaternary catchments);
- Recharge estimations based on:
  - Terrain lithology (geological members, i.e. arenites, shale, mudrock or dolerite capping); and
  - The National Groundwater Maps (WRC, 1995).
- Detail geology.

5.4.3 Delineation Approach and results

Due to the fact that the GRUs were delineated using a high-level approach, which in many cases fitted with the original surface water IUAs, only a few quaternary catchments were moved to fit into the most recent demarcated IUAs for the current assessment.

As mentioned above the groundwater resource units (GRUs) have been selected on a high-level assessment of hydrogeological, soil, climate and links with surface water source characteristics during DWAF 2009 study. No attempt has been made to reinterpret this approach however, some quaternary catchments have been shifted to fit the GRUs into the 2020 IUA demarcations.

5.4.3.1 Groundwater Resource Category

The 2009 groundwater reserve has stated that the groundwater resource category is “Fair” and “Good/Fair”. There are, however, cases where the resource category status could be regarded as close to the upper limits of a “Fair” classification, e.g. GRUs, which fall in the IUA 3 - Middle Buffalo, could be regarded as a ”category” due to the impacts of acid mine drainage from poorly managed coal mining.

5.4.3.2 Groundwater Reserve

The groundwater Reserve estimations (based on the 2009 Reserve determination) indicates that some IUAs becomes risky in terms groundwater Reserves (SI – stress index):

- 1 – Upper Buffalo (No risk <50% SI)
- 2 – Ngagane River (No risk <50% SI)
- 9 – Middle/Lower Bushmans (No risk <50% SI)
- 4 – Lower Buffalo River (No risk <50% SI)
- 12 – Middle Thukela River (No risk <50% SI)
- 13 - Lower Thukela River (Low risk <70% SI)
- 7 - Upper Mooi River (Low risk <70% SI)
- 8 - Mooi River (Low risk <70% SI)
- 14 – Escarpment (Low risk <70% SI)
- 5 - Blood River (Low risk <70% SI)
- 10 - Upper Thukela River-R (Low risk <70% SI)
- 6 - Sundays River (Medium risk 70-80% SI)
- 7 - Upper Mooi River (High risk >80% SI)
- 11 - Klip River (High risk >80% SI)
- 10 - Upper Thukela River (High risk >80% SI)
- 10 - Upper Thukela River (High risk >80% SI)
- 10 - Upper Thukela River (High risk >80% SI)
- 3 - Middle Buffalo River (High risk >80% SI)

These risks are based on the groundwater stress indices transferred from the 2009 GRU estimations. Due to the higher groundwater use in some quaternary catchments, these SI-factors may increase, *i.e*. some of the “Low risk” categories could change to Medium Risk categories. The following quaternary catchments are regarded as “Highly Stressed” (in terms of groundwater use and impacting on the Reserve):

- V11M, V13E and V14A 10 - Upper Thukela River;
- V50D 13 - Lower Thukela River; and
- V32B, V32C, V32D, V32E and V32F 3 - Middle Buffalo River.

5.4.3.3 Localised pollution

Groundwater resources in Middle Buffalo are at risk due to acid rock drainages from coal mines in the area.

5.4.3.4 Stress Index/Hotspots

Stress indices varies between 22% and 97% for the Thukela catchment. These figures are based on the 2009 study. As noted in section 5.3.4, the groundwater use (domestic and irrigation has increased) since the 2009 assessment – thus the Stress Index will increase concurrently by ~2-5%.

Hotspots in terms of groundwater use is developing in Upper Thukela and Middle Buffalo due to groundwater use and groundwater quality deterioration.

Details of the groundwater stress indices are listed in the individual IUA discussions in Section 9.

5.4.3.5 Contribution to baseflow (as applicable)

As noted above, the 2009 groundwater Reserve determination contains a high-level groundwater baseflow assessment based on the Herold Methodology. The baseflow figures can therefore be regarded as applicable for prevailing climate conditions. Based on the long-term groundwater level trends, (see section 2 above - 5.3.2), groundwater levels [as an indicator of groundwater replenishment] has recovered from what seems to be a drier period between the 2011-2012 and 2015-2016 hydrological cycles. These conditions would impact on the baseflow; however, the groundwater levels show a recovery from the drier period and baseflow will recover to the long-term estimates *e.g.* as determined by the DWAF, 2009 study.

6 STATUS QUO WETLANDS

6.1 Overview

Use was made of the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland layer (Nel *et al*., 2011) to identify and map the significant wetland resources in the Thukela catchment. The resulting map of the wetlands was used during the IUA workshop to support the IUA delineations. An indication of preliminary Priority Wetlands per IUA is provided in Figure 32 with a summary of the extent of wetlands per type, and a list of the preliminary Priority Wetlands per IUA, indicated in Table 30. This preliminary Priority Wetland list was supported by information gathered from Begg (1989) and www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa. The list of Preliminary Priority Wetlands may be updated as more information on the wetlands within each IUA is collected during the course of the study.

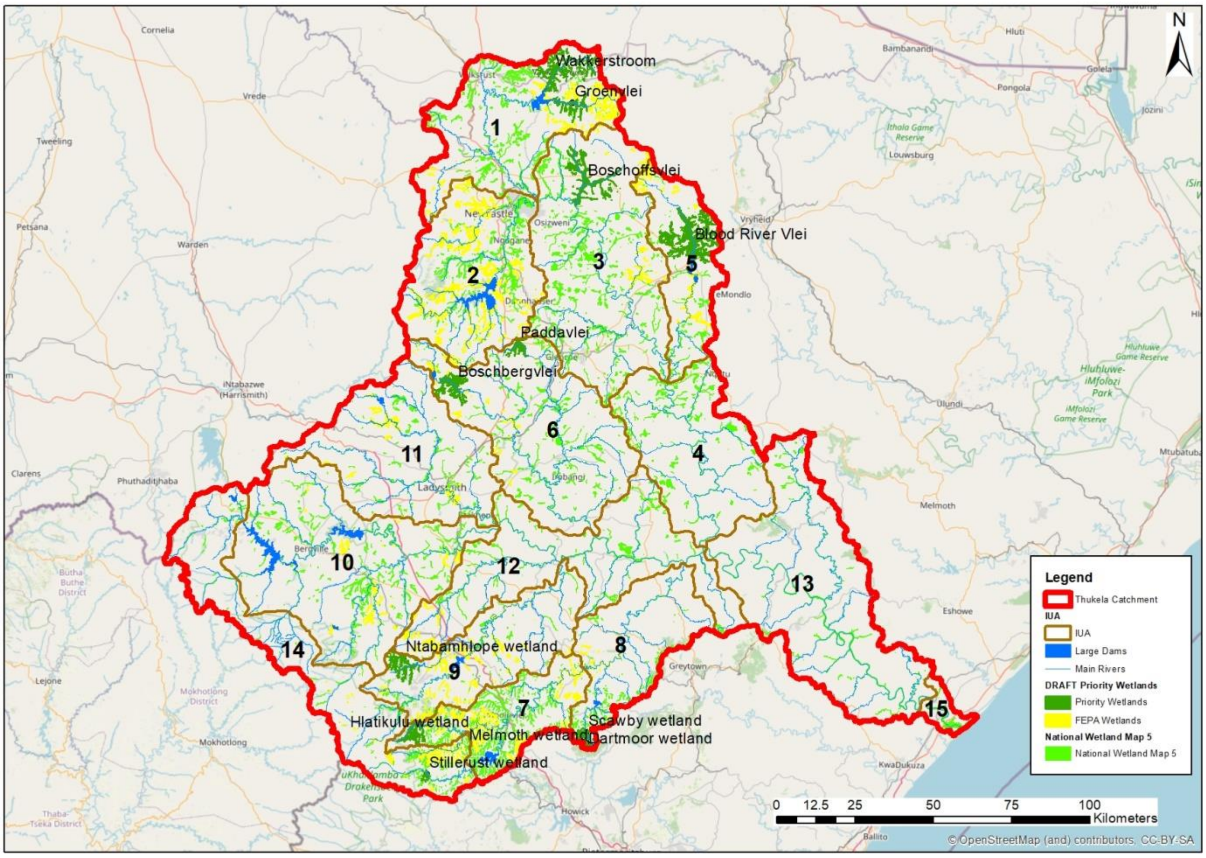


Figure 32: Map showing the extent of wetlands mapped per IUA and the location of the preliminary Priority Wetlands (compiled from GIS coverage of Van Deventer *et al*., 2018 and Nel *et al*., 2011)

Table 30: Wetland extent (area) and percentage of area per IUA for Depressions, Floodplains, Seeps, and Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al*., 2018 and Nel et al., 2011 with River systems removed from the GIS coverage). Also indicated is a preliminary list of Priority Wetlands per IUA verified from Begg, 1989 and www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa.

Catchment (IUA)	Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchannelled VB		Preliminary List of Priority Wetlands
				ha	%	ha	%	ha	%	ha	%	ha	%	
Upper Buffalo (1)	198465	16 723	8.4%	155	0.9%	862	5.2%	9 947	59.5%	3 326	19.9%	2 433	14.5%	Wakkerstroom and Groenvlei
Ngagane (2)	195658	20 665	10.6%	113	0.5%	2 333	11.3 %	11 620	56.2%	2 226	10.8%	4 373	21.2%	
Middle Buffalo (3)	295660	17 383	5.9%	526	3.0%	0	0.0%	11 245	64.7%	3 050	17.5%	2 563	14.7%	Boschoffsvlei
Lower Buffalo (4)	183601	6 181	3.4%	28	0.5%	0	0.0%	5 216	84.4%	190	3.1%	746	12.1%	
Blood River (5)	105978	13 110	12.4%	51	0.4%	137	1.0%	2 897	22.1%	9 473	72.3%	553	4.2%	Blood River Vlei
Sundays River (6)	248088	10 643	4.3%	2 483	23.3 %	207	1.9%	6 254	58.8%	587	5.5%	1 111	10.4%	Paddavlei, Boschberg Vlei
Upper Mooi (7)	137362	17 326	12.6%	17	0.1%	821	4.7%	4 773	27.5%	9 276	53.5%	2 438	14.1%	Hlatikulu
Mooi (8)	132507	3 217	2.4%	2	0.1%	1	0.0%	1 371	42.6%	729	22.7%	1 115	34.7%	Headwaters of the Mnyamvubu River including the Melmoth, Dartmoor and Scawby wetlands
Middle/Lower Bushmans (9)	154983	6 813	4.4%	33	0.5%	10	0.1%	5 047	74.1%	983	14.4%	740	10.9%	Ntabamhlope
Klip River (10)	349159	10 534	3.0%	39	0.4%	9	0.1%	8 895	84.4%	340	3.2%	1 251	11.9%	
Upper Thukela (11)	215393	6 473	3.0%	36	0.6%	641	9.9%	3 730	57.6%	176	2.7%	1 890	29.2%	
Middle Thukela (12)	234469	5 719	2.4%	13	0.2%	0	0.0%	4 892	85.5%	162	2.8%	653	11.4%	
Lower Thukela (13)	295293	1 014	0.3%	6	0.6%	0	0.0%	868	85.6%	104	10.2%	36	3.6%	
Escarpment (14)	141624	1 469	1.0%	0	0.0%	225	15.3 %	822	55.9%	357	24.3%	66	4.5%	Many headwater wetlands including the Natal Drakensberg Park Ramsar Site and Stillerust being one of the larger wetlands in the Ramsar Site
Thukela Estuary (15)	14700	152	1.0%	1	0.7%	11	7.3%	140	92.0%	0	0.0%	0	0.0%	
	2902943	**137 421**	**4.7%**	**3 503**	**2.5%**	**5 257**	**3.8%**	**77 715**	**56.6%**	**30 979**	**22.5%**	**19 968**	**14.5%**	

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 (see www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa) which includes the Stillerust wetland comprising parts of the escarpment region. Based on the data from the GIS layer comprising the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland layer (Nel *et al*., 2011), for five IUAs wetlands comprise more than five percent of the IUA area (IUAs 1, 2, 3 5 and 7). Of these only IUA 2 does not have any Priority Wetlands identified at this stage.

The IUAs with the largest percentage of wetland area are Upper Mooi and Blood River at approximately 12.6% and 12.4% respectively. Blood River Vlei makes up the bulk of the wetland area in the Blood River catchment. Hlatikulu is a Priority Wetland in the headwaters of the Nsonge River in the Upper Mooi catchment. While Ngagane catchment has the third highest percentage wetland area (at approximately 10.6%), no Priority Wetlands have been identified in this area to date despite a number of wetland systems occurring along the headwater tributaries of the Ngagane River. This is followed by Upper Buffalo catchment with a wetland area comprising approximately 8.4% of the IUA. The Wakkerstroom wetland and Groenvlei have been identified as Priority Wetlands in this IUA. The Middle Buffalo, IUA 3, has the fifth largest percentage wetland area (5.9%). One Priority Wetland has been identified in this IUA, being Boschoffsvlei. In IUA 6 and IUA 9 wetlands comprise around 4.3% of the IUA area with Paddavlei and Boschberg Vlei being Priority Wetlands in IUA 6 and Ntabamhlope being a Priority Wetland in IUA 9. While IUA’s 14 and 8 have smaller percentages of wetland area (approximately 1.0% and 2.4% respectively) compared to the IUAs discussed above, IUA 14 includes the Natal Drakensberg Park Ramsar site (which also includes Stillerust wetland), while IUA 8 includes three Priority Wetlands associated with the headwaters of the Mnyamvubu River, being the Melmoth, Dartmoor and Scawby wetlands.

6.2 General Description of Wetlands

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland attribute data (Nel *et al*., 2011), five different hydro-geomorphic (HGM) wetland types have been described as occurring in the Thukela catchment. These include:

- Seeps;
- Depressions;
- Floodplains;
- Channelled Valley Bottom systems; and
- Unchannelled Valley Bottom systems.

Typically Seep wetlands were found to be the most extensive wetland type within the Thukela Catchment, making up 56.6% of the total wetland habitat mapped (Table 30), and varying from as low as 26.1% of wetlands in the Blood River catchment to almost 86% of wetlands in the Middle and Lower Thukela. Channelled Valley Bottom wetlands make up the second most extensive wetland type at 22.5% of wetland area, followed by Unchannelled Valley Bottom wetlands (14.5%), Floodplain wetlands (3.8%) and Depression wetlands, which make up only 2.5% of wetland area within the Thukela Catchment.

The wetlands within the Thukela Catchment occur across 5 different Bioregions: Drakensberg Grassland (along the western watershed); Mesic Highveld Grassland (along the northern watershed); Sub-Escarpment Grassland (upper central portions of the Catchment); Sub-Escarpment Savanna (lower central portions of the Catchment); and the Indian Ocean Coastal Belt Bioregions. The bulk of wetland habitat identified by the National Wetland Map 5 (Van Deventer *et al.,* 2018) occurs within the Sub-Escarpment Grassland Bioregion, with approximately 75% of wetland habitat falling within this Bioregion. Extensive wetland habitat also occurs within the Mesic Highveld Grassland Bioregion 17.4%, while 5.4% of wetland habitat falls within the Sub-Escarpment Savanna Bioregion.

6.3 General Conditions of Wetlands

Use was made of the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland attribute data (Nel *et al*., 2011) to provide a general description of the condition of the wetlands in each of the catchments. A summary of wetland condition per sub-catchment is provided in Table 31. It is important to point out that as there is limited to no recent field verification of the ecological categorisation of most the wetland systems in the Thukela catchment, the general description of the condition of the wetlands taken from the datasets above may not be an accurate representation of the actual current ecological state of the wetlands. It should thus be seen as indicative and only provides a broad-scale perspective of the likely condition of the wetland systems in each sub-catchment. In addition, the grouping of wetland HGM units used to derive the condition estimates is likely to over-simplify the ecological state indicated for a particular wetland complex.

From the National Wetland Map 5 (Van Deventer *et al*., 2018) dataset it is clear 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), as detailed in Table 31. 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). Contrasting with these results are the findings of the wetland condition assessment results included as part of the NFEPA wetland layer (Nel *et al*., 2011), which classified 50.4% of the natural wetland area mapped within the Thukela Catchment as Natural to Largely Natural (wetland condition category A/B), 42.9% as Moderately Modified (wetland condition category C) and only 6.8% as Largely to Critically Modified (wetland condition category D/E/F and Z1, Z2 and Z3). Although it could be assumed that the change in wetland condition between the NFEPA dataset from 2011 and the National Wetland Map 5 from 2018 reflects on the ground changes within the wetland systems assessed, it is more likely that such a significant shift in wetland condition results between the two projects is related to changes in the assessment methodology. It is apparent that some uncertainty exists in relation to the condition of wetlands within the Thukela Catchment and that further work is required to get a more accurate assessment thereof. It is unclear at this stage which of the scenarios presented more accurately reflects actual wetland conditions within the Thukela Catchment. However, for the purpose of this report, the wetland condition as presented by the more recent National Wetland Map 5 (Van Deventer *et al*., 2018) has been selected to inform the assessment of wetland condition per sub-catchment.

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 (Table 31). The Middle Buffalo sub-catchment with the second most extensive (2 100 ha) Natural to Largely Natural wetlands was determined to be (which includes the Boshoffsvlei Priority Wetland) at 12.1%. The Thukela Estuary sub-catchment which includes the reach of the Thukela River in V50D with the highest percentage of wetlands within the Natural to Largely Natural category where 36.4% of wetlands fall within this category, though this totals only 55 ha of wetland habitat. The lowest percentage (3.7%) of Natural to Largely Natural wetlands was found to occur in Blood River sub-catchment (which includes the Blood River Vlei Priority Wetland).

From Table 31 it can be seen that the IUA with the greatest extent (17 762 ha) of Largely to Critically Modified (D/E/F) wetlands is the Ngagane River Catchment, where 86% of wetland area was classified as such. The Blood River catchment, which includes the Blood River Vlei Priority Wetland and has the second highest percentage wetland area of the Thukela Catchment, has the second largest extent of Largely to Critically Modified wetlands with 11 341 ha, or 86.5% of wetlands, falling within this category. The lowest percentage (54.7%) of Largely to Critically Modified wetlands was found within the Sundays River catchment.

Table 31: Wetland condition summary per IUA for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018 and Nel *et al.,* 2011).

Sub-Catchment	Area (ha)	Extent of wetlands (ha) in IUA	Wetland Condition A/B		Wetland Condition C		Wetland Condition D/E/F	
			ha	%	ha	%	ha	%
Upper Buffalo	198465	16 723	2 630	15.7	4 018	24.0	10 079	60.3
Ngagane	195658	20 665	1 129	5.5	1 777	8.6	17 762	86.0
Middle Buffalo	295660	17 383	2 100	12.1	2 441	14.0	12 849	73.9
Lower Buffalo	183601	6 181	678	11.0	1 004	16.2	4 503	72.9
Blood River	105978	13 110	487	3.7	1 289	9.8	11 341	86.5
Sundays River	248088	10 643	822	7.7	3 997	37.6	5 826	54.7
Upper Mooi	137362	17 326	949	5.5	2 309	13.3	10 207	58.9
Mooi	132507	3 217	305	9.5	732	22.8	2 182	67.8
Middle/Lower Bushmans	154983	6 813	560	8.2	1 196	17.6	4 716	69.2
Klip River	349159	10 534	705	6.7	2 300	21.8	7 262	68.9
Upper Thukela	215393	6 473	638	9.9	1 497	23.1	4 339	67.0
Middle Thukela	234469	5 719	336	5.9	773	13.5	4 612	80.6
Lower Thukela	295293	1 014	71	7.0	158	15.6	785	77.5
Escarpment	141624	1 469	629	42.8	493	33.6	4 820	328.0
Thukela Estuary	14700	152	55	36.4	0	0.0	97	63.8
	2 902 943	**137 421**	**12 095**	**8.8**	**23 985**	**17.5**	**101 379**	**73.8**

7 STATUS QUO 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. The water quality planning limits used for the assessment (Table 32) were derived using the Resource Water Quality Objectives (RWQOs) Model (Version 4.0) (DWAF, 2006) which uses as its basis the South African Water Quality Guidelines (DWAF, 1996), Quality of Domestic Water Supplies: Assessment Guide, Volume 1 (WRC, 1998) and Methods for determining the Water Quality Component of the Reserve (DWAF, 2008) and are based on the strictest water user criteria (thus represent fairly conservative limits). With respect to ionised ammonia, the General and Special Standard Effluent limit was applied due to the absence of an available water quality limit value.

Table 32: Water quality criteria used to assess the present water quality status

Variable	Units	Bound	Ideal	Acceptable	Tolerable	Unacceptable
Calcium	mg/l	Upper	10	80	80	>80
Chloride (Cl)	mg/l	Upper	40	120	175	>175
DMS (TDS)	mg/l	Upper	200	350	800	>800
EC	mS/m	Upper	30	50	85	>85
Fluoride	mg/l	Upper	0.7	1	1.5	>1.5
K (potassium)	mg/l	Upper	25	50	100	>100
Magnesium (Mg)	mg/l	Upper	70	100	100	>100
Sodium (Na)	mg/l	Upper	70	92.5	115	<115
Ionised Ammonia (NH4-N)	mg/l	Upper	2.0	2.5		>3.0
NO3 (NO3-N)	mg/l	Upper	6	10	20	>20
pH	units	Upper	≤8	≤8.4	≤8.4	
		Lower	≥6.5	≥6.5	≥6.5	
PO4-P	mg/l	Upper	0.025	0.075	0.125	>0.125
SO4	mg/l	Upper	80	165	250	>250

The fitness for use is described using four water quality categories: Ideal (blue), Acceptable (green), Tolerable (yellow), and Unacceptable (red) for concentrations greater than the upper boundary of the Tolerable range. The more blue and green colours that are visible in the compliance tables, the better the water quality. The more yellow or red observed, the poorer the water quality.

7.1 Data sources

The Department's Resource Quality Information Services (RQIS) water quality database, the Water Management System (WMS) has been used as the primary source of the water quality data for the analysis. In terms of water quality data assessment, the water quality monitoring stations and related information are largely concentrated on main stem rivers and tributaries. Data gaps exist for the smaller tributary catchments which have been identified as high PES and ecological importance and sensitivity.

Historical data for water quality monitoring points in the study area were obtained from the National Chemical Monitoring Programme (NCMP) on WMS for the period 2008 to 2019. The monitoring points within the Thukela Catchment are primarily located on the main stem Thukela River and the major tributaries (Bushmans, Buffalo, Mooi and Sundays rivers). 196 registered points on the WMS have been monitored since 2000, however the frequency and extent of monitoring varies considerably. The routine DWS river and reservoir water quality monitoring points for the study area are listed in Appendix A and their locations are shown in Figure 34. Microbiological assessment (*E.coli*) was not undertaken due the unavailability of data for the Thukela catchment on the National Microbial Monitoring Programme (NMMP) database of DWS.

The WMS database primarily includes monitoring data for Electrical Conductivity, Total Dissolved Salts (TDS), pH, Sodium, Magnesium, Calcium, Hardness, Potassium, Fluoride, Chloride, Sulphate, Phosphate as P, Total Alkalinity as $CaCO_3$, Ammonium as N, Nitrate + Nitrite as N, Chemical Oxygen Demand, *Escherichia coli*. No trace metal or organic analysis is performed as part of this routine monitoring. Total suspended solids and turbidity are also not monitored. For the purposes of this study, the certain indicator variables have been used to assess status quo. No *E.coli* data was available on the DWS database to assess status.

Water quality monitoring data is lacking/ for the following quaternary catchments:

- V31A – Headwaters Slang River
- V32A – Upper Dorpspruit
- V32G – Upper Blood River
- V33C; V33D – Lower Buffalo and tributaries
- V60A – Headwaters of the Sundays river; V60F Lower Sundays and tributaries
- V20G; V20J – Mooi River and associated tributaries begore confluence with Thukela
- V70G – Lower Bushmans River before confluence with Thukela
- V11A; V11G; V11B; V11K – Headwaters of Thukela and associated mountain tributaries
- V13A – Headwaters of Little Thukela and tributaries V13B - Sterkspruit; V13E - Kaalspruit
- V12A; V12B; V12C; V12D; V12E - Upper Klip River catchment
- V14C – Upper Bloukrans and V14E – Thukela River below Klip River confluence
- V60H; V60K – Sampofu and Nadi – tributaries of Middle Thukela River
- V40A; V40B; V40C; V40D – tributaries of lower Thukela River
- V50B; V50C – Lower Thukela River upstream estuary

7.2 Compliance Assessment

The water quality compliance assessment has been based on the routine monitoring data collected by the DWS over the past 10 years. Water quality status at monitored points for the period 2008 to 2019 was assessed by categorising the current water quality state using the fitness for use criteria (Table 32). For the sampling points listed in Appendix A, the 50th percentile (median), 5th and 95th percentile statistics were calculated and assessed against the criteria to determine compliance. Percentiles are descriptive statistics. The median statistic is representative of average water quality conditions, the 5th percentile statistic means that 5 percent of the concentrations were lower or equal to the statistic, and the 95th percentile represents the high concentrations observed at the sampling point.

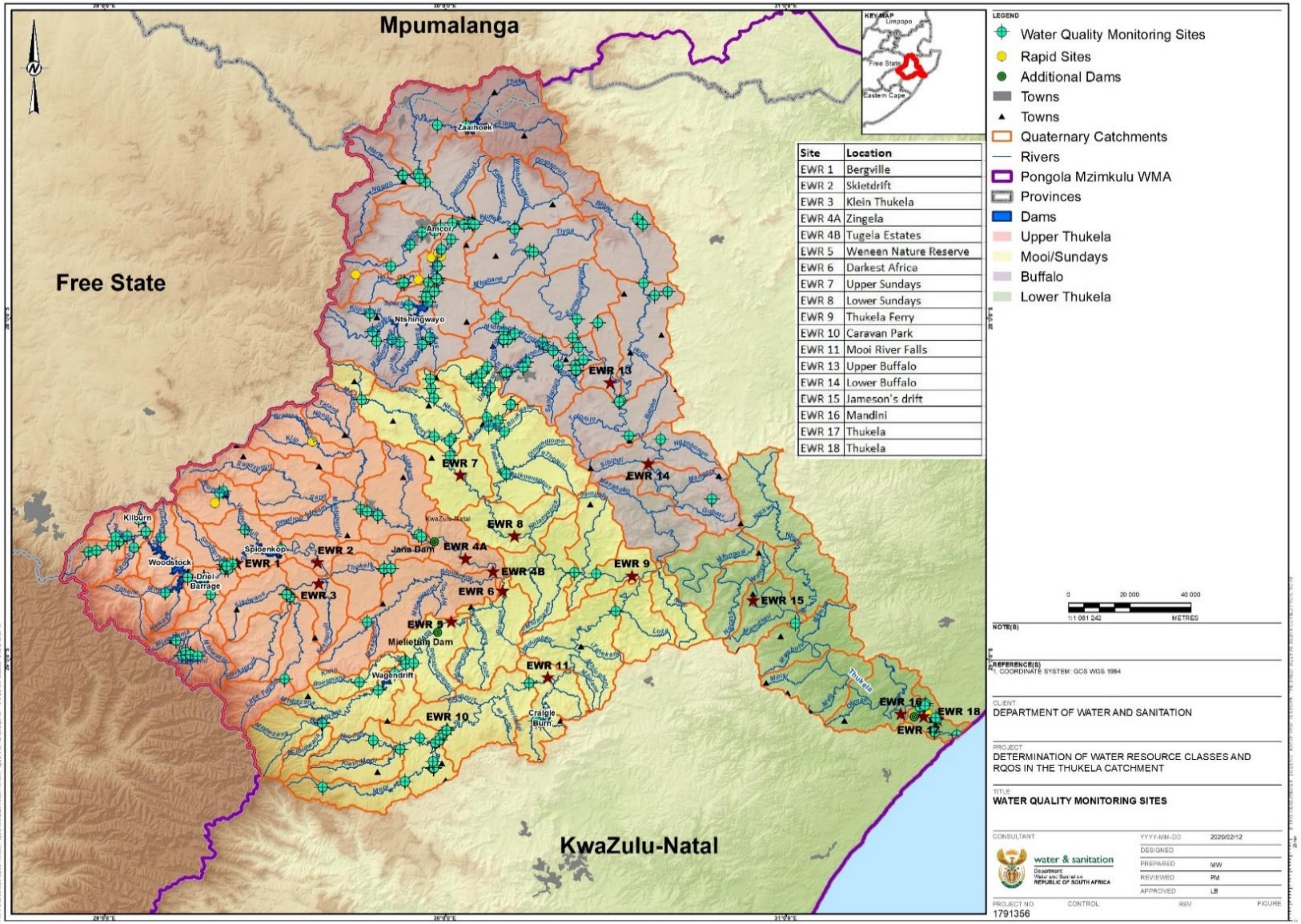


Figure 33: Location of water quality monitoring sites in the Thukela catchment

The suite of water quality variables assessed serve as indicators of salinity, nutrient enrichment (eutrophication), agricultural impacts, aquatic toxicity, as well as natural variability of the water resources, the key water quality issues of relevance.

The variables assessed included:

- Physico-chemical:
    - pH, Total Dissolved Salts/ Solids (TDS), Electrical Conductivity (EC)
- Major Ions:
    - Calcium (Ca), Magnesium (Mg), Sodium (Na), Fluoride (F), Sulphate (SO_4) and Chloride (Cl)
- Nutrients
    - Ortho-phosphate (PO_4), Nitrate as N (NO_3-N) and Ionised Ammonia as N (NH_4-N)

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. In some sub-catchments such as the Lower Thukela and Bushman's River, very little monitoring occurs. Microbiological data for recent years is lacking. The water quality status of some catchment areas is thus represented by the analysis of data at a minimum of one monitoring site while others up to 25 sites. This variation may thus skew the perspective of the water quality situation dependent on the location of the monitoring site relative to the area of impacts (specifically were only one or two sites are present at a secondary catchment).

7.3 Overview Status

Water user requirements and water quality impacts need to be understood. A number of localised water quality issues around the towns, industrial areas, mining and related to agricultural practices are highlighted. This is key to understanding the extent of impacted areas with respect to driving ecological condition, identification of hotspots and to the development of RQOs and numerical limits in the Thukela catchment. Lack of recent monitoring information and/or infrequent monitoring has impacted on the assessment in some sub-catchments, while in other sub-catchment areas the lack of any baseline water quality monitoring data is a gap.

An overview water quality assessment of the Thukela Catchment is provided here, with more detail per delineated IUA provided in Section 9. The summary of the water quality compliance observed per secondary catchment with respect to the number of monitoring sites assessed is provided in Table 33. The 95th percentile compliance value is presented for pH, TDS, EC, Ca, Mg, Na, F, SO_4, Cl and ionised ammonia; and the 50th percentile compliance value for nitrate and orthophosphate, per site. The identified water quality issues that are of concern within the Thukela catchment are discussed.

The assessment indicates that overall, the water quality of the Thukela Catchment is relatively good with localised areas of impact related to land use. The key issues of concern are related to salinity and nutrient impacts prevalent in all secondary catchments, indicated by the non-compliance to the electrical conductivity, orthophosphate criteria and ionised ammonia.

Table 33: Summary of water quality compliance to the water quality criteria per secondary catchment for the monitoring sites assessed

Sub-catchment	Calcium (mg/l)				Chloride (mg/l)				Total Dissolved Salts (mg/l)			
	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable
V1 - Upper Tugela	55%	40%		5%	95%			5%		88%	6%	6%
V2 - Mooi River	80%	20%			100%				86%	7%	7%	
V3 - Buffalo River	17%	67%		15%	83%	13%	4%		25%	28%	30%	18%
V4/V5 - Lower Tugela		100%			100%					100%		
V6 - Sundays River	5%	71%		24%	71%	14%		14%	5%	30%	15%	50%
V7 - Bushmans River	80%	20%			100%				80%	20%		

Sub-catchment	Electrical Conductivity (mS/m)				Flouride (mg/l)				Magnesium (mg/l)			
	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable
V1 - Upper Tugela	36%	9%	40%	15%	100%				95%			5%
V2 - Mooi River	85%	5%	5%	5%	100%				100%			
V3 - Buffalo River	19%	8%	46%	27%	60%	29%	5%	7%	86%	10%	4%	
V4/V5 - Lower Tugela	8%	8%	17%	67%	100%				100%			
V6 - Sundays River	3%	24%	17%	55%	60%	10%	15%	15%	67%	14%		19%
V7 - Bushmans River	63%	25%		13%	80%	20%			100%			

Criteria	Calcium (mg/l)	Chloride (mg/l)	Total Dissolved Salts (mg/l)	Electrical Conductivity (mS/m)	Flouride (mg/l)	Magnesium (mg/l)
Ideal	10	40	200	30	0.7	70
Acceptable	80	120	350	50	1	100
Tolerable	80	175	800	85	1.5	100
Unacceptable	>80	>175	>800	>85	>1.5	>100

Sub-catchment	Sodium (mg/l)				Ionised Ammonia (mg/l)				Nitrate (mg/l)			
	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable
V1 - Upper Tugela	100%				54%	11%	7%	28%	100%			
V2 - Mooi River	100%				90%	5%		5%	100%			
V3 - Buffalo River	7%	57%	15%	20%	62%	7%	1%	30%	92%	5%	3%	
V4/V5 - Lower Tugela	100%						86%	14%	92%		8%	
V6 - Sundays River	42%	4%		54%	85%			15%	100%			
V7 - Bushmans River	100%				63%		13%	25%	100%			

Sub-catchment	pH				Orthophospate (mg/l)				Sulphate (mg/l)			
	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable	Ideal	Acceptable	Tolerable	Unacceptable
V1 - Upper Tugela	47%	34%		19%	40%	2%	15%	43%	100%			
V2 - Mooi River	36%	41%		23%	91%			9%	100%			
V3 - Buffalo River	40%	28%		33%	24%	28%	11%	36%	37%	33%	9%	20%
V4/V5 - Lower Tugela	42%	33%		25%	8%		25%	67%	100%			
V6 - Sundays River	7%	28%		66%	55%	24%	3%	17%	30%	30%	10%	30%
V7 - Bushmans River	62%	38%			50%		25%	25%	100%			

Criteria	Sodium (mg/l)	Ionised Ammonia (mg/l)	Nitrate (mg/l)	pH	Orthophospate (mg/l)	Sulphate (mg/l)
Ideal	70	0.015	6	≤8 and ≥ 6.5	0.025	80
Acceptable	92.5	0.044	10	≤8.4 and ≥ 6.5	0.075	165
Tolerable	115	0.073	20	≤8.4 and ≥ 6.5	0.125	250
Unacceptable	>115	>0.073	>20		>0.125	>250

V1 – Upper Thukela

The water quality in the upper Thukela, upstream of Woodstock Dam, and in the headwater catchment of the Thukela River and tributaries is generally good, with minimal impact. Overall, most variables were compliant to the water criteria. High salinity is however observed within the lower reaches of quaternary catchments V11A, V11C, and within V11J, V13D, V14A and V14B, with compliance to electrical conductivity in the largely tolerable level, and some non-compliance observed. This could be attributed to the localised settlements in these areas, the towns of Bergville and Colenso and the agricultural activity in the lower areas below Driel Barrage and Spioenkop Dam. Intensive irrigation does occur in the lower reaches of the catchment (V11J, V13D, V14A and V14B). High ortho-phosphate levels are also observed at the same sites within these quaternary catchments, with tolerable levels and some non-compliance observed.

Non-compliance to electrical conductivity and ortho-phosphate is found in the Klip River catchment in the vicinity of Ladysmith (V12G). The quality can be attributed to the impacts from the town and surrounding development, which includes the non-compliant discharges from the wastewater treatment works (WWTW).

Some quaternary catchments exhibit non-compliance to ioinised ammonia limit which is an indication of a high organic load to the system (related to sewage pollution).

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V11A (lower)	Thukela	Moderate	WWTW discharges, elevated nutrients/salts, rural towns and tourist resorts
V11C	Majaneni/Thukela	Moderate	Elevated nutrients, agriculture, numbered small WWTWs
V11G (lower)	Mlambonja	Moderate	WWTW discharges, elevated nutrients/salts, rural towns and tourist resorts
V11J	Sandspruit	Moderate	WWTW discharges (Bergville), elevated nutrients/salts; irrigation, erosion
V12B	Ngogo	Moderate	Erosion and over-grazing
V12G	Klip	Large	WWTW discharges, industrial discharges (Ladysmith), elevated salts/nutrients
V13B	Sterkspruit	Large	Elevated nutrients, irrigation, some erosion, piggeries
V13C/D	LittleThukela (lower)	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Winterton)
V14A	Thukela	Moderate	Elevated nutrients, intensive agriculture
V14B	Thukela	Moderate	Elevated nutrients, intensive agriculture; WWTW discharges (Colenso)

V2 – Mooi River

Water quality in the Mooi River catchment is very good. The compliance assessment indicates that for almost all variables at all sites water quality is at for the most part ideal and acceptable levels. Slightly elevated pH is observed in quaternary catchment V20D and at the outlet upstream of confluence with the Thukela. Intensive agricultural activity does occur in quaternary catchment V20B (lower reaches), V20D and V20E but limited impact is evident in terms of salinity or nutrients. Increase use of fertilizers and high irrigation return flows is becoming a concern.

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V20D	Mooi/Klein Mooi	Moderate	elevated nutrients, irrigated agriculture
V20E	Mooi	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Mooi River)

V3 – Buffalo River

The water quality in the upstream catchment of the Buffalo River is good (V31A, V31B) in the Slang River. Slightly elevated salinity and nutrients is observed in the upper Buffalo River in the vicinity of the town of Volkrust (V31B), with non-compliant electrical conductivity, orthophosphate, nitrate and ionised ammonia levels observed. Electrical conductivity concentrations in V31C are within tolerable levels, possibly due to agricultural activity in the Ngogo River catchment. However, the outflow of the Buffalo River at V31C at Schurvepoort is good with water quality at ideal and acceptable levels.

Water quality in the upper Ngagane catchment (to Chelmsford Dam) is relatively good, with the exception of the Horn River (V31F) and V31G and V31K which has high electrical conductivity and sulphate levels and slightly elevated pH. Tolerable and non-compliant concentrations of orthophosphate is observed in V31K. This water quality is due to impacts of the coal mining in the area (from acid mine drainage), and the impacts from the town of Newcastle.

The middle Buffalo river catchment area, V32C, V32D, V32E, and V32F have high salinity, nutrients and elevated pH. Tolerable and non-compliant levels are observed. This is most likely attributable to the unrehabilitated defunct mines in the region (V32E – Sterkstroom in the Dundee area), upstream impacts from the Ngagane catchment, local towns, and the agricultural practices along the Buffalo River. The Blood River is also impacted by agriculture activities in the lower catchment. High levels of electrical conductivity, orthophosphate and nitrate are present. The lower Buffalo River (upstream confluence with the Thukela) shows similar quality. Non-compliance to ionised ammonia is observed in the middle to lower catchment.

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V31B	Buffalo	Moderate	elevated nutrients/salts, WWTW discharges (Volkrust),
V31F	Horn	Large	elevated nutrients/salts, mining, agriculture, acid mine drainage, erosion
V31J	Ncandu	Large	WWTW discharges, industrial discharges (Newcastle); urban impacts; elevated nutrients/salts

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V31G (lower)	Ngagane	Moderate	elevated nutrients/salts, irrigation, mining, acid mine drainage
V31K	iNgagane	Moderate	elevated nutrients/salts, WWTWs and industrial, mining, acid mine drainage, urban impacts
V32B	Dorpspruit	Moderate	WWTWs discharge (Utrecht); sand mining
V32C	Buffalo	Moderate	WWTWs discharge (Osizweni); industrial discharges; upstream impacts of Ngagane, Dorpspruit; Madadeni; elevated nutrients/salts
V32D	Buffalo	Moderate	elevated nutrients/salts,erosion, agriculture, over-grazing; WWTW discharges (Winterton)
V32E	Sterkstroom	Large	Elevated nutrients, intensive agriculture; WWTW discharge (Glencoe and Dundee); inactive and active mining, possible acid mine drainage
V32F	Buffalo	Moderate	Elevated nutrients/salts, agriculture; erosion; upstream impacts, WWTW discharges; industrial/mining, towns

V4/V5 – Lower Thukela

No water quality data is available for quaternary catchments V40A to V40D, V50B, V50C and limited data is available for the remaining quaternary catchments (only electrical conductivity and nutrients). Catchment V40E and V50A have elevated electrical conductivity and nitrate levels (tolerable) and non-compliance to orthophosphate. Water quality in V50D, the Thukela River upstream of the Thukela Estuary is impacted, and compliance indicates unacceptable levels of electrical conductivity and orthophosphate. This is attributable to the impacts from the town of Mandini, the discharges from the paper mill and changes in river flow due to bulk water abstraction.

Water Quality hotspot areas include

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V40E	Thukela	Moderate	elevated nutrients,/salts, rural communities, subsistence agriculture, over-grazing
V50A	Thukela	Small	elevated nutrients/salts, rural communities, subsistence agriculture, dryland sugarcane, over-grazing, erosion (sediments); small scale sand mining on Mamba
V50D	Thukela	Moderate	WWTW discharges (Mandini), industrial discharges (per mill); urban impacts; high nutrients and salinity

V6 – Sundays River Catchment

The water quality in the upper Sundays River at Waterfall and Kleinfontein is good with low salts and low nutrients concentrations and ideal pH. Non-compliance to ionised ammonia is also observed in some parts of the catchment. Some localised impact of salinity is observed. Unacceptable levels of electrical conductivity, sodium, sulphate, and non-compliant pH levels were found in V60B in the Nkuzi catchment, and V60D and V60E, the Wasbank catchment. The poor water quality is a result of coal mining decants in the Nkuzi and upper Wasbank with acid mine drainage being a key concern, as well as from agricultural activity and local towns.

Water quality in the middle Thukela River is good (V60G, V60J) with acceptable and ideal levels of analysed variables observed. High levels on orthophosphate is found in V60G, the middle Thukela River. This is likely attributable to the upstream impacts related to agricultural run-off and the impacts from the Klip River.

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V60B	Nkunzi	Serious	High salts and nutrients; WWTWs discharges (Biggarsberg); piggery, erosion – sediments, coal mining and acid mine drainage in lower reaches
V60D	Wasbank (upper)	Large	Elevated nutrients, high salinity; coal mining and acid mine drainage decant
V60E	Wasbank (lower)	Moderate	Elevated nutrients, high salinity; upstream impacts; sand-mining, over-grazing, erosion; rural communities
V60E	eTholeni	Large	WWTWs discharges (Tholeni); sand-mining, over-grazing, erosion;
V60K	Thukela	Small	WWTW discharges (Tugela Ferry); nutrients

V7 – Bushmans River Catchment

Based on the assessment the water quality in Bushmans River catchment is good with ideal and acceptable levels of water quality variables present. High nutrients are evident in V70E, with elevated (tolerable and non-compliant) orthophosphate in V70D, V70E and 70F. The sources of these nutrients are agricultural and with impacts from the town of Estcourt and surrounding areas.

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V70D	Little Bushmans	Serious	WWTW discharges and pump station failures (Estcourt and Wembesi); industrial area impacts; forestry in upper reaches; sand mining, agriculture; elevated nutrients
V70E	Bushmans	Moderate	Elevated nutrients; intensive irrigated agriculture
V70F	Bushmans	Moderate	Elevated nutrients, high salinity; intensive irrigated agriculture
V70G	Bushmans	Moderate	WWTW discharges and pump station failures (Weenen); extensive irrigation; erosion

7.4 Water Quality Impacts

The assessment has shown that the water quality of the Thukela Catchment in its entirety is relatively good. The assessment and analysis indicate 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 and related to agricultural practices. Land use for the Thukela Catchment is shown in Figure 34. The key impacts are as follows:

- 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 area respectively. Although many of the collieries in the catchment are inactive, they impact on the quality of the water resources in the area. Acid mine drainage from defunct mines is a concern, resulting in high concentrations of salts entering the water resources. The water quality impacts are observed in the Ngagane Catchment and through to the lower Buffalo River, which is further influenced by agricultural activity.

- Sand Mining – the Buffalo River from the Ngagane River confluence to the lower reaches is impacted by sand mining, which is causing high sediment load within the river channel that has been observed. This is further compounded by increased soil erosion due to poor land management practices in the catchment.
- Poor performing 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. The towns of Weenen, Wembezi and Estcourt were rated as critical risk WWTPs (90-100% risk rating), and Ladysmith, Bergville, Colenso, Ekuvukeni, Winterton, Ezakheni, Utrecht and Tugela Ferry were rated as high risk WWTPs (70 - <90% risk rating) in the 2013 Green Drop evaluation. While the findings of the 2019 Green Drop report is still to be released, it is apparent, based on feedback from the KZN DWS Office that the situation with these WWTWs has not significantly improved. Microbial contamination of water resources may also be prevalent, but insufficient valid data precludes meaningful comment on this at a catchment scale. The poor performing WWTWs, failing sewer infrastructure and overflowing sewer manholes is a major threat to the water quality of the Thukela Catchment.
- A number of rural settlements with high population densities are scattered through the Thukela catchment. A number of these settlements are unserviced (e.g. along the Lower Thukela River) which is a potential concern to catchment water quality, contributing to the organic load observed. Currently reasonably large volumes of water in the Thukela River originating from the well-watered upstream tributary sub-catchments could be diluting any significant impact.
- Industrial activity – The catchment areas largely impacted by industrial activity are the Ngagane, Lower Thukela, Bushmans, Klip and the Mooi Rivers. Large industrial development in the Newcastle area (Madadeni) impacts on the salinity levels of the Ngagane River and on the downstream Buffalo River. The Sappi Paper Mill at Mandini has a significant water quality impact on the Lower Thukela River caused by effluent releases which requires sufficient river flows for dilution. Fibres from this industrial process could possibly be affecting the downstream biota. In the Mooi River catchment, the Klip Rivre (outside Ladysmith) and in the Bushmans River below Estcourt, industrial waste from the various factories in the towns are discharged into the river systems. These industrial discharges/impacts can be associated with the high salinity observed in these quaternary catchments.
- Agricultural activity occurs extensively throughout the Thukela Catchment. Subsistence agriculture as well as intensive farming occurs in the upper and middle Thukela, Buffalo River, Bushmans River, Mooi River and Sunday River catchments. Water quality impacts are observed within these areas (high salinity and nutrients) 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. The loss of habitat and modifications to instream conditions and wetlands is largely driving the moderately modified PES (C category) observed for many rivers.

The above impacts and areas of water quality concern require necessary intervention to ensure that the impacts are mitigated, adequately managed and/or minimised, in order to protect the water quality of the Thukela catchment. The current good water quality must be maintained, and areas of impact should be improved through appropriate source directed controls. Additional and more extensive water quality monitoring is however required within the catchment to better understand the water quality status.

The Thukela has a number of strategic water source areas that support water resource use and economic activities nationally. As the volumes of water generated from these areas should be maintained and afforded a level of protection, so to, should the water quality.

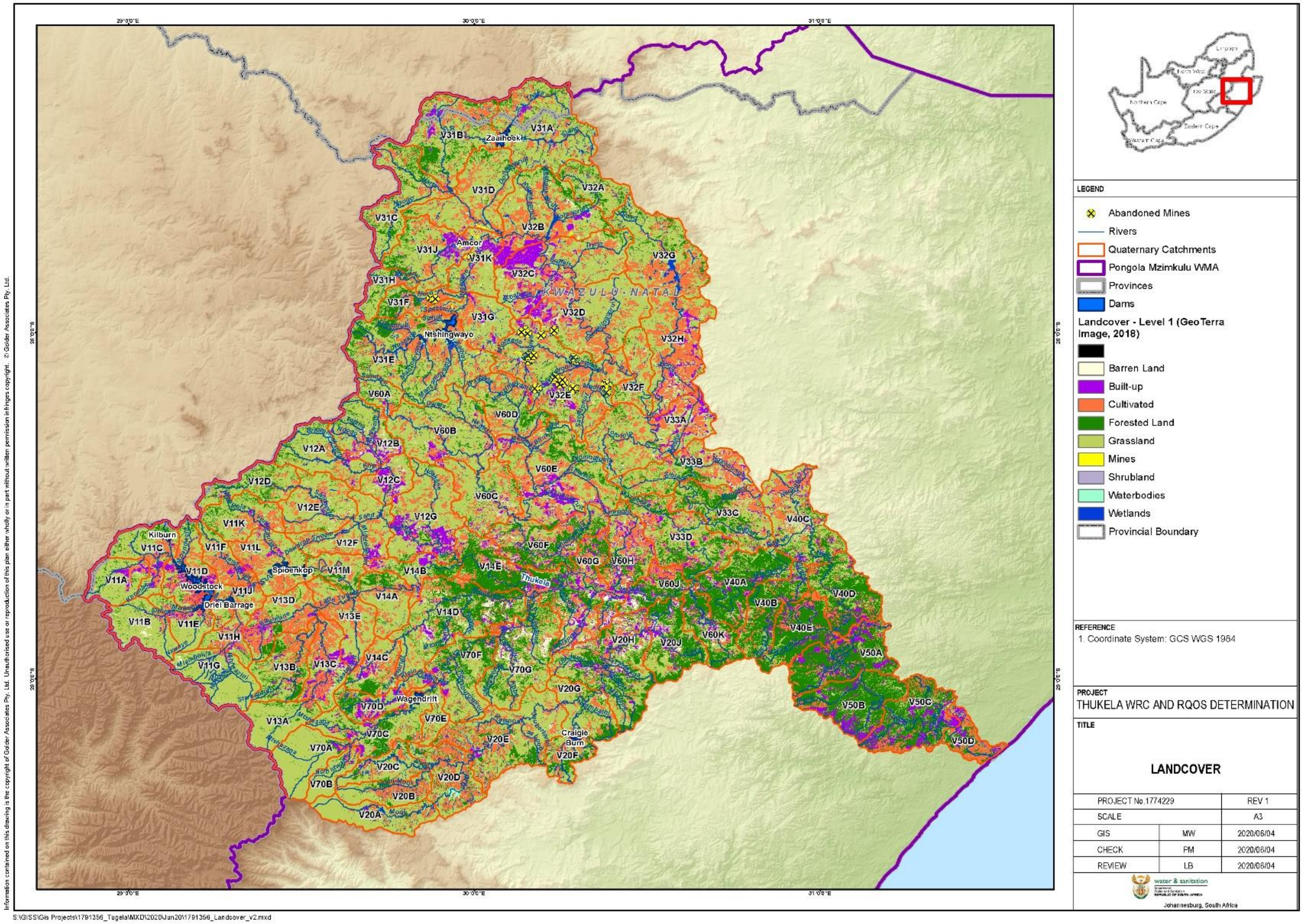


Figure 34: Land cover map

8 STATUS QUO THUKELA ESTUARY

8.1 Overview

The Thukela Estuary (31°29'57"S; 29°13'26"E) is located within the sub-tropical biogeographical coastal region of South Africa's east coast and is classified as an open river mouth (large fluvially dominated) (Whitfield 1992; Whitfield and Baliwe 2013; van Niekerk *et al*. 2019). This estuary forms the downstream extent of the Thukela River, which is the largest river system along the KwaZulu-Natal (KZN) coastline. The shallow Thukela Bank, which formed as a sediment plume just off the Thukela Estuary mouth, supports several fisheries, notably the prawn trawl and line fisheries (De Lecea and Cooper 2016). De Lecea and Cooper (2016) noted that recent studies have shown that the biology of the Thukela Bank is primarily maintained by riverine organic matter and nutrients, mainly from the Thukela River. During the wet season it provides the nutrients and organic matter necessary to maintain a planktonic pelagic food-web on the Thukela Bank (De Lecea and Cooper 2016).

The Thukela Estuary is located within the Pongola-Mtamvuna Water Management Area approximately 100 km north of Durban. The estuary falls within the recently declared uThukela Marine Protected Area (MPA) that includes the adjacent marine and coastal zones outside the estuary mouth and up to a point (29°11'59.1"S, 31°25'27.1"E) that is approximately 8.5 km from the estuary mouth (Government Gazette No. 42478, 2019) (Figure 35).

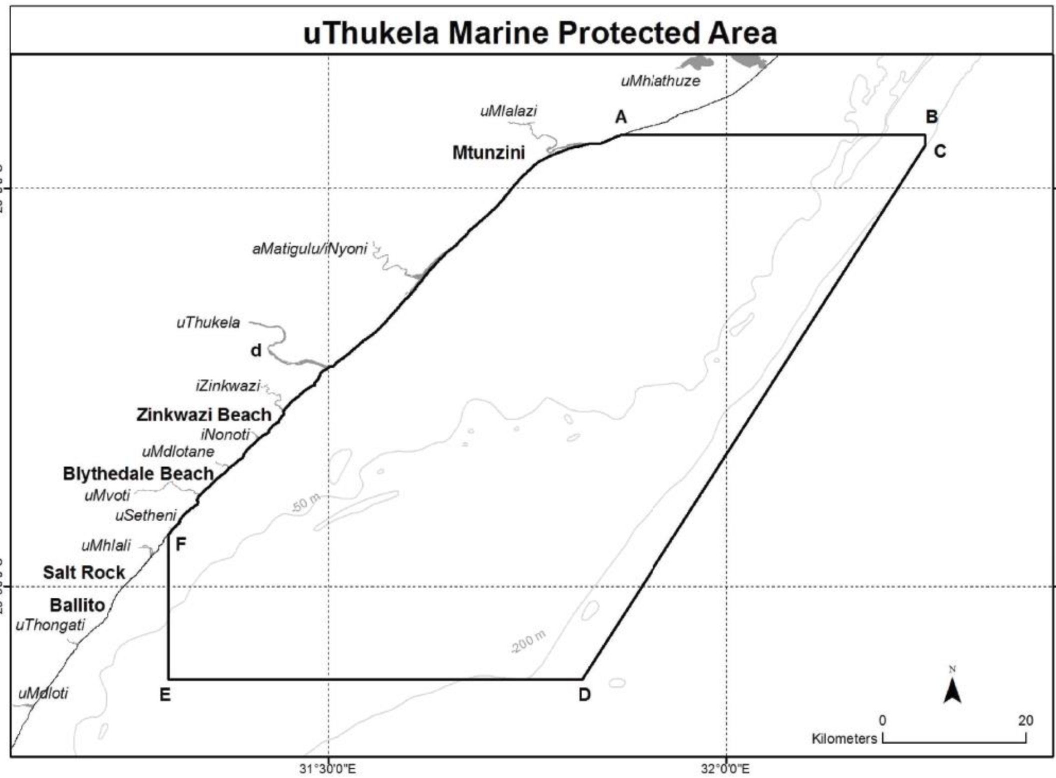


Figure 35: Boundaries of the uThukela Marine Protected Area; note that point d is located within the Thukela Estuary is approximately 8.5 km upstream of the estuary mouth (Government Gazette 42478 2019)

The estuarine area of the Thukela River is small, which is the result of high riverine runoff, while the surface area of the estuary during low flow periods is approximately 0.6 km^2.

Changes in river flow have caused considerable changes in the morphometry of the estuary as is evident during periods of high flows when the estuary floods the banks and extends out to sea (Begg 1978; DWAF 2004a). The axial length is estimated to be 800 m during low flow, with a shoreline length of approximately 2 km. The maximum width of the Thukela Estuary during natural flow periods is approximately 350 m. The channel width of the estuary is approximately 50 m and increases to over 1 km during high flow periods and floods (Begg, 1978).

In terms of the National Biodiversity Assessment (NBA) 2018 (van Niekerk *et al*. 2019), the Thukela Estuary has been allocated an Ecosystem Threat Status of Endangered, while the Ecosystem Protection Level of the estuary is poorly protected (van Niekerk *et al*. 2019).

The Present Ecological State (PES) of the estuary was set as Ecological Category C, based on an estuarine health score of 70, which means that the system is "moderately modified" (DWAF 2004). However, according to the findings of the NBA 2018, the Thukela Estuary has been assigned a PES of D, indicating that the estuary is heavily modified as a result of significant loss of Process and Pattern (van Niekerk *et al*. 2019).

The estuary importance rating system allocated the estuary an importance score of 76, which was regarded as "important" (DWAF 2004). The estuary's importance rating was reaffirmed in the recent National Biodiversity Assessment 2018 (van Niekerk *et al*. 2019).

8.2 Description

Based on the latest National Biodiversity Assessment 2018 by van Niekerk *et al*. (2019), the Thukela Estuary is a predominantly open, large, fluvially-dominated system on KwaZulu-Natal's subtropical coast. The cumulative pressure on the estuary is categorised as high and can be unthreaded as follows:

- Flow modification: Medium
- Pollution: High; largely attributed to agriculture in the catchment and plastic from marine and stormwater sources.
- Habitat loss: High
- Fishing effort: This has increased from high (17 tons; DEFF 2011 cited in van Niekerk *et al*. 2019) to very high (30 tons; DEFF 2018 cited in van Niekerk *et al*. 2019). Bait collection also occurs in the estuary.
- Alien fish: Very high

The boundaries of the Thukela Estuary (Figure 36) used during the Estuarine Flow Requirements study (DWAF, 2004) were defined as follows (Gauss Projection, Clarke 1880 Spheroid) (Figure 37):

- Downstream boundary: Estuary mouth (31°29'56" E, 29°13'24"S) (Figure 1.2.2)
- Lateral boundaries: Five metre contour from MSL along banks
- Upstream boundary: Approximately 6 km from the mouth

However, the Estuarine Functional Zone (EFZ) of the estuary as described in the National Biodiversity Assessment 2018 (van Niekerk *et al.* 2019) now recognises the upper boundary as being 8.7 km from the estuary mouth. This is the same boundary used in the uThukela

MPA in terms of Section 22A of the National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003) at GPS point 29°11'59.1"S, 31°25'27.1"E (which corresponds with -29.199736, 31.424198 as defined in the Government Gazette No. 42478, 2019).

Figure 36: Google Earth image of Thukela Estuary with locations of estuary mouth (downstream boundary) and the two upstream boundaries; DWAF (2004a) and uThukela MPA (2019)

Figure 37: Mouth of the Thukela Estuary during low flow period with well-developed sand berm to the right hand side of the image (photo taken 18-10-2019)

Based on Whitfield's (1992) classification scheme, the estuary was classified as a river mouth and has been rated as important largely because it is an essential conduit and source of organic matter and nutrients to the coastal and marine environments. Much research has been published since the 2004 EWR study on the near-shore sediment dynamics and links to the Thukela Banks crustacean and linefish fisheries (Flemming 1978, 1980, 1981; Felhaber 1984; Flemming and Hay 1988; Bosman *et al*. 2007; Flemming and Bartholomä 2012; Green and MacKay 2016). The KwaZulu-Natal coast is regarded as being oligotrophic but the bight itself receives allochthonous inputs from riverine outwelling, where the Thukela is a major source, and coastal upwelling (Untiedt and MacKay 2016). Nutrient enrichment and particulate organic material from these sources support the growth of macrobenthic communities' secondary producers.

On the inner shelf at the Thukela River mouth the sediment characteristics and elevated phytoplankton chlorophyll *a* influence macrobenthos distribution (MacKay *et al*. 2016). The deposit feeders, which commonly dominate the benthos from the inner to outer shelf off of the Thukela, have a preference for muddy substrates and freshly deposited organic material. De Lecea and Cooper (2016) provide a review of the available information that highlights the importance of riverine organic matter and nutrients, primarily from the Thukela River, on the biology of the KwaZulu-Natal Bight. The review describes the delicate balance that managers and politicians need to make between protecting the subsistence, recreational and commercial fisheries associated with the Thukela River, and increasing water abstraction to meet the needs of a growing human population. To support these difficult decisions around this trade off, Turpie and Lamberth (2010) investigated the potential impacts of reducing Thukela River flow on the Thukela Banks crustacean and line-fish fisheries.

In order to maintain the Thukela Estuary in a high Category C – the Ecological Category (EC) – it is important that non-flow anthropogenic activities do not exert increasing pressure on the estuary and that the hydrology remains within the boundaries identified in the 2004 EFR study. The recommended Reserve was aligned with Scenario: River Category B, which ensured that the estuary remained within a high Category C and allowed for a narrow window of larval recruitment of the crab *Varuna litterata* during late autumn each year; the species has an obligate marine phase during its lifecycle. The Scenario: River Category B required a minimum mean annual runoff (MAR) of 2258.4 x 10^6 m^3/a and the allocation over a period of a year is summarised in Table 34. Scenario: River Category A was also acceptable and in terms of the yield scenarios 1 to 6 were also acceptable.

Table 34: Initial Scenario: River Category B flow distributions in m^3 x 10^6

%ile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
90%ile	33.39	65.47	151.76	302.51	534.73	275.35	96.11	33.97	24.35	19.04	16.93	24.54
80%ile	33.15	49.04	96.90	205.43	378.13	210.88	81.59	33.74	24.19	18.91	16.80	24.38
70%ile	32.54	48.28	87.28	129.35	238.21	148.53	60.92	33.14	23.79	18.63	16.50	23.84
60%ile	30.99	47.14	78.04	80.55	195.40	115.05	55.88	31.84	22.96	17.94	15.98	20.64
50%ile	28.68	44.60	68.19	71.02	169.96	90.94	50.57	29.91	21.49	16.74	14.88	16.02
40%ile	24.94	40.73	55.40	61.48	157.05	86.90	44.40	26.37	18.99	14.91	13.19	14.50
30%ile	19.61	34.06	47.05	49.00	110.62	76.23	35.78	21.48	15.29	12.17	10.76	13.62

%ile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
20%ile	14.24	25.27	33.42	33.81	77.72	51.42	25.57	15.73	11.50	9.11	8.17	11.03
10%ile	9.25	15.35	19.90	21.32	45.23	30.98	16.95	10.89	8.07	6.51	5.87	7.44
1%ile	6.96	8.4	9.91	13.51	24.77	17.00	12.94	8.64	6.51	5.27	4.79	5.80

During dry periods, such as winter and droughts, the river flow into the estuary is particularly low and the contribution of groundwater flow is really important. Dennis and Dennis (2009) detailed the groundwater reserve and classification study for the entire Thukela River catchment. The geology and geohydrology are described for the area, and estimates of the most probable depth to groundwater level within the resource unit that includes the Thukela Estuary – RUY - was estimated at 7.2 mbgl; this ranges from approximately 400 mbgl in the north west of RUY to 0 mbgl along the coast in the south east. Details related to groundwater recharge, contribution to baseflow, use and quality are provided in the report.

8.3 Biota and distribution

8.3.1 Biogeography

The distribution of fauna and flora in the Thukela is driven by a complex interaction of physical and chemical parameters. The Estuarine Freshwater Requirements (EFR) protocol recognises these to be hydrology, hydrodynamics, water quality and sediment dynamics. Almost all physico-chemical information is based from the EFR study, with limited new information linked to biotic studies referred to below.

Hydrology

The hydrology of the Thukela Estuary for the preliminary Reserve was determined using topographical data collected by the Department of Water Affairs and Forestry (DWAF) in November 1996; full details provided in Huizinga and van Niekerk (1997). These data include cross sections of the beaches adjacent to the estuary mouth and of the estuary from the mouth to the old N2 Bridge. There were no data available on berm height during closed mouth conditions, although +2.5 m MSL was expected, resulting in the backing up of water to about 8 km upstream.

Sediment loads into the Thukela Estuary were determined using a sediment load-discharge rating curve obtained from sediment samples collected between 1971 and 1984 at the Mandini gauging station (V5H002 – 29º8’26” E; 31º23’31” S) by DWAF. Sediment yields from other parts of the Thukela catchment were available from Dollar (2001) and Rooseboom (1992) (cited in DWAF, 2004b).

River discharge data for the estuary were obtained from the Mandini gauging station (V5H002); the station gauged discharge from a catchment area of 28 920 km^2 (DWAF, 2004b). Although the DWAF (2004b) report indicated that water level recordings were being collected inside the mouth of the Thukela Estuary since 12 November 1999, the data appear to be sporadic at times and full details are included in an unpublished report by Huizinga and van Niekerk (1997). River flow and mouth condition data provided by SAPPI – Mandini, provided for the period 10/1991 – 09/1995 (DWAF 2004b), indicate that mouth closure periods were short, and only occurred when river flows were 7.7 m^3/s and lower.

Water column salinity profiles obtained for 29/10/1992 (low tide), 06/11/1997 (low tide), 20/08/2001 (low and high tides), and 12/02/2002 (low and high tides) provided an indication of salinity penetration into the estuary at a range of flows (< 5 – 40 m^3/s) and tidal stages. Flows were limited to ~5 m^3/s and ~40 m^3/s where salinity penetration was up to 3 km from the mouth and fresh throughout, respectively.

Water quality

The relationship between salinity and river flow in the Thukela Estuary was based on measurements made in October 1992, May 1996, November 1997, August 2001 and February 2002 (DWAF 2004b). When river flow was low (<6 m^3/s; 29 October 1992 and 20 August 2001), the intrusion of saline water extended up to 3.5 km from the mouth and remained fresh throughout the estuary when flow was high (~40 m^3/s; 4 December 1997 and 12 February 2002).

The relationships between salinity and other water quality variables (excluding nutrients) were obtained from three full estuarine surveys; May 1996, August 2001 and February 2002 (DWAF, 2004b). The water quality variables included temperature (°C), pH, total suspended solids (mg/L), and dissolved oxygen (mg/L). Salinity-nutrient relationships were drawn from nutrient concentrations measured throughout the estuary on 30 May 1996 and 20 August 2001. The nutrients included nitrate/nitrite-N (Total Oxidised Nitrogen), reactive phosphate-P, total ammonia-N (ammonium plus ammonia), and reactive silicate-Si. In addition to the measurements made throughout the estuary, sea and river concentrations were included from measurements made on 21 August 2002.

Continuous water quality measurements in the river were measured at a maximum of four sites located just upstream of the estuary: Mandini gauging station (V5H002), and three SAPPI monitoring sites (John Ross Bridge (north), Ultimatum Tree, and Havelock Farm) (Table 2.2.3.3). The Mandini gauging station (V5H002) is approximately 19.8 km from the estuary mouth at 29°10'07.21"S; 31°22'33.56"E, John Ross Bridge (north) site approximately 13.4 km from the mouth (north) at 29°10'24.73"S; 31°26'18.08"E, Ultimatum Tree at the N2 Bridge 7.0 km from the mouth at 29°12'44.96"S; 31°26'09.74"E, and Havelock Farm 5.3 km from the mouth at 29°13'13.72"S, 31°27'01.97"E.

Temperature data were available for Thukela Estuary EWR study for the period January 1997 to October 2001 (DWAF 2004b). These data, sourced exclusively from SAPPI long-term monitoring sites (Table 35), showed clear seasonal fluctuations in temperature within a range of ~17°C and 30°C. River water pH was available from all four monitoring sites where the Mandini gauging station data were used for reference (1977-1985) and present (1995-2001) conditions (DWAF 2004). The median present pH (8.2) was considerable higher than the reference pH (7.1) for reasons unknown. Total suspended solids and turbidity measurements are limited to sampling sessions of the estuary on 30 May 1996, 20 August 2001 and 12 February 2002; there has been no regular monitoring of these parameters upstream of the estuary. Available data suggest that turbidity and suspended solids increased in concentration with river flow (ranges of 3-153 NTU 16-33 mg/L, respectively) and mention was made of fibre-like suspended material in the estuary; source of this material is unknown (DWAF 2004).

Dissolved oxygen and Chemical Oxygen Demand (COD) were measured at the three SAPPI long-term monitoring sites and not at the Mandini gauging station. Dissolved oxygen generally exceeded 5 mg/L during the period January 1997 to October 2001 but there was a period during July-October 1999 where concentrations dropped to <4 mg/L, which was associated with a period where there was a distinct peak in COD (>80 mg/L at John Ross Bridge) (DWAF 2004b). This peak in COD was attributed to a probable discharge of biodegradable organic matter of anthropogenic origin but did not appear to have an impact on the estuary, which was shown to be well-oxygenated during May 1996, August 2001 and February 2002 studies.

Table 35: Availability of water quality data (temperature, pH, Total Suspended Solids (TSS)/turbidity, and dissolved oxygen) from four long-term sampling sites upstream of the Thukela Estuary for the 2001-2004 EWR study (DWAF 2004); Mandini gauging station, John Ross Bridge, Ultimatum Tree, and Havelock Farm

	Temperature	pH	TSS/turbidity	Dissolved oxygen
Mandini gauging station	✗	✓	✗	✗
John Ross Bridge	✓	✓	✗	✓
Ultimatum Tree	✓	✓	✗	✓
Havelock Farm	✓	✓	✗	✓

Monthly nitrite/nitrate-N, reactive phosphate-P and reactive silicate-Si concentrations from the Mandini gauging station showed that there was no significant differences between the reference period (1977-1985) and the period that represented the present state (1995-2001) (DWAF 2004b). Nitrite/nitrate-N ranged from 20 µg/L to 1379 µg/L in the river at Mandini and was approximately 50 µg/L in the sea (DWAF 2004b). Reactive phosphate-P ranged from 3 µg/L to 325 µg/L in the river and ~19 µg/L in the sea, and reactive silicate-Si ranged from 2370 µg/L to 9505 µg/L in the river and ~104 µg/L in the sea. Total ammonia-N concentration was not measured at the Mandini gauging station, so concentrations used in the DWAF (2004b) EWR study were based on those collected in the fresh upper reaches in May 1996 and August 2001. Ammonia-N concentrations in the river were generally low (<40 µg/L) so it was expected that concentrations within the estuary should not exceed 50 µg/L.

Trace metals collected from the sediments in the Thukela Estuary during May 1996 (two sites) and August 2001 (six sites) found that there was a peak in concentrations in very fine muds that were 0.75 km from the mouth but these were all within the bounds of natural variability with there being no evidence that anthropogenic inputs had any marked affect. This conclusion was based on very limited data and should be considered within this context.

Sediment dynamics

The impacts of two proposed dams in the Thukela River catchment on hydrodynamics and sediments in the estuary were determined based on river flow simulations and sediment yields for the entire catchment. The study determined that existing dams had decreased the average peak discharge of floods by 8% and the addition of two dams (Jana Dam on the Thukela River and Mielietuin Dam on Bushmans River) would decrease the peaks to 19%. An estimated increase in sediment yield from ~200 Ton/km^2 (reference) to ~400 Ton/km^2 (present) is likely to have decreased the length of the estuary from 8.5 km to 5.0 km and made the estuary shallower. It was determined to be unlikely that the additional dams would affect sediment equilibrium in the estuary from present, although the estuary would most likely become narrower, shorter and shallower.

8.3.2 Microalgae

Microalgae, which are differentiated into free-floating (phytoplankton) and benthic, are essential primary producers in estuaries. Changes in water quality and river flow can bring about measurable changes in the abundance and community composition. The Present Ecological Status of microalgae in the Thukela Estuary was based on a once-off sampling session in August 2001 at a river flow of ~6 m^3/s (DWAF 2004b). Phytoplankton biomass was determined by using chlorophyll *a* as an index. Chlorophyll *a* concentrations in the estuary (up to the N2 Bridge) ranged from <10 µg/L to >100 µg/L, which is regarded as being high when compared to other permanently open estuaries (Snow 2008). Chlorophyll *a* exceeded 20 µg/L in large parts of the estuary, which is the threshold for phytoplankton bloom concentrations and indicates nutrient-rich and eutrophic conditions (Snow 2008). Phytoplankton cell abundances were extremely high, ranging from >200 x 10^3 cell/mL to >1200 x 10^3 cells/mL, and peaked at 3 km from the estuary mouth where salinity was <10. The phytoplankton were dominated by flagellates and diatoms throughout the estuary. Cyanobacteria and euglenophytes were present in the fresh upper reaches of the estuary indicating poor water quality.

Benthic microalgae were collected from the intertidal and subtidal zones of four sites along the length of the estuary. Chlorophyll *a* biomass ranged from 2.5 to 20.5 µg/g (units can be converted to mg/m^2 by multiplying the values by 1.67; Snow, 2008). Diatoms collected from all sites were used for community analyses and consisted of cells that inhabit coarse-grained sand (episammic) and fine mud (epipelic).

8.3.3 Macrophytes

The botanical (macrophyte) characteristics of the Thukela Estuary were based on surveys conducted in June 1996 and August 2001. A vegetation map was produced that indicated the distribution of macrophytes at the time of the DWAF (2004b) study. No further studies have been conducted since then.

Behind the dune ridge and dune vegetation on the south bank there was a wetland area, which was dominated by common reed, *Phragmites australis*. Within this wetland there was a homogenous stand of sedge, *Schoenoplectus scirpoideus*, and some patches of lagoon hibiscus, *Hibiscus tiliaceus*. The wetland area covered ~12 ha. Dense stands of Brazilian pepper trees (*Schinus terebinthifolius*) together with some dune forest species occurred approximately 2 km from the mouth. For some distance upstream these trees occurred behind a narrow band of *P. australis* or were interspersed with reed patches and thereafter they formed dense stands at the water's edge. The floodplain area in this vicinity was largely disturbed as a result of agriculture.

In 2001, a large sedge marsh consisting of *Schoenoplectus scirpoideus* (area ~1 ha) was found at the mouth on the north bank. In 1996, the estuary mouth had a completely different morphology and these sedge areas were absent. Areas of the rush *Juncus kraussii* were found as well as scattered brackwater mangrove trees (*Barringtonia racemosa*). The intertidal area was mostly narrow with little wetland or estuarine vegetation present.

The study described clear shifts in community structure from reference and predicted changes related to changes in flow with the construction of two additional dams in the river catchment.

8.3.4 Invertebrates

Studies of the invertebrates of the Thukela Estuary were split into three categories: macroinvertebrates, zooplankton and macrocrustacea. Prior to 1997, there were numerous once-off and historical eyewitness accounts of macroinvertebrates in the estuary (Begg 1978; Day 1981; Cooper *et al*. 1993). After that, there were more intense studies conducted in 1997-1998 (MacKay and Cyrus 1998), and during low (August 2001) and high flows (February 2002). All information was consolidated into the Thukela Estuarine Freshwater Requirements study (DWAF 2004a, b).

The EFR study found that the benthic fauna of the freshwater-dominated estuary resembled assemblages more typical of freshwater than estuarine environments. It was only during periods of low flow that there was an influx of estuarine organisms into the lower estuary. The Thukela Estuary was found to support over 150 taxa of macroinvertebrates, which were all typical of other freshwater-dominated estuaries. A large backwater that was located just behind the sand berm near the mouth in 1997-1998 supported the highest biomass and diversity of species in the system, dominated by freshwater oligochaete worms. However, the location of the estuary mouth is transient and by August 2001 had migrated from the south to the north bank. This change in mouth location resulted in the backwater move from the north to south bank and the low river flow in August 2001 saw estuarine taxa become dominant, with the freshwater oligochaete being replaced by polychaete tube-forming worms.

Many penaeid prawns of commercial importance such as *Penaeus japonicus*, *Metapenaeus monoceros*, *P. canaliculutus* and *Macrobrachium* spp. were recorded in the Thukela Estuary (DWAF 2004b), which could highlight the importance of the estuary as a nursery and spawning habitat.

More recently, Vezi *et al*. (2019) sampled for zooplankton during high and low periods from 2014 to 2016 and found that the Thukela Estuary was dominated by copepod *Pseudodiaptomus hessei* and *Acartia natalensis*, particularly during periods of low flow. The study found that pH and water turbidity were the main factors determining zooplankton community structure.

It is worthwhile to note that a master’s study by Venter (2013) described the macroinvertebrate and fish responses to the eMandeni River and Sappi effluent discharge point. The communities were largely natural in the Thukela River upstream of the confluence with the eMandeni River, which is the receiving environment for the Sappi effluent. However, the communities were largely modified to severely modified below the confluence. Historically, the overall ecological integrity state of the lower Thukela River and associated eMandeni River were classified as being moderately to largely modified (Stryftombolas 2008; O’Brien *et al.* 2010a). The cumulative impacts of activities at eMandeni has caused a decline in the EcoStatus of habitat, macroinvertebrates, fish and water quality around the confluence between the eMandeni River and the Thukela River (Stryftombolas 2008).

8.3.5 Fish

Fish community, in relation to river flow, is well studied in the Thukela Estuary with gillnet studies conducted in May 1996, February 1997 and February 1999, and seine net studies in July 1986, May 1996, February 1997 and February 1999; a minimum of eight seine samples along the length of the estuary were conducted on each sampling trip (DWAF 2004b). The studies showed that high river flows (>50 m^3/s) prevented the intrusion of saline water into the estuary and limited the nursery areas available to many marine fish species. Being a river mouth, the estuary does not support a rich or diverse community of ichthyofauna. As river flow decreases, the study showed a clear increase in the Fish Recruitment Index scores up to a point where mouth closure was predicted. This increase in abundance and community richness of fishes was in response to an increase in more stable estuarine habitats and increasing availability of zooplankton and zoobenthic invertebrate resources. However, it should be recognised that under natural conditions, elevated productivity would be outside of the estuary on the continental shelf so these changes should be regarded as a change from natural. Low river flow, which is likely to result in estuary mouth closure, is a threat to the ichthyofauna associated with the estuary, particularly with regards to the migration of anguillid eels between the marine and river environments.

8.3.6 Birds

A comprehensive assessment of the current status of avifauna of the Thukela Estuary was based on bird counts conducted in June 1996, 1997-1998 (12 monthly counts), August 2001 and February 2002. The DWAF (2004b) assessment found that the aquatic bird community of the estuary was relatively diverse and consisted of Palaearctic migrant and resident populations. The estuary does provide feeding and roosting areas, providing habitat to birds that have been displaced from surrounding areas that have been impacted by human activities. The backing up of water and flooding of suitable roosting and feeding habits as a result of reduced river flow and mouth closure is the biggest threat facing the Thukela Estuary bird community.

Cyrus and MacKay (2007) provided an outline of the Environmental Reserve methodology and made use of the DWAF (2004b) study data to illustrate the process. No other published studies of avifauna linked to the Thukela Estuary are available.

8.4 Impacts on the Estuary

8.4.1 Quality and Quantity of flows

The Thukela Estuary is characterised by a significant dominance of freshwater characteristics. One of the conclusions of the DWAF (2004) study stated that its general physico-chemical state tended more towards riverine than estuarine conditions, while the associated benthic fauna were primarily freshwater invertebrates that are also found in other local rivers. The general impression, as stated in the study, was therefore that the Thukela Estuary 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 (DWAF 2004) 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. Furthermore, as with many estuarine systems, the dynamics of the Thukela mouth is a key aspect in the functioning of the estuary and is therefore also a key threat. The DWAF (2004) study reported that historically the mouth was largely in a permanently open state, however had started closing more frequently in recent times.

The water quality of the lower Thukela River is considered to be in a modified state, while the ecological integrity of the lower Thukela River reflected a moderately modified (Class C) state (DWAF 2004; Venter, 2013). Water quality impacts are largely associated with industrial effluent and Sappi paper mill effluent. Mining activities and a brick-making plant situated close to the John Ross Bridge on the R102 further contribute to water quality impacts. Impacts include elevated levels of chemical and biological oxygen demands (CODs and BODs), suspended solids, sodium and temperature (DWAF 2004; Venter, 2013). Stryftombolas (2008) also reported that decreased oxygen levels were caused by a combination of industrial wastewater in the eMandeni River and the Sappi Tugela paper mill effluent.

Reduction in the quantity of river flow is a key driver of changes in biotic communities in the estuary. Phytoplankton spatial distribution along the horizontal axis of the estuary was strongly influenced by the dynamic interaction between river inflow and the incoming tide (DWAF 2004). Changes in river inflow could therefore alter the position of the river/estuary interface (REI) zone resulting in a change in the region of highest phytoplankton production. This in turn could impact on food web dynamics within the Thukela Estuary.

A reduction in freshwater input associated with high nutrient input could result in reed and sedge encroachment into the main channel. During the 2004 study commissioned by DWAF, the sedge *Schoenoplectus scirpoides* colonised the mouth area on the north bank of the estuary since the 1996 flood (DWAF 2004). An increase in the frequency of mouth closure and associated rise in water level to greater than 1 m, furthermore, is likely to impact the reed and sedge beds if inundation persists for longer than a 3 months period (DWAF 2004). Seedling establishment is also adversely affected by water level fluctuations and inundation. The seedlings of *S. scirpoides*, for example, are more capable of establishing and developing under water than the common reed *Phragmites australis* (DWAF 2004).

Macroinvertebrate as well as the fish community structures below the confluence of the eMandeni River and Sappi effluent discharge point were classified to be in a largely modified to a severely modified state. Historical results showed that the lower Thukela River was generally classified to be in a moderately modified and largely modified ecological integrity state regarding the overall integrity state of the lower Thukela River and associated eMandeni River revealed (Stryftombolas 2008; Venter 2013).

A reduction in freshwater inflow would result in the dominant freshwater fauna decreasing in number and possibly disappearing as tidal influence increases. This could result in an increase in salinity of the lower reaches of the system, ultimately increasing in the current numbers of estuarine species, which would eventually replace the freshwater species in dominance. The DWAF (2004) study concluded that although there may not be a vast reduction in current densities, the species composition and assemblages in the system would change entirely.

A decrease in freshwater inflow could result in the Thukela Estuary mouth closing more often and for longer periods resulting in limited exchange with the marine environment. This would cause the river component to influence the physical-chemical processes within the system to a greater extent resulting in the estuary becoming fresher in its abiotic characteristics (DWAF 2004). The estuary is furthermore an important conduit for crab and prawn developmental stages (Mackay and Cyrus 1999; Mackay and Cyrus 2002). If the mouth were to close for long periods during low flow conditions it is very likely that the lifecycle of these species, including others that use the estuary as a nursery area, would be interrupted (DWAF 2004).

8.4.2 Land use impacts/changes

The lower reaches of the Thukela River catchment are characterised by sugarcane agricultural activities which have resulted in the loss of natural habitat, may cause accelerated erosion and siltation. The area also supports some highly industrialised areas including the Mandini and Sundumbili industrial complexes, which include Tugela Rail, a textile factory and a vegetable-oil factory (Stryftombolas 2008; Venter 2013).

Another major industry that may contribute to the excessive use of the ecosystem services provided by the lower reaches of the Thukela River is the Sappi Tugela Mill. According to DWAF (2004b) the Sappi Tugela Mill is responsible for the largest water use in the area with an estimated water requirement of 24 x 10^6 m^3/a. The Sappi Tugela pulp and paper mill has both extraction and discharge points in the same region, accompanied by extensive sugarcane plantation irrigation (Stryftombolas 2008). The Sappi Tugela Mill discharges its effluent directly into the Thukela River close to the confluence with the eMandeni River. The eMandeni River supports the Isithebe rural area and industrial complex as well as rural sewage treatment works from both Isithebe and Mandini.

8.4.3 Invasives

Although invasive fishes have been highlighted as an issue in the NBA 2018 (van Niekerk et al. 2019), no details were provided. The only invasive species mentioned in the DWAF (2004b) report were in the macrophyte section: Brazilian pepper trees and Spanish reeds. There are other invasive plant species in the area such as *Lantana camara* (pers. obs.) that have not been listed.

8.4.4 Disturbance of functional zone

The majority of impacts on the estuary from flow, sediment and water quality related activities fall outside of the Estuarine Functional Zone (EFZ). Impacts within the EFZ that were highlighted in the EFR study (DWAF 2004a) include the following:

- Harvesting of sedge on the north bank
- Macruran prawns (*Macrobrachium* and *Penaied spp*.) are caught for bait by local fishermen.
- Recreational and subsistence fishing.
- Illegal gill and seine netting in the lower reaches of the estuary.
- Bird disturbance as a result of human activities; e.g. recreational and illegal fishing.
- Agriculture has removed ~80% of natural floodplain vegetation (loss of 22 ha reeds, 1.5 ha swamp forest).

- Although upstream of the EFZ, stormwater, sewage discharges, and paper and mill plant discharges within the Mandini area affect water quality in the estuary. Impacts include reduced dissolved oxygen, elevated total suspended solids and elevated inorganic nutrient loading.
- Invasive plant species include Brazilian pepper trees and Spanish reeds.
- There has been anecdotal evidence that the construction of the weir at Mandini may hinder the migration of species between the ocean and river catchment. These species include anguillid eels, and macrocrustacea such as *Macrobrachium spp*., *Varuna litterata* and *Scylla serrata*. There has also been evidence of elevated levels of illegal fishing and the use of gill nets since the EFR study, and possible sand mining in the EFZ (this needs to be confirmed).

9 INTEGRATED UNITS OF ANALYSIS

9.1 Delineation of IUAs

9.1.1 Approach

IUAs are the spatial units that are defined as significant water resources. The objective of defining IUAs is to establish broad scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on the ecological conditions at a sub-catchment scale (DWA, 2007a).

Delineation of units of analysis is required as it would not be appropriate to set the same water resource class for all water resources in a catchment. The delineation of a catchment into IUAs for the purpose of determining the water resource classes for significant rivers is done primarily according to a number of socio-economic criteria and drainage region (catchment) boundaries. IUAs are thus a combination of socio-economic zones and watershed boundaries (DWA, 2007b). Ecological information and biophysical characteristics also play a role in the delineation.

The process followed in terms of IUA delineation is 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, 2007b).

In the IUA delineation process overlaying the required data does not necessarily result in a logical and clear delineation and expert judgement, a consultative process and local knowledge may be required for the final delineation of the IUAs. The practicalities of dealing with numerous significant water resources and associated tributaries within one study must also be considered to determine a logical and practical set of IUAs.

9.1.2 Delineation

The following suite of characteristics was analysed, assessed and reviewed for delineation of IUAs within the Thukela catchment:

- Socio-economic zones (SEZs)
- Catchment area boundaries (drainage regions and water resource systems)
- The resolution of the hydrological analysis and available water resource network configurations within the water resource models.
- Location of significant water resource infrastructure.
- Land use characteristics.
- Distinctive functions of the catchments in context of the larger system.
- The Present Ecological State (PES) of each biophysical node was considered, the type of impacts and the homogeneity of the status and impacts.
- The practicalities of the existing model setup and network in terms of the scenario evaluation of each IUA.

- Present status of water resources.
- Stakeholder input.

Based on the SEZs determined and the assessment of the information and considerations outlined in Sections 2 to 8, fifteen IUAs have been delineated for the Thukela catchment. The availability of representative EWR sites within each IUA, catchment boundaries and modelling nodes included in the WRYM were also considered. Overlaying these aspects and data has resulted in the delineation of the IUAs which are similar from all the various components perspective and which can be managed as an entity, in addition comprising a logical unit for which scenarios can be designed and evaluated.

The fifteen IUAs delineated are listed in Table 36 and illustrated in Figure 38. The identified IUAs have been discussed with the DWS and preliminary accepted by stakeholders within the Thukela catchment.

Table 36: IUAs delineated in the Thukela catchment

IUA	Delineation	Quaternary Catchments
1	Upper Buffalo River	V31A; V31B; V31C and V31D
2	Ngagane River	V31E; V31F; V31G; V31H; V31J; V31K
3	Middle Buffalo River	V32A; V32B; V32C; V32D; V32E; V32F;
4	Lower Buffalo River	V33A; V33B; V33C; V33D
5	Blood River	V32G; V32H
6	Sundays River	V60A; V60B; V60D; V60C; 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; 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)

IUA	Delineation	Quaternary Catchments
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

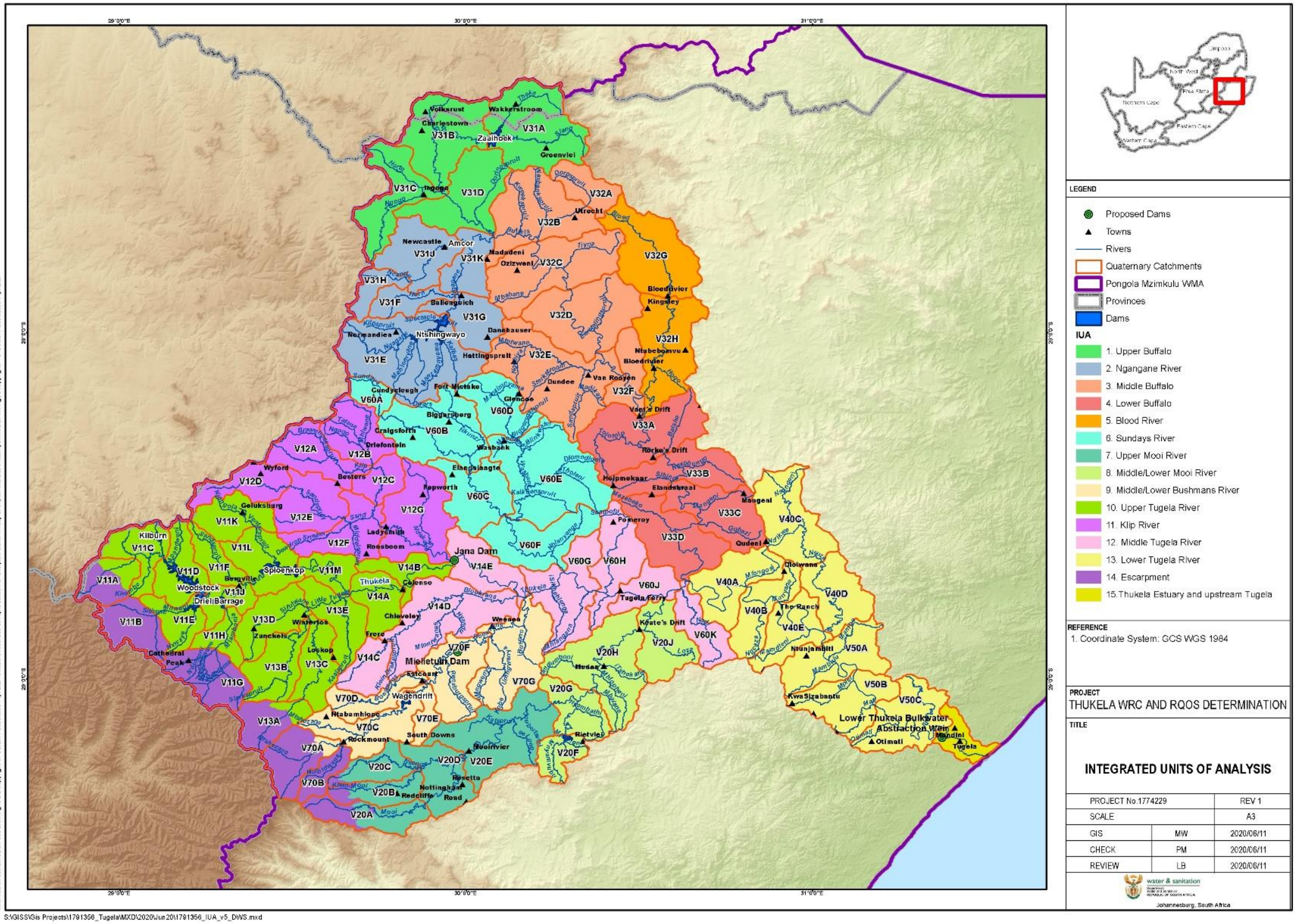


Figure 38: Delineated IUAs in the Thukela Catchment

9.2 Integrated Units of Analysis (IUA) Descriptions

Each of the IUAs delineated in the Thukela catchment is described in further detail in the following sections

9.2.1 IUA 1: Upper Buffalo

IUA 1 comprises the upper Buffalo River and tributaries up to the confluence with the Ngagane River.

Rationale

The IUA delineation is based on the upper Buffalo headwater system reach and tributaries being in fairly good ecological condition and overall good state. Similar high lying ecoregion (topography, vegetation, altitude, rainfall, physical attributes, etc) and associated land uses. Logical break in system to just upstream confluence with the Ngagane River and catchment boundaries.

Overview

IUA 1, the Upper Buffalo IUA, straddles the border of Mpumalanga (Dr Pixley Ka Isaka Seme Local Municipality) and KwaZulu-Natal (Newcastle and Emadlangeni Local Municipalities) provinces (Figure 39). The IUA principally includes the towns of Volksrust, Wakkerstroom, Charlestown and Groenvlei as well as the Mabola Protected Environment and Tafelkop Nature Reserve to the north-east.

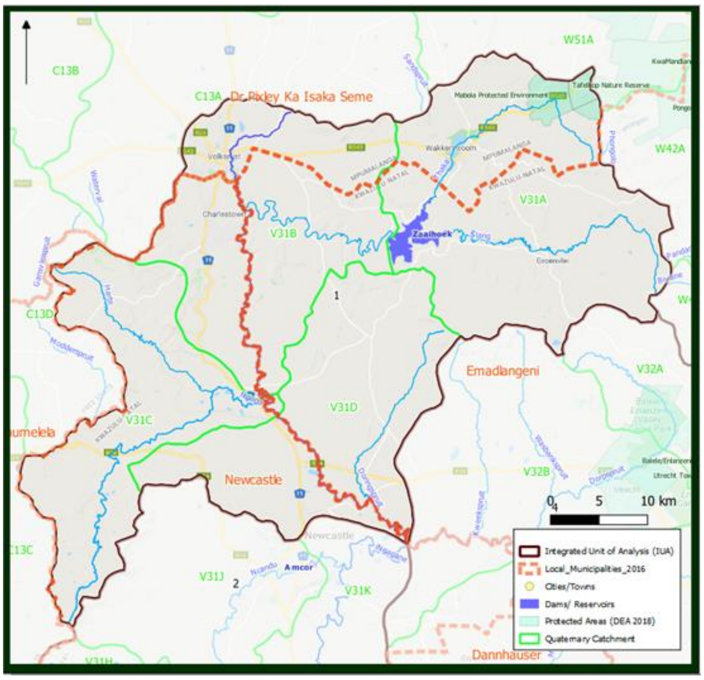


Figure 39: IUA 1 Upper Buffalo

Water Resources

Water resources in the IUA include the Upper Buffalo River and tributaries (Table 37) as well as the Zaaihoek dam. The area includes the important Wakkerstroom wetland area and a number of priority channelled valley bottom wetlands. Key water transfers are from the

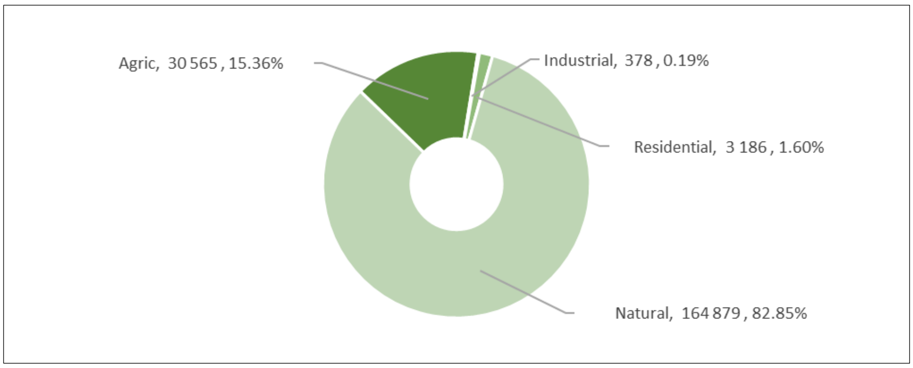
Zaaihoek Transfer Scheme transferring water to the Vaal system. Water is transferred from the Zaaihoek Dam in the Slang River to Majuba Power Station in the Mpumalanga Province. Surplus water is released into the Vaal River to flow into Grootdraai Dam, thus increasing the capacity of the Vaal River system. The IUA represents areas defined as Strategic Water Source Areas, especially that of catchment V31A.

Table 37: Water resources and catchments of IUA 1

IUA	Main Rivers	Tributaries	Quaternaries
1	Upper Buffalo	Ngogo River Harte River Thaka River Slang River Doringspruit	V31A; V31B; V31C and V31D

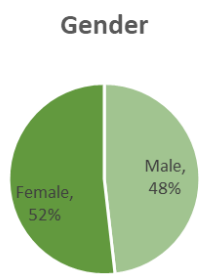
The region falls into the Mixed-Use Socio-Economic Zone with land uses transforming 17% of the landscape. Agricultural land uses represent 15% and industrial and residential the remaining 2%.

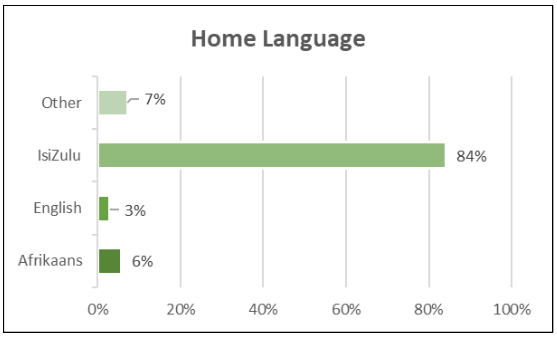
Land Transformation per category (Ha, %)



Socio-Economic Profile

The population of IUA 1 is approximately 46 051 with approximately 10 509 households. 84% of residents speak IsiZulu, 6% Afrikaans and 3% English. Only 35% of residents completed secondary school (Figure 40).





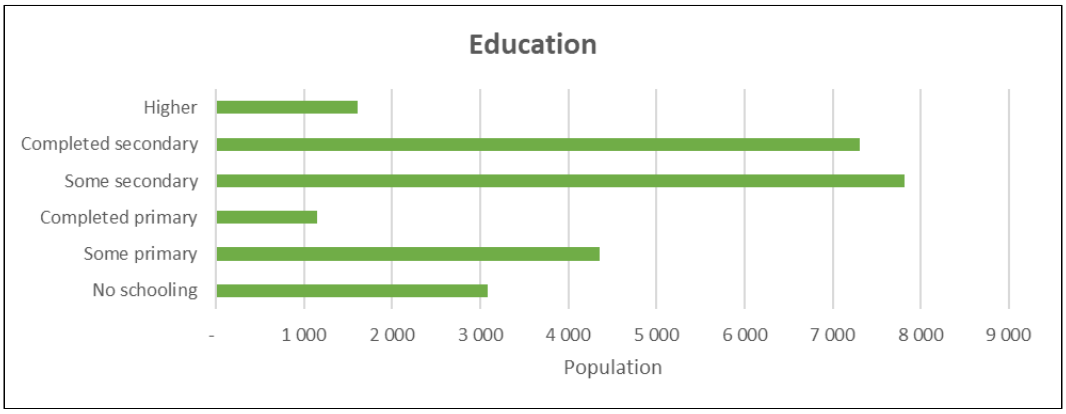
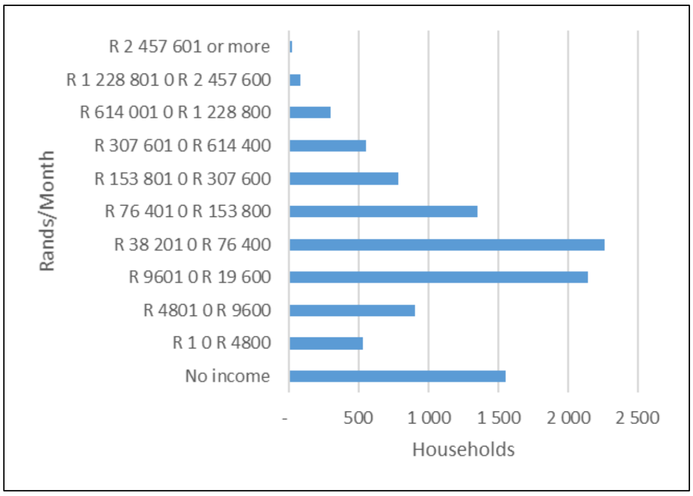


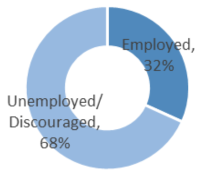
Figure 40: Demographic profile of residents in IUA 1 (StatsSA - Census 2011)

Only 32% of economically active residents are employed with 71% being employed in the formal sector (Figure 41). A relatively small proportion, 5% of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

Income



Employment



Employment Sector

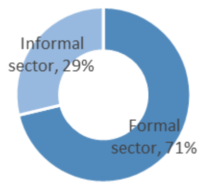


Figure 41: Economic profile of residents in IUA 1 (StatsSA - Census 2011)

Access to services varies greatly among residents with 21% having limited access to piped water (>50m away from their dwelling), 32% having no access to refuse disposal services, 30% with no flush toilets and only 23% having 24 hour access to the internet (Figure 42).

Varied access to services indicates varied levels of wellbeing throughout the catchment. A relatively high, 9%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 22% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent) (Figure 42).

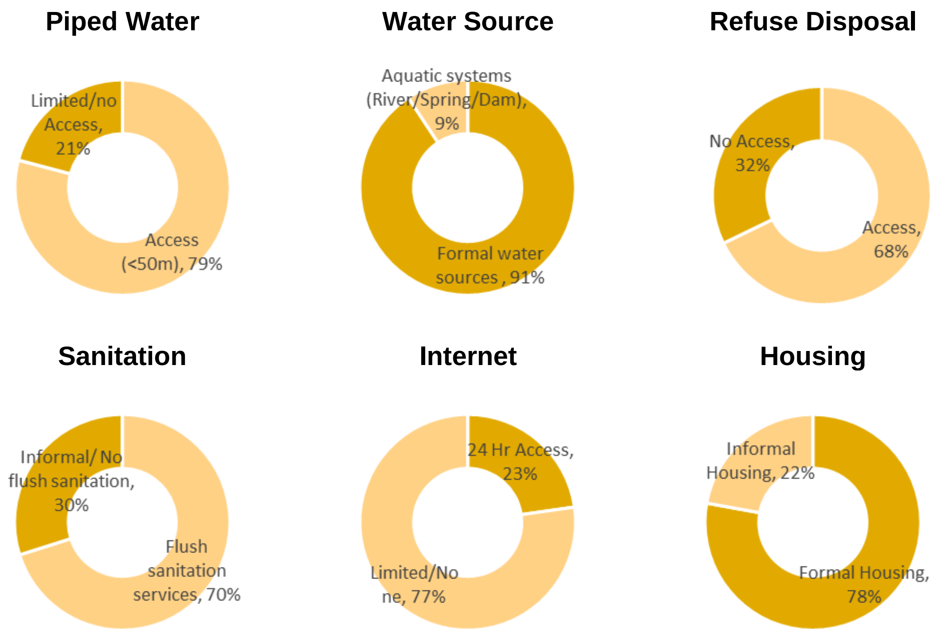


Figure 42: Access to services and indicators of wellbeing of residents in IUA 1 (StasSA – Census 2011)

Land tenure is represented by predominantly privately owned land with State and Communally owned land to a lesser degree (Figure 43).

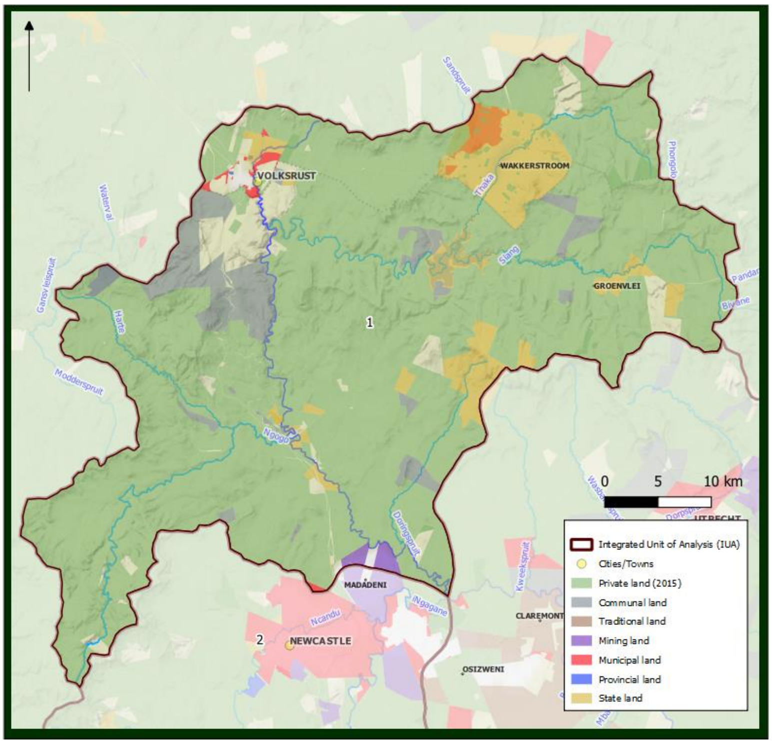


Figure 43: Land ownership within IUA 1 (DRDLR 2015)

Mixed commercial dryland and irrigated agriculture dominate the land use within the IUA which are supported by local economies around the key towns (Figure 44). Only 17% of the landscape has been transformed most of which is represented by various agricultural activities (15%).

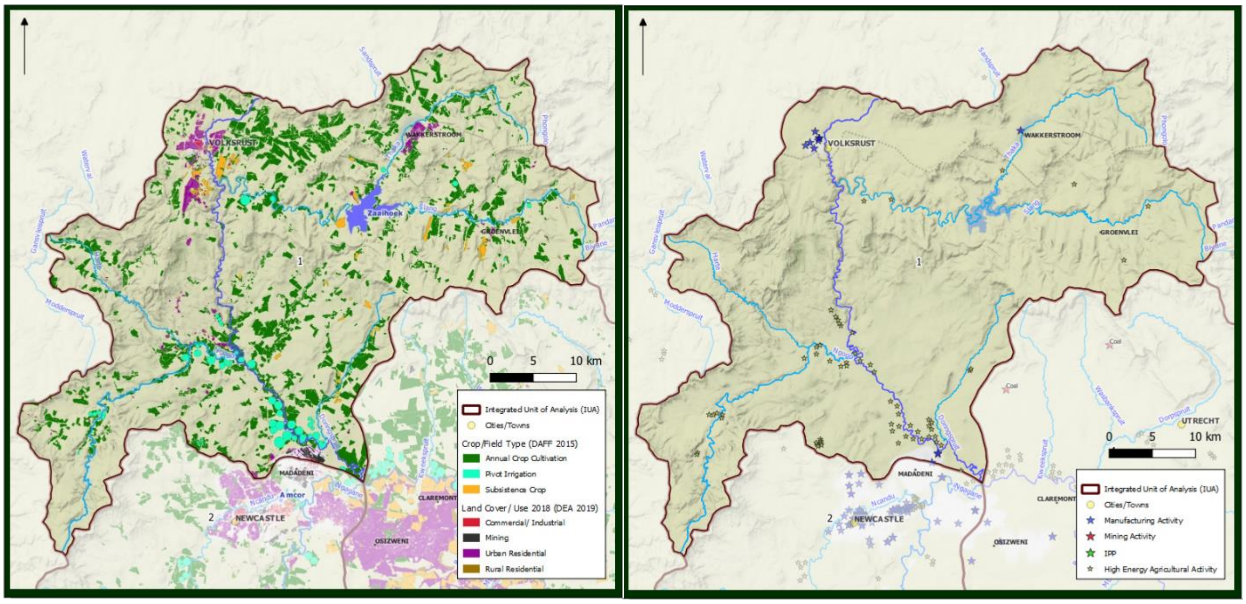


Figure 44: Land use by land cover in IUA 1(DEA 2019/DAFF 2015) and locality of high energy industries in IUA 1

The town of Volksrust represents the commercial centre of the IUA, accounting for most of the region's manufacturing and commercial activities. Irrigation for agriculture is distributed along the Buffels and Ngogo Rivers (Figure 45).

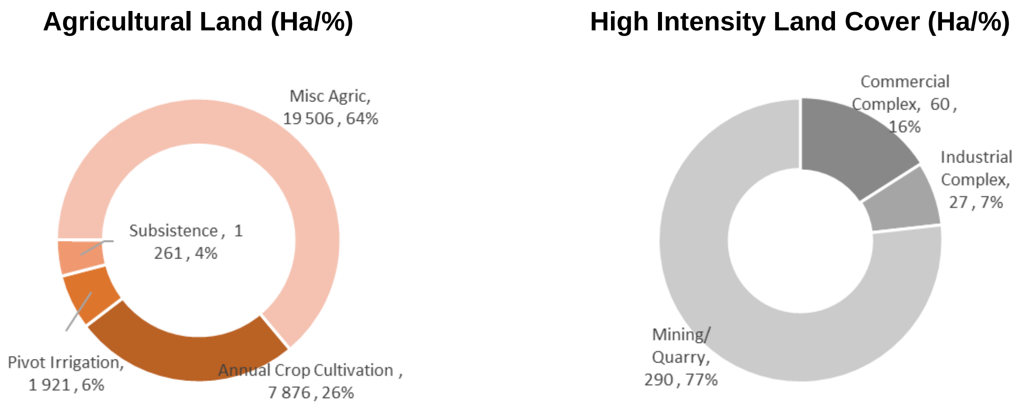


Figure 45: Classification of Agricultural Land and of High Intensity Land Cover in IUA 1

Table 38 below provides details on the municipalities which form part of IUA 1, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA. Tourism activities are centred around the birding, recreational fishing (trout fishing) and other tourism in the Wakkerstroom, Groenvlei and the Zaaihoek Dam.

Table 38: Municipalities located within IUA 1 boundaries

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 1
Pixley Ka Isaka Seme	• **Agriculture,** • Trade, • Community Services, • Construction, • Finance, • Manufacturing, • Transport, • **Utilities,** • **Mining.**	The IUA includes 6 wards (*i.e*. ward 1, 2, 3,5,6 and 10) and the towns Volksrust, and Wakkerstroom. Water demand is mainly for domestic and business use, but agricultural activities within the municipal jurisdiction are also dominant and demand huge water supply. Volksrust receive their water from Mahawane dam, near the town and Rand water is their service provider. Wakkerstroom has the richest open space system, which forms part of the wetland around the town. Wakkerstroom supply bulk water to Volksrust.
Emadlangeni	• **Agriculture;** • Trade; • Finance; • Government services; • Mining; • **Tourism**.	The IUA includes 2 wards (*i.e*. ward 1, and 4) and the town is Groenvlei. The Zaaihoek Dam located on the north eastern region of the municipality forms part of the Groenvlei wetland system. The area is part of a protected area and has limited potential for commercial production
Newcastle	• Trade; • Community services; • Finance; • Manufacturing; • Construction; • Transport; • **Agriculture**	The IUA includes 4 wards (*i.e*. ward 1, 2,5, and 31) and the town is Charlestown. Uthukela Water (Pty) Ltd is the only external service provider of the Newcastle Municipality, for which bulk water services is being rendered. The municipality major water source is the Ngagane Scheme which abstract from: Ntshingwayo Dam (80 Ml/day); Buffalo River (20 Ml/day); and Ngagane River (20 Ml/day).

Water Resource Use

This IUA is characterised by the transfer of water from the Zaaihoek Dam to the Majuba Power Station in the Vaal River System, and for support to the Grootdraai dam. While the support to the Majuba power plant may reduce due to a gradual reduction in the power plants operations, the volume of water has already been assumed to be available for greater support to the Vaal, and included in the water balance and classification of the Vaal System Water Resources. Compensation releases from Zaaihoek have been occurring, although little of this passes the abstraction for Newcastle.

Bulk and industrial water users include Wakkerstroom, Esizamelani, Volksrust, Charlestown and Vukhuzakhe.

Ecosystem Services

Situated in the northernmost extent of the catchment IUA 1 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Ngogo, Harte, Thaka and Slang River which form the headwaters of the Buffalo river (Figure 46). The landscape is characteristic of a variety of wetland systems, predominantly seeps (56%) and channelled-valley bottoms (24%) (Figure 47).

Regionally significant water resources include the Upper Buffalo River, Zaaihoek Dam and the wetlands at Wakkerstroom and Groenvlei. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 39).

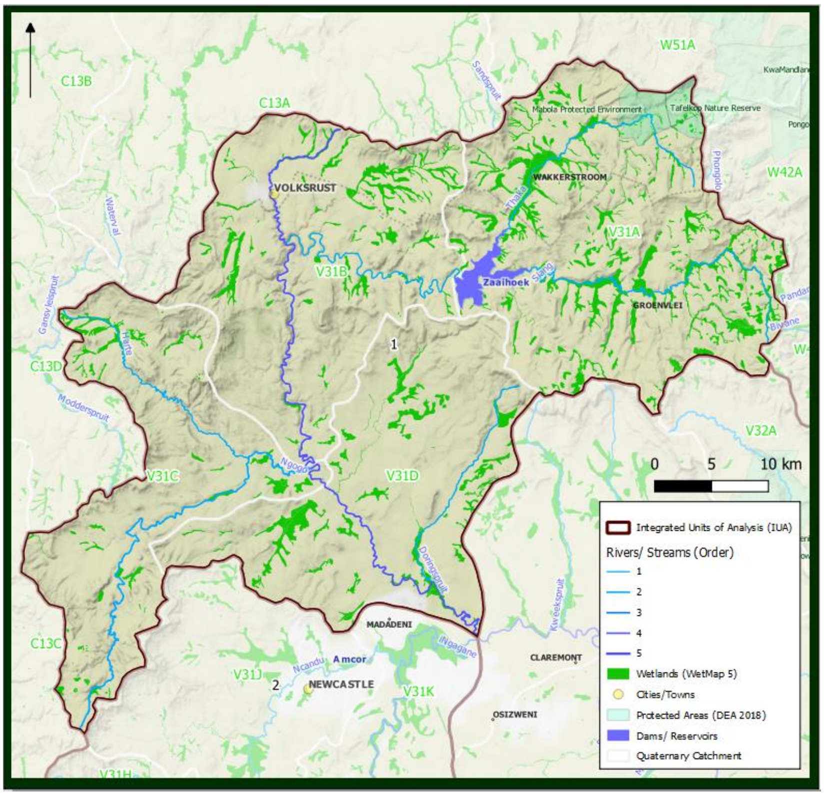


Figure 46: Locality of water resources in IUA 1

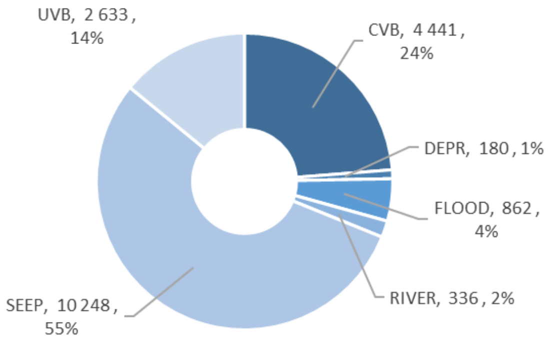


Figure 47:Wetland extent and type in IUA 1 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Flood plain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 39: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sectors in IUA 1 (relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 1	Sector (12 Sectors)
Provisioning	**Food**	Zaaihoek Dam; Rivers; Wetlands	Significance to Rural Communities in the east (Fishing, collection); Subsistence agriculture (livestock grazing)	Lower	
	Fresh Water	Zaaihoek Dam; Rivers; Wetlands	Major significance: Commercial agriculture and irrigation activity throughout the IUA; Towns and communities of Volksrust and Wakkerstroom; Limited manufacturing and industry; The Vaal catchment through water Transfers from Zaaihoek Dam	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Raw materials	Wetlands	Significance to Subsistence Farmers	Lower	
	Medicinal resources	Wetlands	Significance to Rural Communities	Lower	
Regulating	**Climate regulation**	Extensive Wetland systems	Major Significance to Global Beneficiaries	Higher	**Society**
	Water quantity regulation	Wetlands; Groundwater	Major significance: Commercial agriculture and irrigation activity throughout the IUA; Towns and communities of Volksrust and Wakkerstroom; Limited manufacturing and industry; The Vaal catchment through water Transfers	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Water purification & waste management	Wetlands; SWSA in upper Catchment	Major significance: Commercial agriculture and irrigation activity throughout the IUA; Towns and communities of Volksrust and Wakkerstroom; Limited manufacturing and industry;	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Erosion control/ Soil stability	Wetlands	Major significance to commercial agriculture sector	Higher	**Agriculture**
	Biological control	Wetlands	Major significance to commercial agriculture sector	Higher	**Agriculture; Households**
Cultural	**Landscape & amenity values**	Rivers; Protected environments/ Nature Reserves and Zaalklop Dam	Major Significance: To tourism industry and rural communities through cultural value	Higher	**Households; Tourism; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The water quality in the upstream catchment of the Buffalo River is good (V31A, V31B) on the Slang River, but with non-compliant ammonium levels. Slightly elevated salinity and nutrients is observed in the upper Buffalo River in the vicinity of the town of Volkrust (V31B), with non-compliant electrical conductivity, orthophosphate, nitrate and ammonium levels observed. Electrical conductivity concentrations in V31C are within tolerable levels, possibly due to agricultural activity in the Ngogo River catchment. However, the outflow of the Buffalo River at V31C at Schurvepoort is good with water quality at ideal and acceptable levels. The Buffalo River in V31B is a potential hot spot due to elevated nutrients/salts and WWTW discharges from Volkrust (non-compliant). No monitoring data is available for the headwaters of the Slang River (V31A).

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 1 - Upper Buffalo														
102778	V31A	10.5	10.1	101.9	14.8	0.5	2.8	6.1	8.6	0.22	0.1	8.1	0.010	12.9
102771	V31B	14.2	7.5	110.6	15.7	0.5	2.8	7.0	8.2	0.10	0.1	8.1	0.010	12.2
189704	V31B				54.2			16.8	55.0			8.3		107.1
100000982	V31B	24.4	129.7		113.8	0.4		18.0	99.4	43.21	1.9	8.9	5.40	61.1
100000983	V31B	31.2	103.3		134.7	0.4		24.6	112.6	79.10	13.2	8.6	9.60	
102750	V31C	16.6	13.9	176.9	25.3	0.7	3.3	12.6	13.9	0.11	0.2	8.3	0.010	19.4
189701	V31C				61.6			20.3	42.2			8.3		90.4
189702	V31C				67.2			21.0	44.0			8.1		117.6
189703	V31C				54.9			18.7	39.3			8.0		97.9

Rivers Ecological information and PES

Rivers are in a B and C PES ecological category driven by flow and nonflow impacts, with localised water quality issues mainly around towns. There are no EWR sites in the IUA, however a Rapid site is proposed for the biophysical node on the Upper Buffalo River just before confluence with Ngagane River.

Wetlands

IUA 1 is located in the north of the Thukela Catchment within the Grassland Biome, with roughly half of the IUA falling within the Mesic Highveld Grassland Bioregion and the remainder within the Sub-Escarpment Grassland Bioregion. Wetlands cover 16 723 ha of IUA 1, or 8.4% of the land surface, with the bulk of the wetlands (73%) falling within the Mesic Highveld Grassland Bioregion. Most of this IUA falls within the Grasslands Important Bird Area (IBA) (IBA #SA020).

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018) data summarised in Table 30, the most extensive wetland type within the IUA is Seep wetland, which makes up 59.5% of the wetland area and covers 9 947 ha. Channelled Valley Bottom and Unchannelled Valley Bottom wetlands are the next most extensive wetland type at 19.9% and 14.5% respectively. The least common wetlands within the IUA are Depression wetlands which cover only 155 hectares and make up less than 1% of the wetland area within the IUA. Floodplain wetlands make up 5.2% of the wetland habitat.

Priority Systems in IUA 1

Two Priority Wetlands, being Wakkerstroom and Groenvlei, have been identified in IUA 1. The Wakkerstroom wetland is approximately 950 ha in extent with the main body of the wetland extending approximately 9 km from its upstream end to its outlet ((Oellerman *et.al*., 1994). The wetland comprises various vegetation communities including reed marsh, Carex acutiformis marsh, sedge/bulrush marsh and wet grassland (Oellerman *et.al*., 1994). It is also known to support Crowned cranes and many other bird species including the rare White-winged flufftail (Oellerman et.al., 1994). The wetland contains peat and is thus referred to as a peatland (Grundling, et. al., 2017). In addition to the very high ecological value of the system, the wetland is likely to have other key functional values in the headwaters of the Thaka River, including, but not limited to, water quality maintenance, water storage particularly in the peat sections of the wetland, and streamflow regulation including water supply to the Zaaihoek Dam immediately downstream of the wetland. Begg (1989) rated the water storage function of the system as very important. Working for Wetlands (WfW) have carried out some rehabilitation work in the main system as well as some of the arms of the main system, including, but not restricted to, gabion and concrete weirs as well as earthwork berms (SANBI, Wetland Interventions 2012).

Groenvlei is approximately 762 ha in extent (Begg, 1989) and is the largest wetland in the catchment of the Slang River. Sections of the wetland comprise floodplain habitat and according to Begg (1989), several ox-bows and backwater areas occur in the system as a result of channel switching. Begg (1989) suggested that due to the incised nature of the system and its vegetation characteristics, water storage may not be as important a function in this system compared to, for example, the Wakkerstroom wetland. The presence of floodplain habitat suggests the system is likely to be important for flood attenuation and sediment trapping and Begg (1989) also indicates it is likely to be important for water purification. According to Begg (1989), Crowned cranes have been recorded in the system.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 40, 60% of wetlands within IUA 1 are considered to be Largely to Critically Modified (wetland condition D/E/F), with around 15.7% of wetlands in a Natural to Largely Natural condition (wetland condition A/B). Depression wetlands are generally in the best condition with 64.7% of these wetlands falling within the A/B category.

The Wakkerstroom Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel et al., 2011) indicates the main body of the wetland to be in a wetland condition of A/B. Groenvlei Priority Wetland is indicated as having a wetland condition of mostly C with some tributaries D/E/F (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel et al., 2011) indicates the main body of the wetland to be in a wetland condition of A/B.

Table 40: Wetland condition summary for IUA 1 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 1	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	1 975	2 541	5 434	233	490	2 604	322	950	1 161		1	861	100	36	19
%	19.8	25.5	**54.6**	7.0	14.7	**78.3**	13.2	39.0	**47.7**		0.1	**99.9**	**64.7**	23.4	11.9

Threats/Impacts

Land use within IUA 1 is dominated by extensive commercial agriculture with limited cultivation, though future expansion of cultivation activities is expected. Threats to wetlands include livestock utilisation (grazing and trampling) leading to erosion, while some evidence has also been presented suggesting increased water stress due to reduced runoff resulting from climate change impacts (pers. comm. B. Scholes, March 2020). At least 4 WWTW occur within the IUA that contribute to water quality deterioration, including the Wakkerstroom WWTW located just upstream of the main body of the Wakkerstroom Priority Wetland. The Working for Wetlands (WfW) rehabilitation work would likely have addressed some of the erosion impacts and the success of the interventions, and whether or not new impacts and the threats identified previously still exist today, or have increased, are unknown and will, if existing information allows, be investigated further as this study progresses and more information is collected on the Priority Wetland systems. For Groenvlei, evidence of cultivation, damming and what appears to be canalisation or draining impacts to the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap). Road crossings also appear to have had an impact on the system.

Groundwater

The groundwater characteristics in IUA 1 are as follows:

- Geology: Karoo Supergroup –
    - Beaufort (arenite and mudstone)

  - Vryheid (arenite, coal and shale)
  - Volksrust (shale).

- Dolerite intrusions: dikes and sills (Potential contact zone aquifer systems)
- Borehole yield class (Insignificant to minor: 0.1 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging (medium) 15 $mm \cdot a^{-1}$
- Groundwater quality ($mS \cdot m^{-1}$): <70. Coal mining areas present where surface water gets polluted due to acid rock drainage from abandoned mines. Expect deteriorating groundwater quality around the Volksrust-Newcastle developments.
- Groundwater Reserve status (allocations): Low risk. (SI=45%)
- Wetland present – the large Wakkerstroom Wetland (dependence on groundwater to be investigated).

9.2.2 IUA 2: Ngagane River

IUA 2 comprises the Ngagane River catchment to its confluence with Buffalo River.

Rationale

The IUA delineation is based on the land use and associated impacts in the catchment area. Rivers in a similar state due to similar land use and impacts. Hardworking catchment area with industrial, mining, agriculture and urban development. Logical break in system to just upstream confluence with the Buffalo River and catchment boundary.

Overview

IUA 2 includes the Newcastle and Dannhauser local municipalities. The IUA includes the towns of Newcastle, Dannhauser and iNgagane as well as the Ncandu Nature reserve and Chelmsford Nature Reserve (Figure 48).

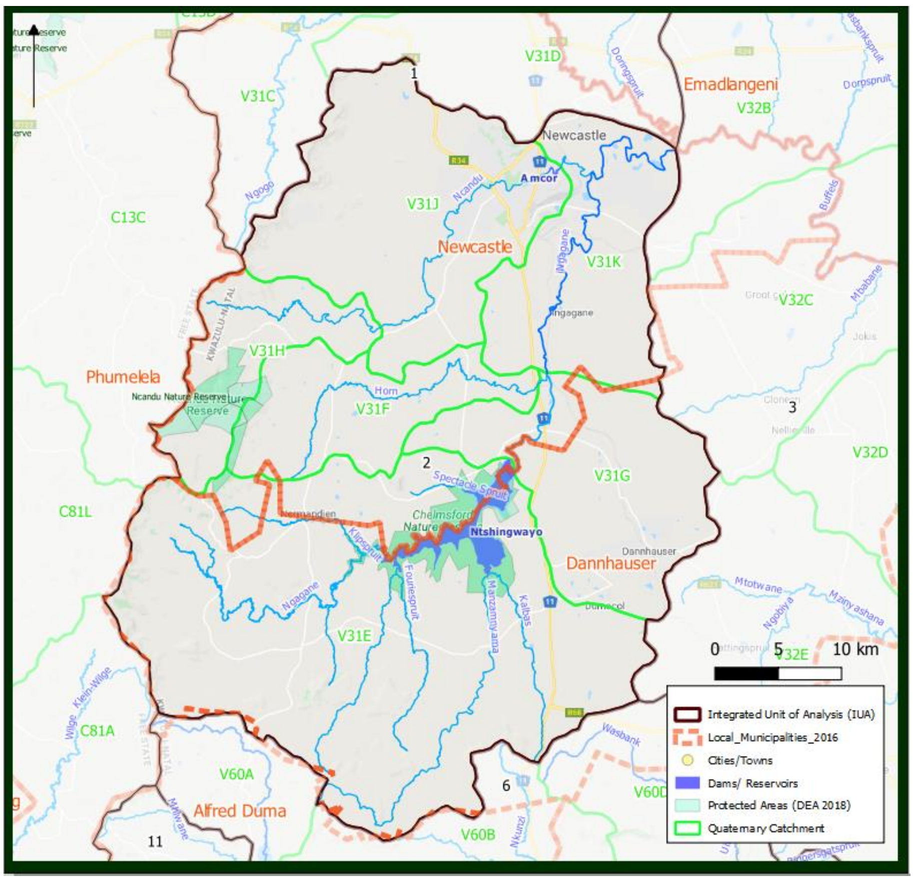


Figure 48: Overview of boundaries and features in IUA 2

Water Resources

Water resources in the IUA include the Ngagane River and tributaries (Table 41) as well as the Ntshingwayo and Amcor dams. The IUA represents areas defined as SWSAs, especially along the escarpment to the west.

Table 41: Water resources and catchments of IUA 2

IUA	Main River	Tributaries	Quaternaries
2	Ngagane River	Ncandu River; Horn River Klipspruit; Mahlomyane River; Fouriespruit; Manzamnyama River; Kalbas River	V31J; V31H; V31F; V31E; V31K; V31G

The region falls into the Mixed-Use Socio-Economic Zone with land uses transforming 23% of the landscape. Agricultural land uses represent 18% and industrial at 1% and residential at 4% (Figure 49).

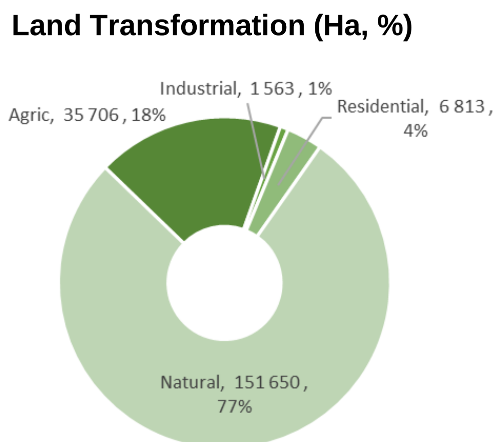
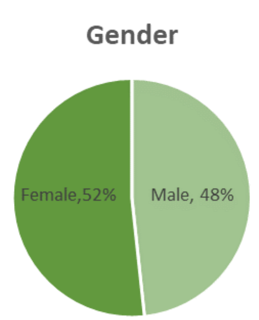
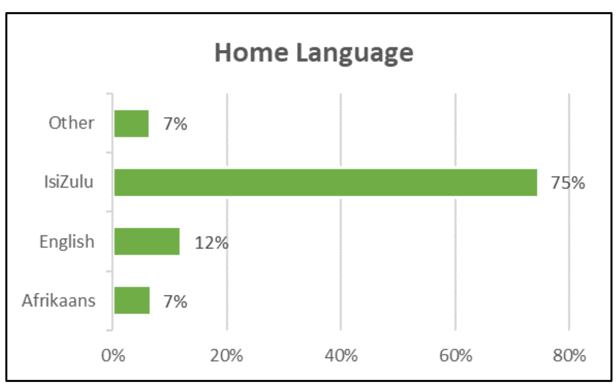


Figure 49: Land transformation per category in IUA 2 (Ha, %)

Socio-Economic Profile

The population of IUA 2 is approximately 173 661 with approximately 42 634 households. 75% of residents speak IsiZulu, 12 % English and 7% Afrikaans (Figure 50). In IUA 2 51% of residents completed secondary school.





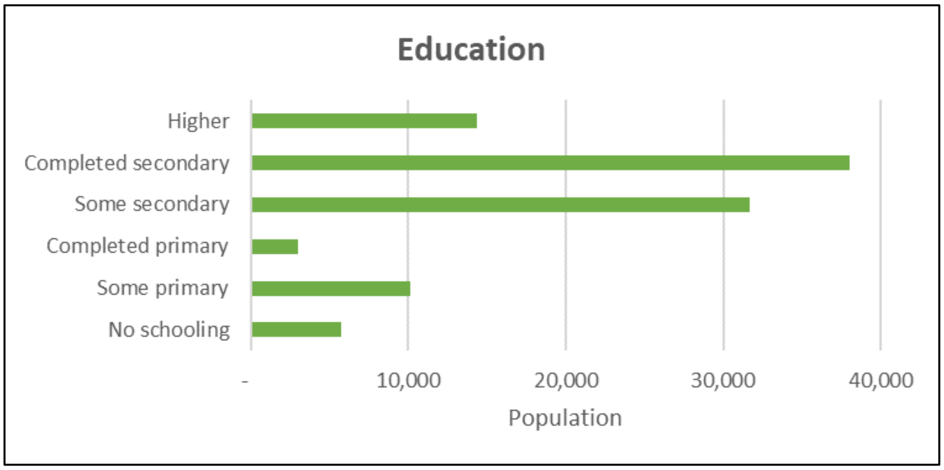


Figure 50: Demographic profile of residents in IUA 2 (StatsSA – Census 2011)

Only 34% of economically active residents are employed with 76% being employed in the formal sector (Figure 51). A relatively small proportion, 5% of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

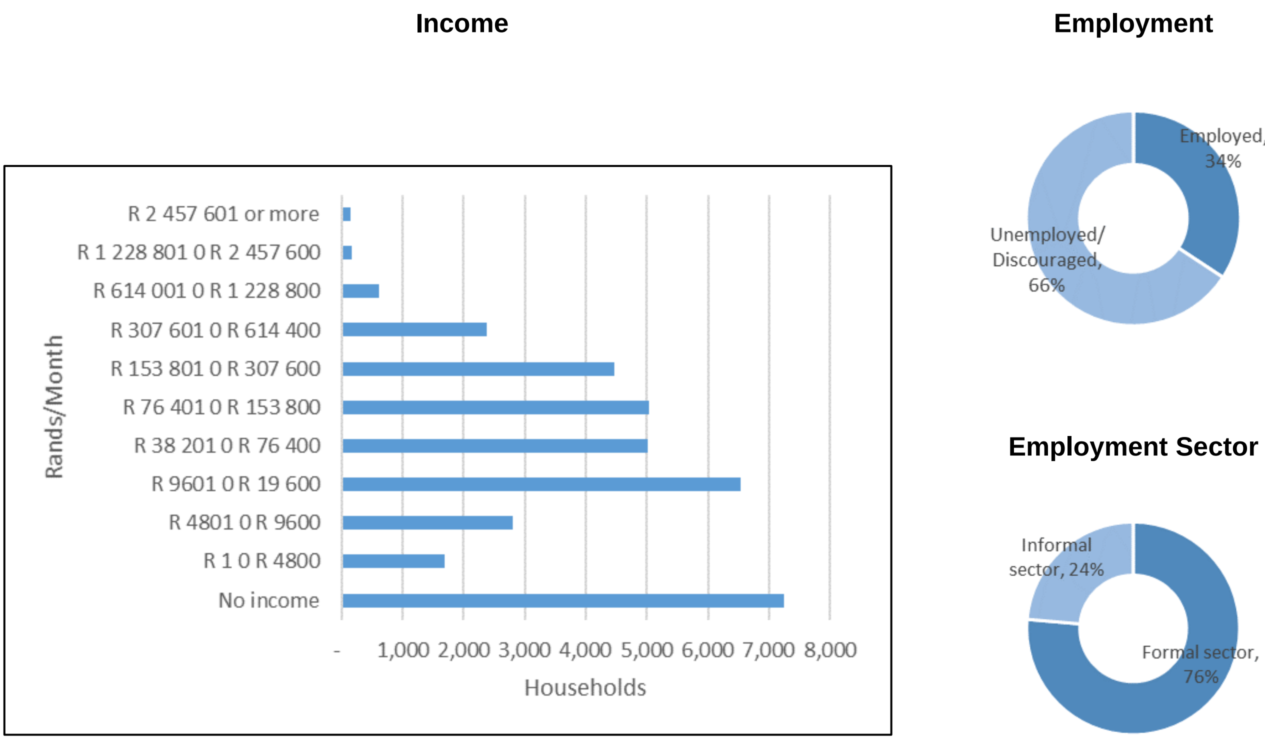


Figure 51: Economic profile of residents in IUA 2 (StatsSA – Census 2011)

Access to services varies greatly among residents with 11% having limited access to piped water

(>50m away from their dwelling), 13% having no access to refuse disposal services, 21% with no flush toilets and only 29% having 24 hour access to the internet (Figure 52). This varied access to services indicates varied levels of wellbeing throughout the catchment. A relatively low, 3%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and a small number 9% are dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

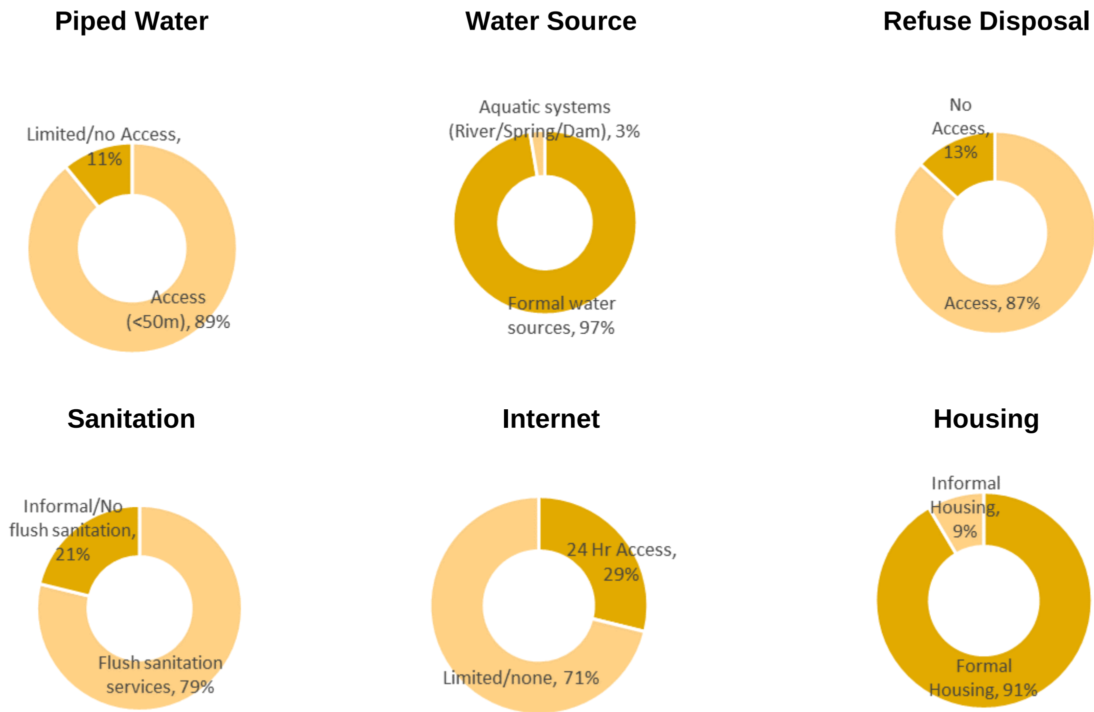


Figure 52: Access to services and indicators of wellbeing of residents in IUA 2 (StatsSA – Census 2011)

Land tenure is represented by mainly privately owned land, followed by State and Municipal land and then land owned by mines (Figure 53).

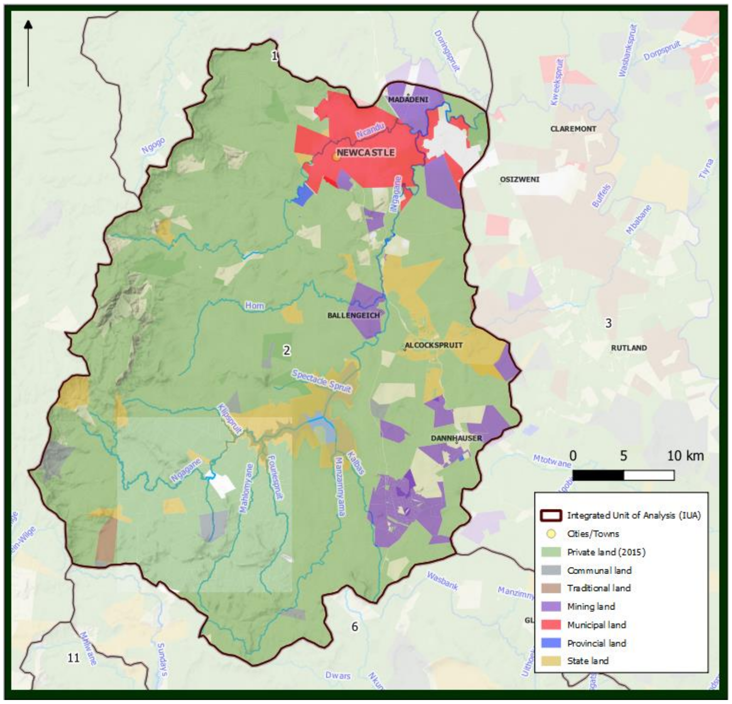


Figure 53: Land ownership within IUA 2 (DRDLR 2015)

Mixed commercial dryland and irrigated agriculture dominate the land use within the IUA which are supported by local economies around the key town of Newcastle, where there is also significant manufacturing activity (Figure 54).

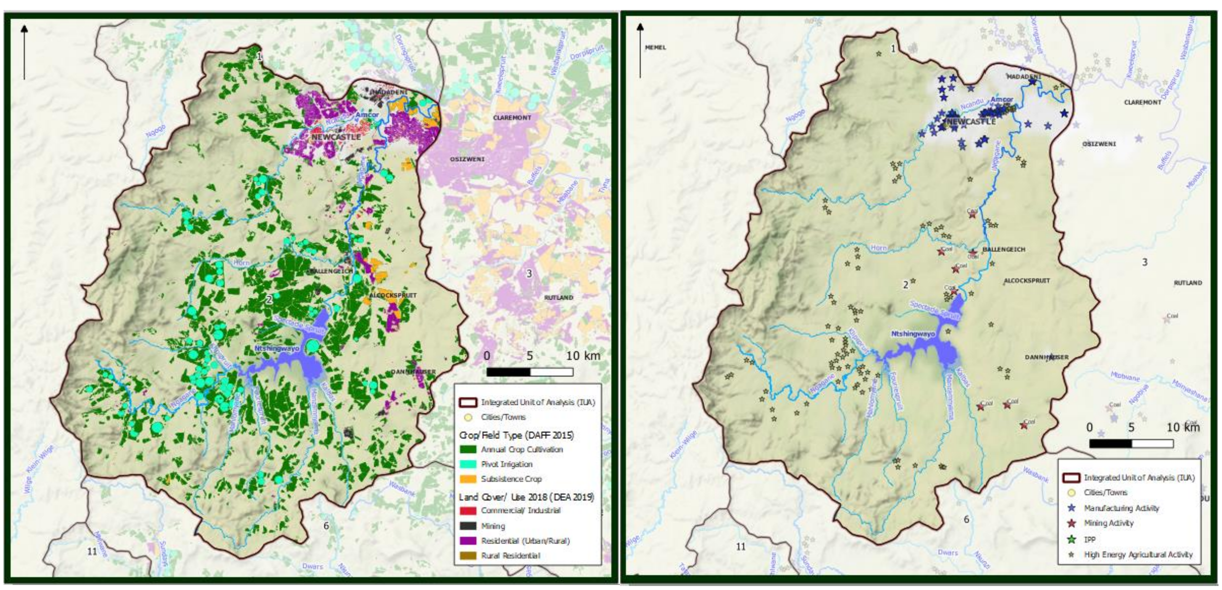
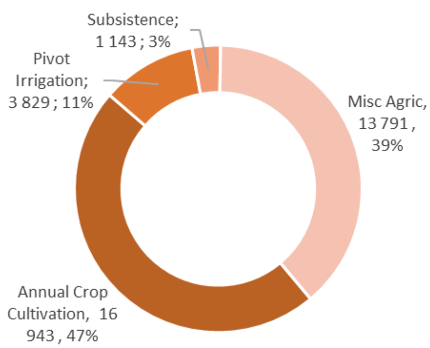


Figure 54: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 2

The land use is described in the charts below. IUA 2 can be seen to have a large area devoted to annual crop cultivation and miscellaneous agriculture. Although there is significant commercial and industrial land use, high intensity land cover appears to be dominated by mining and quarrying (Figure 55).

Agricultural Land (Ha/%)



High Intensity Land Cover (Ha/%)

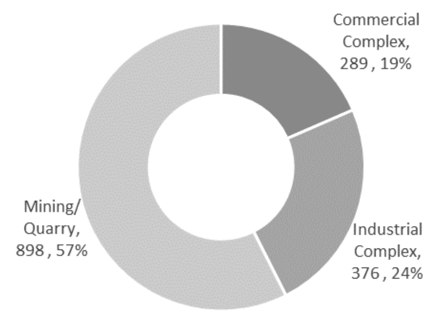


Figure 55: Classification of Agricultural Land and of High Intensity Land Cover in IUA 2

Table 42 below provides details on the municipalities which form part of IUA 2, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 42: Municipalities located within IUA 2 boundaries

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 2
Newcastle (KZN) **Wards: 1, 2, 3, 4, 5, 14, 16, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, and 31**	• Trade • Community services • Finance • **Manufacturing** • Construction • Transport • **Agriculture**	The IUA includes 19 wards. The main town is Newcastle. There is significant heavy industry activity around the commercial hub of Newcastle. This includes a large AMCOR plant. Various coal mines also operate in the southern portion of the area. Annual and pivot crop cultivation account for significant water demand of the area, along with domestic and commercial usage. Most of the area is supplied by the Chelmsford dam.
Danhauser (KZN) **Wards: 1, 2, 3 and 5**	• Community Services • **Mining** • Manufacturing • Trade • **Agriculture** • Finance • Transport • Construction • **Electricity (1%)**	The IUA includes 4 wards and the main towns are Danhauser and Durnacol. There is significant coal mining activity in the area, mainly in ward 1. This ward also has high levels of annual crop cultivation throughout the area, and pivot irrigation agriculture in the eastern section. The Chelmsford dam, or Ntshingwayo Kamahole Xhosa, falls mainly in this jurisdiction.

Water Resource Use

The water resources in the Ngagane IUA is driven by the presence and operations of the Ntshingwayo Dam. The use from the dam is increasing and there are significant plans for greater supply from the dam for domestic supply are water resource strapped areas further away. The Ntshingwayo dam does also have a flood operating rule in the summer months and makes some emergency releases during drought for abstractions downstream at Tayside for Glencoe and Dundee.

Bulk and industrial users include Durnacol/Dannhauser, Eskom, Siltec and Iscor Newcastle.

Ecosystem Services

Situated in the north-western extent of the Thukela catchment IUA 2 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Ncandu, Horn, Klipspruit, Mahlomyane, Fouriespruit, Manzamnyama and Kalbas River which form the headwaters of the Ngagane River (Figure 56). The landscape is characteristic of a variety of wetland systems, predominantly seeps (55%) and unchannelled-valley bottoms (21%) (Figure 57).

Regionally significant water resources include the Ntshingwayo Dam and Amcor Dam. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 43).

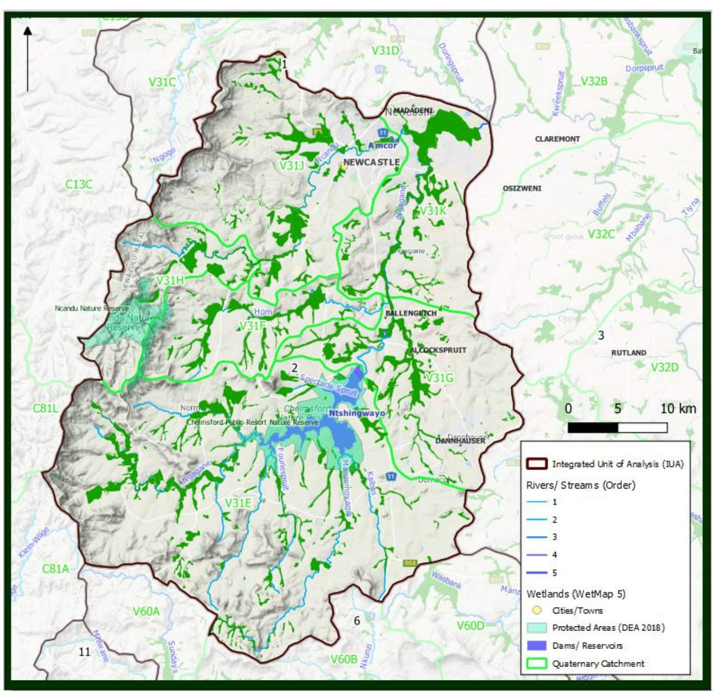


Figure 56: Locality of water resources in IUA 2

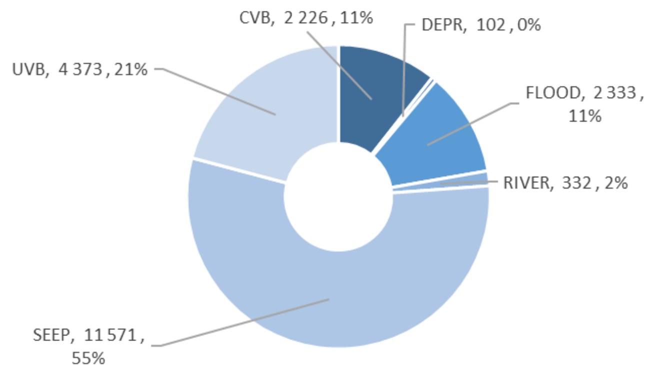


Figure 57: Wetland extent and type in IUA 2 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 43: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 2 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 2	Sector (12 Sectors)
Provisioning	**Food**	Ntshingwayo Dam; Rivers; Wetlands	Significance to rural communities and subsistence agriculture (Livestock) associated with towns of Alcockspruit;	Lower	
	Fresh Water	Ntshingwayo and Amcor Dam; Rivers;	Major Significance: Domestic water services at Newcastle and lesser degree at other towns, Industrial activities around Newcastle and Madadeni; Agricultural and irrigation throughout the catchment; Coal mining industry; to a lesser extent, rural communities associated with Alcockspruit; Subsistence Agriculture (Livestock);	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Raw materials	Wetlands	Significance to rural communities associated with towns of Alcockspruit;	Lower	
	Medicinal resources	Wetlands	Significance to rural communities associated with towns of Alcockspruit;	Lower	
Regulating	**Climate regulation**	Wetlands	Major Significance to global beneficiaries	Higher	**Society**
	Water quantity regulation	Wetlands; Groundwater; SWSA in upper catchment	Major Significance: Domestic water services at Newcastle and lesser degree at other towns, Industrial activities around Newcastle and Madadeni; Agricultural and irrigation throughout the catchment; Coal mining industry; rural communities associated with Alcockspruit; Subsistence Agriculture (Livestock);	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Water purification & waste management	Wetlands; Dams; Groundwater	Major Significance: Domestic water services at Newcastle and lesser degree at other towns, Industrial activities around Newcastle and Madadeni; Agricultural and irrigation throughout the catchment; Coal mining industry; rural communities associated with Alcockspruit; Subsistence Agriculture (Livestock);	Higher	**Agriculture; Mining; Manufacturing; Electricity and Water; Tourism; Households**
	Erosion control/ Soil stability	Wetlands; Rivers; Dams	Major significance: To the commercial and subsistence agriculture activities;	Higher	**Agriculture**
	Biological control	Wetlands; Rivers; Dams	Major significance: To the commercial and subsistence agriculture activities;	Higher	**Agriculture**
Cultural	**Landscape & amenity values**	Protected Areas (Ncandu and Chelmsford Nature Reserves); Escarpment; Ntshingwayo Dam; Rivers	Major Significance: To the tourism industry and catchment associated Towns and Communities	Higher	**Households; Tourism; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Water quality in the upper Ngagane catchment to Chelmsford Dam is relatively good, with the exception of the Horn River (V31F) and V31G and V31K which has high electrical conductivity and sulphate levels and slightly elevated pH. Tolerable and non-compliant concentrations of orthophosphate is observed in V31K. This water quality is due to impacts of the coal mining in the area, and the urban and industrial impacts from the town of Newcastle. Non-compliance to ionised ammonia is observed at a few sites in quaternary catchment V31K.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 2 - Ngagane River														
189028	V31J				26.0					0.54	7.5	7.8	0.050	
189029	V31J				31.2					0.67		7.6	0.050	
189030	V31J				29.0					0.53		7.7	0.050	
102777	V31J	25.8	20.6	259.2	33.9	0.5	10.6	9.8	23.2	0.36	0.1	8.2	0.010	27.2
102753	V31H	9.7	6.1	91.0	13.4	0.6	2.6	4.6	8.5	0.12	0.1	8.0	0.010	12.0
102754	V31F	36.9	38.7	495.8	74.1	0.7	4.5	27.6	98.1	0.12	0.1	8.6	0.010	155.3
187707	V31F	36.9	38.7	495.8	74.1	0.7	4.5	27.6	98.1	0.12	0.1	8.6	0.010	155.3
187708	V31F	40.5	31.1	117.9	45.1	0.7	3.5	22.0	19.6	0.06	0.1	8.2	0.010	60.1
187717	V31F	61.4	76.3		214.2		5.9	48.9	466.2			8.8		507.4
102770	V31E	10.5	9.4	163.9	18.0	0.7	3.0	7.1	15.0	0.48	0.2	8.1	0.012	62.8
1000011639	V31E	176.4			72.8					0.44	0.3	8.3	0.050	223.2
1000011641	V31E	76.3			20.8					0.46	0.3	8.0	0.050	34.1
1000011643	V31E	79.1			25.0					0.32	0.3	8.0	0.050	53.2
1000011645	V31E	80.2			25.5					0.29	0.3	7.9	0.050	56.0
1000011646	V31E	80.1			23.4					0.36	0.4	8.0	0.050	51.0
102772	V31E	11.0	9.3	109.4	17.5	0.5	3.2	6.0	10.5	0.13	0.2	8.1	0.010	22.0
102768	V31K											8.1		
188917	V31K	28.4	26.0	369.3	56.6	0.9	8.9	19.6	50.2	6.38	0.7	8.0	0.050	168.8
188918	V31K	28.0	11.0	313.7	61.5	0.8	2.8	25.3	25.7	1.02	0.5	7.9	0.050	166.7
189366	V31K	29.8	37.7	392.2	61.3	0.7	11.7	14.0	50.7	1.93	7.7	7.5	1.380	153.6
1000011731	V31K	24.0	22.5	275.0	46.8	0.7	5.4	15.8	33.8	1.34	0.7	7.7	0.050	124.8
1000011734	V31K	28.2	27.0	327.8	52.6	0.8	9.0	15.6	43.7	1.95	4.1	7.6	0.555	130.9
188953	V31K				103.1				137.4	34.26		8.9	0.100	
189389	V31K				71.9					9.95		7.4	4.420	
188954	V31K				74.4				127.8	1.51		9.0		
188951	V31K				108.0				113.5	21.90		8.7	0.100	
188866	V31G	52.4	12.0	1977.8	100.6	0.8	4.0	60.9	61.1	1.99	0.4	7.3	0.050	391.7
188867	V31G	11.5	13.7	170.4	25.8	0.8	3.0	9.0	17.6	0.74	0.4	7.9	0.050	64.6
188868	V31G	15.6	9.4	283.7	27.1	0.8	2.8	11.0	17.2	0.74	0.2	8.0	0.050	74.3
188872	V31G	132.0	18.2	2114.0	278.3	1.2	5.6	167.0	91.4	1.90	0.4	7.6	0.050	1492.5

Water Quality hotspot areas include*:*

Quat	River	Impact Rating	Water Quality Issue/Impact
V31F	Horn	Large	elevated nutrients/salts, mining, agriculture, acid mine drainage, erosion

Quat	River	Impact Rating	Water Quality Issue/Impact
V31J	Ncandu	Large	WWTW discharges, industrial discharges (Newcastle); urban impacts; elevated nutrients/salts
V31G (lower)	Ngagane	Moderate	elevated nutrients/salts, irrigation, mining, acid mine drainage
V31K	Ngagane	Moderate	elevated nutrients/salts, WWTWs and industrial, mining, acid mine drainage, urban impacts

River Ecological information and PES

Rivers are largely in a B and C PES ecological category. The Ncandu is in a D category and the Horn River is a seriously modified system (E PES category, one of the very few in the Thukela catchment). Rivers are driven by flow, non-flow and water quality impacts. There are no EWR sites in the IUA, however two rapid assessments were undertaken in 2013.

Wetlands

IUA 2 is located in the upper edge of the Thukela Catchment within the Grassland Biome, and the Sub-Escarpment Grassland Bioregion. Wetlands cover 20 665 ha of IUA 2, or 10.6% of the land surface. IUA 2 has the most extensive wetland habitat of all the IUA's within the Thukela Catchment. The higher lying areas of the IUA fall within the Grasslands IBA (IBA #SA020).

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 2 are Seep wetlands, which make up 56.2% of the wetland area and cover 11 620 ha. Unchannelled Valley Bottom and Floodplain wetlands are the next most extensive wetland type at 21.2% and 11.3% respectively. The least common wetlands within the IUA are Depression wetlands which cover 113 hectares and make up 0.5% of the wetland area within the IUA.

<u>Priority Systems in IUA 2</u>

No Priority Wetlands have been identified in IUA 2 at this stage.

<u>Baseline Ecological State</u>

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 32 and Table 44, more than 86% of wetlands within IUA 2 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 5.5% of wetlands in a Natural to Largely Natural condition (wetland condition A/B). Most of the different wetland types reflect the same level of extensive degradation, with Depression wetlands being generally in the best condition with 54.3% of these wetlands falling within the A/B category.

Table 44: Wetland condition summary for IUA 2 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al*., 2018). Highlights show in which condition

category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 2	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	872	1 194	9 554	24	219	1 983	169	253	3 951	3	95	2 236	61	16	35
%	7.5	10.3	**82.2**	1.1	9.8	**89.1**	3.9	5.8	**90.3**	0.1	4.1	**95.8**	**54.3**	14.5	31.3

Threats/Impacts

IUA 2 includes the towns of Newcastle and Madadeni and associated industrial and mining activities. Coal mining, industry and sprawling urban areas pose a significant threat to wetlands from a water quality and hydrology perspective. 5 WWTW are known to occur within the IUA. Other land uses occurring within the IUA and posing threats to wetlands include plantations within the higher-lying western parts and extensive agriculture and cultivation.

Groundwater

The groundwater characteristics in IUA 2 are as follows:

- Geology: Karoo Supergroup –
  - Beaufort (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale).
- Dolerite intrusions: dikes and sills (Potential contact zone aquifer systems)
- Borehole yield class (Insignificant to minor: 0.1 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging (medium) 15 $mm \cdot a^{-1}$
- Groundwater quality ($mS \cdot m^{-1}$): <70.
- Groundwater Reserve status (allocations): No risk.

9.2.3 IUA 3: Middle Buffalo

The IUA is delineated from the Ngagane River confluence to Blood River confluence and comprises the middle Buffalo River and its tributaries.

Rationale

The IUA delineation is based on the similar biophysical characteristics, ecoregion and geomorphology (lowland river that changes to lower foothills in vicinity of the Blood River confluence), as well as similar land use and associated impacts in the catchment area. It is a hardworking catchment with extensive land use and based on the catchment boundaries and SEZ it comprises a logical entity for management.

Overview

IUA 3, the Middle Buffalo IUA, includes the Emadlangeni, Endumeni and Dannhauser local municipalities (Figure 58). The IUA includes the towns of Dundee, Utrecht, Claremont, Osizweni and Rutland as well as the Balele/Enlanzeni and Utrecht Town Park Nature Reserve.

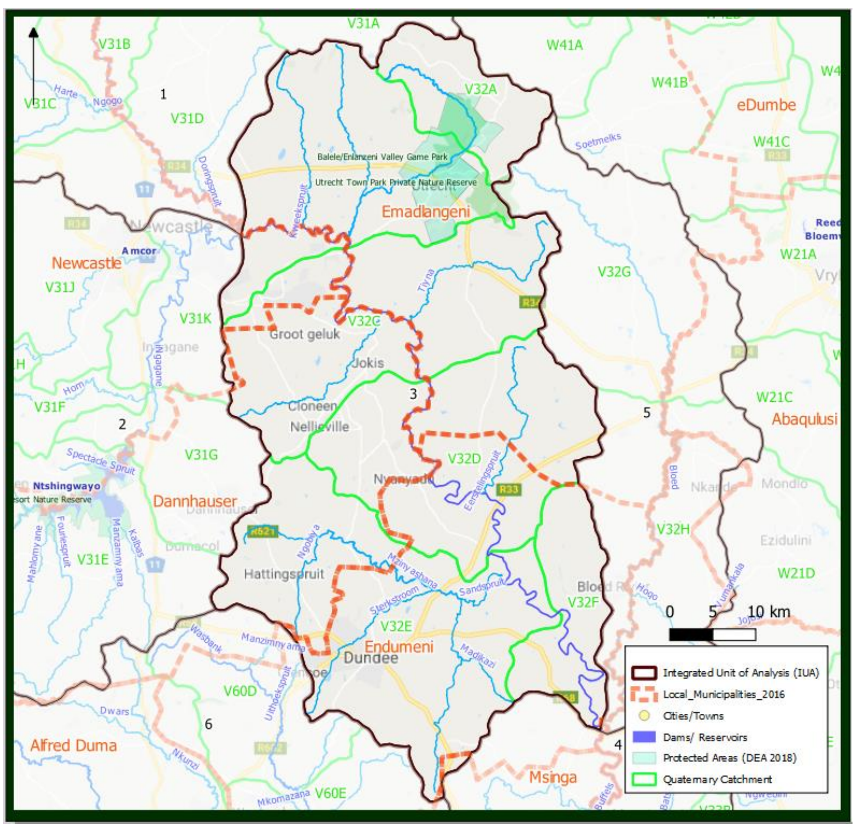


Figure 58: Overview of boundaries and features in IUA 3

Water Resources

Water resources in the IUA include the Middle Buffalo River and tributaries (Table 45). The region falls into the Mixed-Use Socio-Economic Zone with land uses transforming 31% of the landscape.

Agricultural land uses represent 23% and residential at 8% of land cover (Figure 59).

Table 45: Water Resources and catchments of IUA 3

IUA	Main River	Tributaries	Quaternaries
3	Middle Buffalo	Dorpspruit; Wasbankspruit; Kweekspruit; Tiyne River; Mbabane River; Eerstelingsruit; Mzinyashana River; Motwane River; Ngobiya River; Sterkstroom; Sandspruit; Madikazi; Doringspruit; Ngagade River	V32A; V32B; V32C; V32D; V32E; V32F;

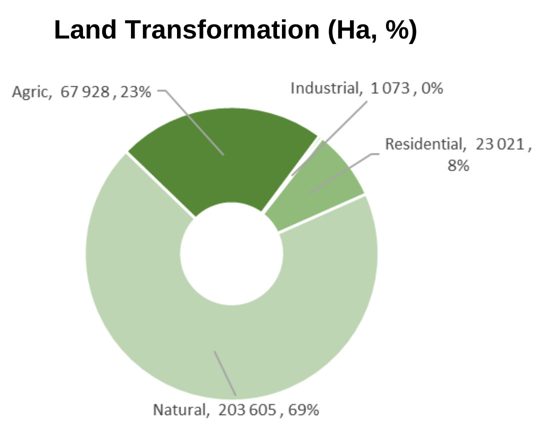
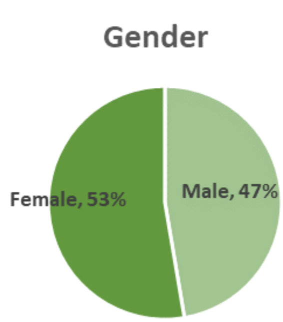
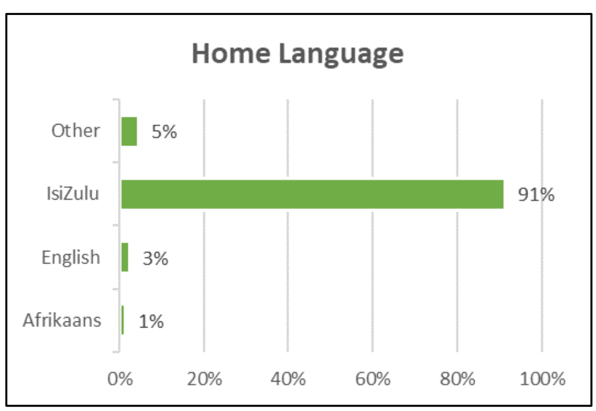


Figure 59: Land transformation per category in IUA 3 (Ha, %)

Socio-Economic Profile

The population of IUA 3 is approximately 342 959, with approximately 75 312 households. Most residents, 91%, speak IsiZulu, 3% speak English and only 1% Afrikaans (Figure 60). Only 34% of residents completed secondary school.





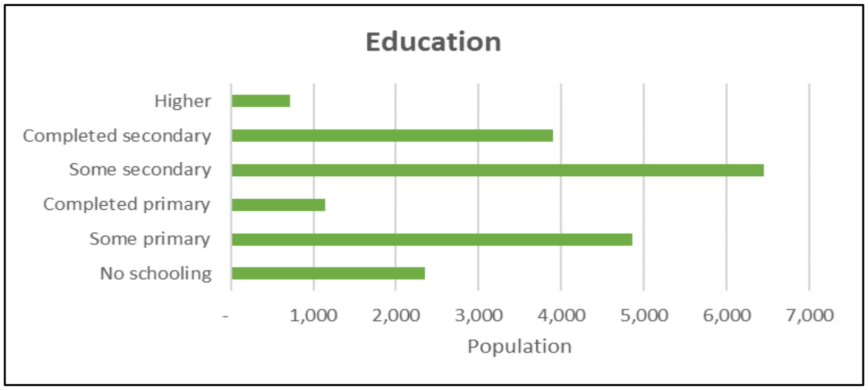
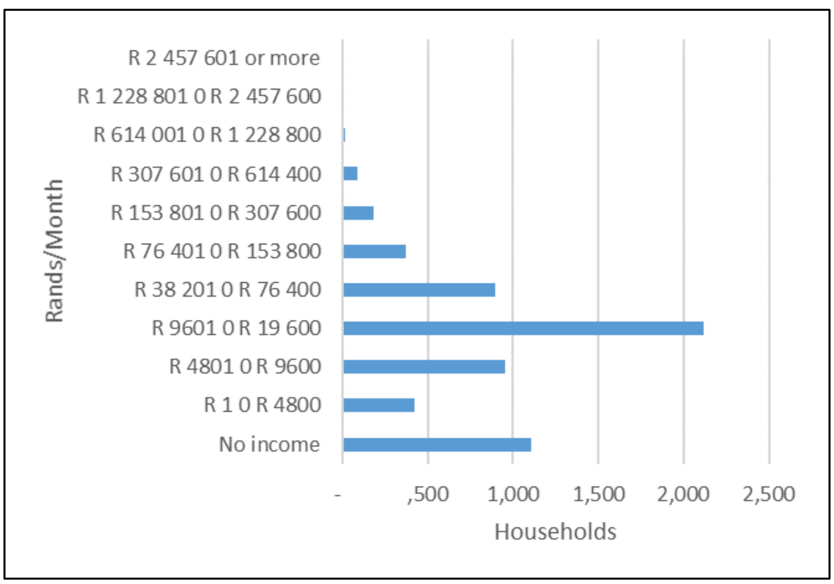


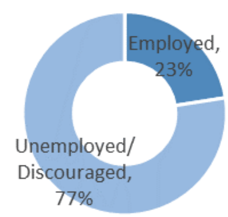
Figure 60: Demographics profile of residents in IUA 3 (StatsSA – Census 2011)

Only 23% of economically active residents are employed with 72% being employed in the formal sector (Figure 61). A relatively small proportion, 7%, of residents earn below the minimum wage (<R4800) (StatsSA-Census 2011).

Income

Employment





Employment Sector

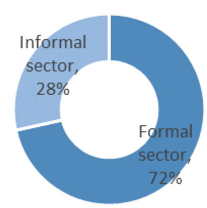


Figure 61: Economic profile of residents in IUA 3 Stats SA-Census 2011)

Land tenure is represented predominantly by privately owned land, followed by Traditional owned land and Communal owned land with State and Municipal owned Land to a lesser extent (Figure 62).

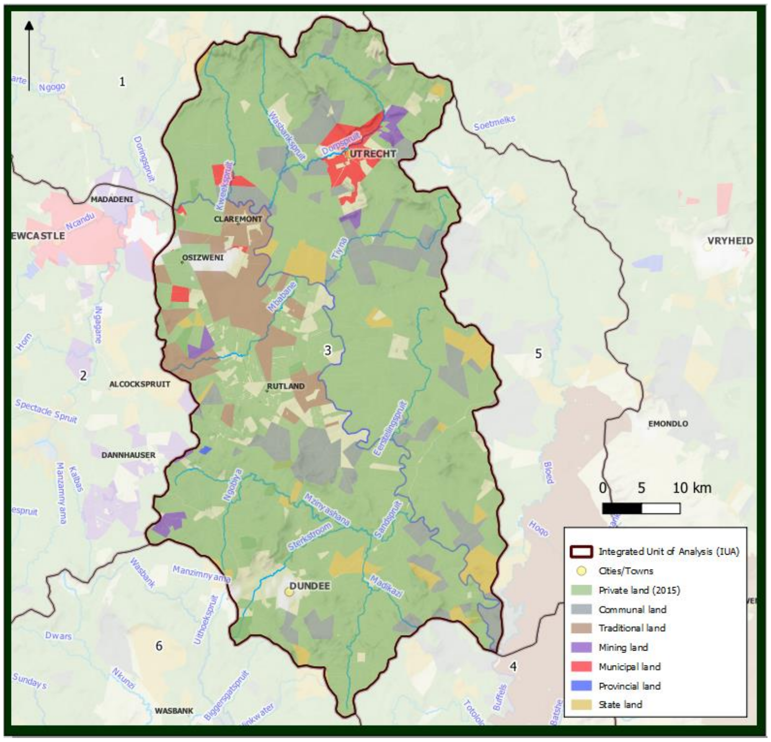


Figure 62: Land ownership within IUA 3 (DRDLR 2015)

Access to services in IUA 3 varies among residents with 27% having limited or no access to piped water (>50 m away from their dwelling), 50% having no access to refuse disposal services, a high proportion, 62%, with no flush toilets and only 18% having 24 hour access to the internet (Figure 63). Varied access to services indicated varied levels of wellbeing throughout the catchment. A relatively low, 5% of residents rely on rivers, streams and dams (impoundments) as their primary source of water and only 11% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

Mixed commercial dryland and irrigated agriculture dominate the land use within the IUA which are supported by local economies around the key town of Utrecht. Some mining and quarrying activity can also be found in this IUA (Figure 64).

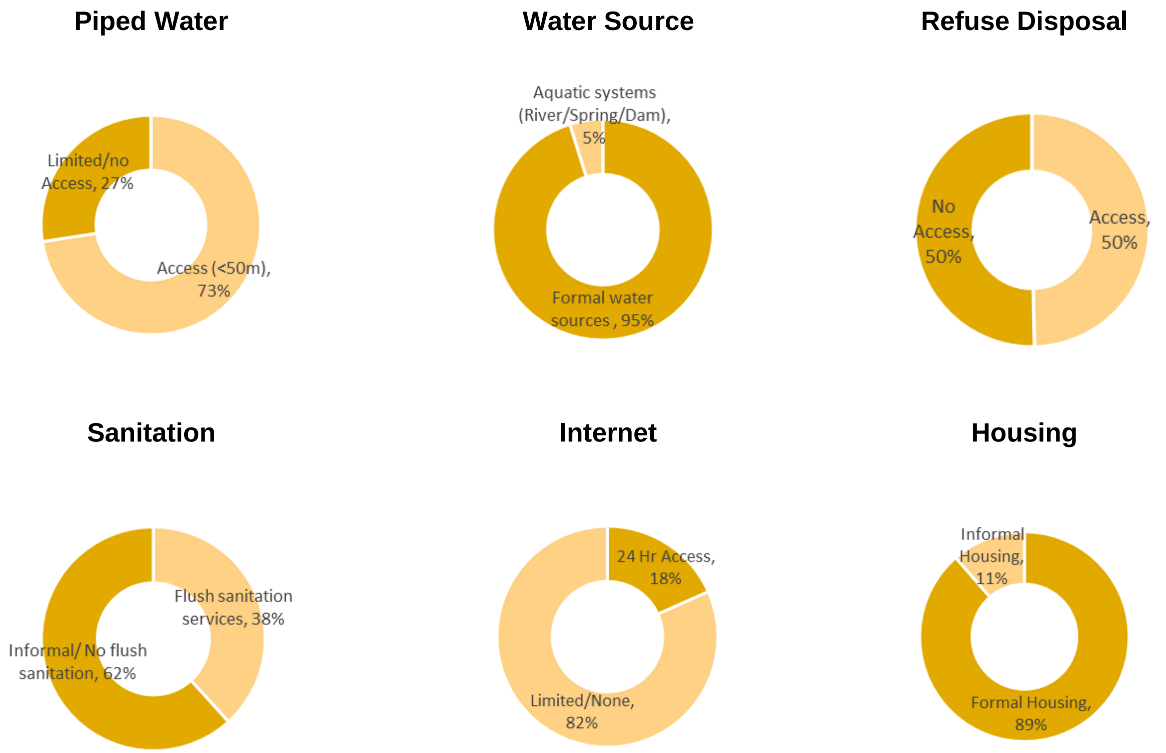


Figure 63: Access to services and indicators of wellbeing of residents in IUA (StatsSA-Census 2011)

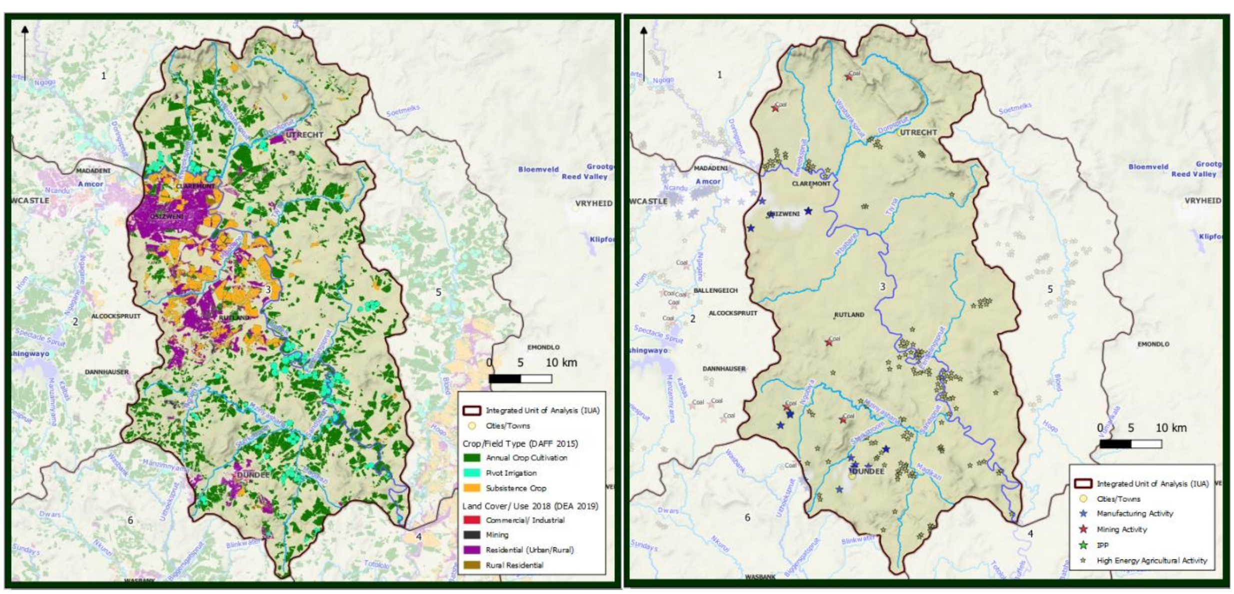
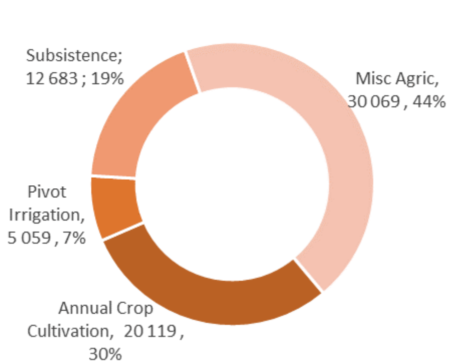


Figure 64: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 3

The land use is described in the charts below. Miscellaneous agriculture appears to be the most significant land cover in IUA 3, while pivot irrigation and residential usage appear to account for the bulk of water demand. Very little commercial or industrial activity is present in this IUA, however there are significant mining operations in the northern and south western areas (Figure 65).



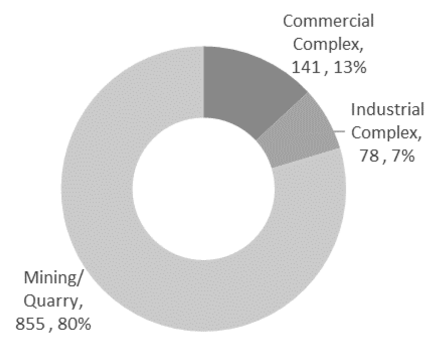


Figure 65: Classification of Agricultural Land and of High Intensity Land Cover in IUA 3

Table 46 below provides details on the municipalities which form part of IUA 3, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 46: Municipalities within IUA 3

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 3
Newcastle LM	• Trade • Community services • Finance • Manufacturing • Construction • Transport • **Agriculture**	Wards: 6, 7, 8, 9, 10, 11, 11, 12, 14, 15, 16, 17, 18, 19, 26, 27, 30, 31, 32 & 33 The rural residential and subsistence area of Osizweni and Claremont covers most of this region. Main drivers of water consumption appear to be residential.
Danhauser LM	• Community Services • **Mining** • Manufacturing • Trade • **Agriculture** • Finance • Transport • Construction • **Electricity**	Wards: 3, 4, 5, 6, 7, 8, 9, 10, 11 & 13 This area is mainly characterised by rural residential usage and subsistence agriculture areas around Rutland. There are, however, some significant coal mining operations, namely Avimore Mine near Rutland, and the Springlake colliery further south, near Hattingspruit.
Emadlangeni LM	• **Agriculture** • Trade • Finance • Government services • **Mining** • Tourism	Wards: 1, 2, 3, 4 & 5 The main town of this region is Uitrecht, with the Balele/Enlanzeni Valley Game Park and Utrecht Town Park Nature Reserve being the most prominent features. There is also a small coal operation just south of the town.

Local Municipality (LM)	**Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)**	**Relevance to IUA 3**
		Further north another Coal Mine (Uitkomst Mine) operates near a tributary of the Wasbankspruit. Some pivot irrigation agriculture can be seen on the northern bank of the Buffels Rivier, near the inflow of the Kweekspruit. The rest of the region is sparsely utilised, with scattered annual crop cultivations.
Endumeni LM (KZN)	• Trade • Private household/domestic workers • **Farming** • Manufacturing • Business services • Construction • Transport • Social services • **Mining** • **Utilities**	Wards: 1, 2, 3, 4, 5 & 6 The regional centre of Dundee, including the mining area of Glencoe fall into IUA 3. A number of tributaries to the Buffels Rivier originate in this area with some coal mining and manufacturing activities situated near the Ngobiya, Mzini Ashana and Sterkstroom Rivers, while high intensity agriculture is situated along the Madikazi. Particularly high intensity pivot irrigation appears higher up the Buffels river, around the inflow of the Eerstelingspruit.

Water Resource Use

This is predominantly a run of river system with limited to no support from the large dams upstream based on current operations. The main abstractions are those at Tayside for Glencoe/Dundee and the abstraction for wells next to the Thukela for the Nqutu area. There is also irrigation along the main stem, and releases are required in drought from Ntshingwayo. Bulk water users include Utrecht, Dundee and Glencoe.

Ecosystem Services

Situated in the north-central extent of the catchment IUA 3 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by various tributaries which flow into the Middle Buffalo river (Figure 66).

The landscape is characteristic of a variety of wetland systems, predominantly seeps (54%), riparian (16%), channelled-valley bottoms (15%) and unchannelled-valley bottoms (11%) (Figure 67). The Balele/ Enlanzeni Valley Game Park represents a regionally significant protected area. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 47).

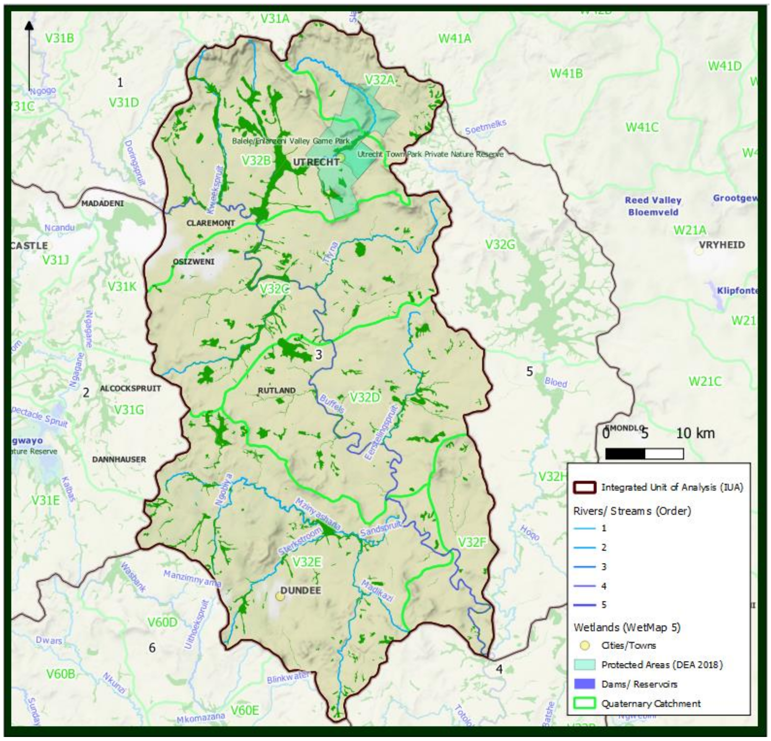


Figure 66: Locality of water resources in IUA 3

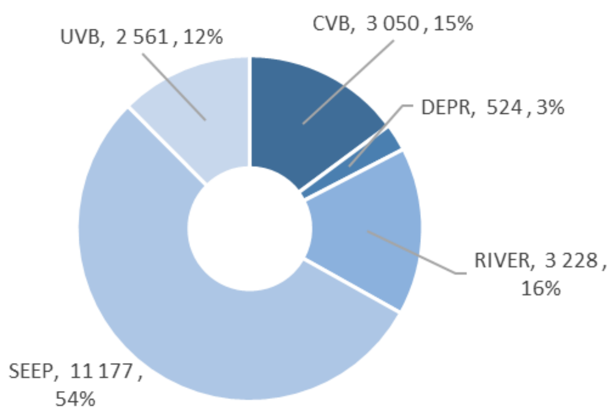


Figure 67: Wetland extent and type in IUA 3 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seep

Table 47: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 3 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 3	Sector (12 Sectors)
Provisioning	**Food**	Wetland, River	Major significance due to relatively large rural settlements associated with Osizweni and Rutland	Higher	**Households**
	Fresh Water	Rivers	Major Significance: Rural Communities associated with Osizweni and Rutland; Subsistence Agriculture (Livestock); Domestic water services at Dundee, Industrial activities around Dundee; Agricultural and irrigation throughout the catchment; Coal mining industry,	Higher	**Households; Agriculture; Manufacturing; Mining**
	Raw materials	Wetland, River	Significance due to relatively large rural settlements associated with Osizweni and Rutland	Lower	
	Medicinal resources	Wetland, River	Significance due to relatively large rural settlements associated with Osizweni and Rutland	Lower	
Regulating	**Climate regulation**	Wetlands	Significance to global beneficiaries	Lower	
	Water quantity regulation	Wetlands	Major Significance: Rural Communities associated with Osizweni and Rutland; Subsistence Agriculture (Livestock); Domestic water services at Dundee, Industrial activities around Dundee; Agricultural and irrigation throughout the catchment; Coal mining industry,	Higher	**Households; Agriculture; Manufacturing; Mining**
	Water purification & waste management	Wetlands	Major Significance: Rural Communities associated with Osizweni and Rutland; Subsistence Agriculture (Livestock); Domestic water services at Dundee, Industrial activities around Dundee; Agricultural and irrigation throughout the catchment; Coal mining industry,	Higher	**Households; Agriculture; Manufacturing; Mining**
	Erosion control/ Soil stability	Wetlands, Rivers	Significance to high level of agricultural activities, however relatively low extent of wetlands in IUA	Lower	
	Biological control	Wetlands, Rivers	Significance to high level of agricultural activities, however relatively low extent of wetlands in IUA	Lower	
Cultural	**Landscape & amenity values**	Balele/ Enlanzeni Valley Game Park and wetland systems	Major Significance centred around the Utrecht protected areas and wetland complex	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The IUA exhibits high salinity, nutrients and elevated pH, specifically in the Sterkstroom. Tolerable and non-compliant levels are observed. Elevated nutrients are also present as can be seen by the orthophosphate and ionised ammonia levels. The impacted water quality is most likely attributable to the defunct mines in the region (V32E – Sterkstroom in the Dundee area), upstream impacts from the Ngagane catchment, local towns and the agricultural practices along the Buffalo River. Non-compliant WWTWs discharges from Utrecht and other towns are also driving the water quality impact. Poor water quality is generally observed in this IUA. Monitoring data is lacking for V32A (the Upper Dorpspruit).

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 3 - Middle Buffalo														
189205	V32B				60.5					3.27		7.8	0.21	
189373	V32B				62.0					15.75		7.6	2.60	
1000003525	V32B	2.2	1.0	34.5	7.9	0.0	2.0	0.8	2.0	2.90	3.7	6.0	0.29	3.8
189204	V32B	26.0	26.1	313.8	49.7	1.0	6.7	17.1	37.1	1.89	2.7	7.6	0.39	132.7
102760	V32C	25.5	31.1	364.8	50.1	0.7	6.9	17.3	47.8	0.86	1.7	8.3	0.08	76.5
188825	V32C				57.8					4.61	2.9	8.2	0.68	
188835	V32C				53.1					2.14	2.7	9.0	0.45	
188842	V32C				55.4					4.72	2.2	8.1	0.58	
188827	V32C				78.3					13.46	2.6	7.8	2.35	
188837	V32C				93.8					18.05	3.4	7.6	2.74	
102755	V32D	31.7	35.0	395.1	57.5	0.7	7.7	21.2	59.8	0.55	1.4	8.6	0.08	103.0
189163	V32D				60.8					1.86	2.2	9.2	0.10	
1000010652	V32E				90.4					23.20		7.8	2.01	
187697	V32E	33.4	29.3	667.3	151.2	1.0	6.4	21.0	323.6	0.05	0.2	8.8	0.04	245.8
187698	V32E	49.5	29.5	311.4	49.1	0.6	6.0	24.2	36.0	0.05	0.3	8.5	0.01	94.6
187706	V32E	78.7	21.4		129.3		3.5	86.6	91.0			8.6		360.9
187711	V32E	35.7	15.6	323.6	45.7	0.8	3.7	29.7	38.0	0.05	0.2	8.4	0.01	166.5
187714	V32E	167.0	19.0		178.1		4.0	96.0	93.8			8.4		716.9
187715	V32E	104.3	31.0		161.0		3.9	96.9	242.9			8.7	291.51	
187719	V32E	103.5	29.5	1822.6	193.4	1.7	5.6	98.9	429.0	0.85	0.2	8.9	0.01	764.8
187721	V32E	46.9	22.1	695.6	81.4	0.6	4.6	40.7	102.6	0.22	0.1	8.5	0.01	163.1
187723	V32E	140.2	22.1		138.4		3.3	78.9	97.2			8.7		352.1
187724	V32E	374.3	27.3	2015.5	435.9	1.6	6.8	232.4	332.5	3.65	0.04	8.8	0.01	2814.1
187725	V32E	45.6	96.2	954.5	84.6	0.7	14.6	28.2	171.7	0.21	1.6	9.1	0.39	161.5
187940	V32E	55.4	25.1	651.5	86.0	0.5	4.6	48.7	120.6	0.03	0.2	8.8	0.01	265.5
188884	V32E				75.4					2.01	0.6	8.3	0.10	
188888	V32E	32.0	83.3	354.0	72.6	0.7	11.8	16.5	69.8	3.07	0.6	7.5	7.70	102.2
192150	V32E	26.6	147.4	335.9	82.3	0.6	20.4	14.7	91.9	0.28	0.5	8.3	0.05	68.9
192151	V32E	91.4	20.5	866.7	134.8	0.9	5.0	58.3	141.5	0.34	0.3	8.3	0.05	484.2
192154	V32E	36.9	52.3	479.0	73.6	0.6	11.0	18.7	69.2	0.26	3.4	8.0	0.26	96.7
192153	V32E	42.9	34.3	307.3	57.2	1.0	7.7	23.7	42.4	0.48	0.4	7.9	0.05	43.7
192466	V32E	41.1	50.4	431.3	73.2	0.7	7.5	22.9	74.0	0.71	0.9	8.6	0.23	98.1
1000010650	V32E				57.5					0.73		7.8	0.05	
1000010651	V32E				89.8					21.18		7.9	1.86	
88497	V32E	43.6	30.7	1297.8	168.8	1.7	6.6	20.9	373.8	1.32	0.1	8.9	0.01	306.6
188887	V32E				97.7					14.50	9.4	7.7	3.35	
1000010323	V32E	2.7	1.7	20.4	4.8	0.2	1.0	1.8	2.0	0.33	0.7	7.2	0.01	5.8
1000010562	V32F				62.5					14.34	2.5	8.3	0.31	
1000010565	V32F				66.3					3.02	1.3	8.3	0.05	
1000010567	V32F				69.9					21.67	3.6	7.8	2.38	

Water Quality hotspot areas include:

Quat	River	Impact Rating	Water Quality Issue/Impact
V32B	Dorpspruit	Moderate	WWTWs discharge (Utrecht); sand mining
V32C	Buffalo	Moderate	WWTWs discharge (Osizweni); industrial discharges; upstream impacts of Ngagane, Dorpspruit; Madadeni; elevated nutrients/salts
V32D	Buffalo	Moderate	elevated nutrients/salts, erosion, agriculture, over-grazing; WWTW discharges (Winterton)
V32E	Sterkstroom	Large	Elevated nutrients, intensive agriculture; WWTW discharges (Glencoe and Dundee); inactive and active mining, possible acid mine drainage
V32F	Buffalo	Moderate	Elevated nutrients/salts, agriculture; erosion; upstream impacts, WWTW discharges; industrial/mining, towns

Ecological information and PES

Rivers are largely in a B and C PES ecological category, driven by flow and non-flow modifications, impacting on instream habitat, continuity and wetlands. The Mbabane tributary is in a D PES category, driven primarily non-flow and water quality impacts. Localised water quality issues around the towns, mining areas and due to the agricultural activity are also resulting in modifications to ecological systems. The IUA includes an EWR site (EWR 13) at the outlet.

Wetlands

IUA 3 is located in the north of the Thukela Catchment within the Grassland Biome, and falls mostly within the Sub-Escarpment Grassland Bioregion, though the extreme north of the IUA extends into the Mesic Highveld Grassland Bioregion. Wetlands cover 17 383 ha of IUA 2, or 5.9% of the land surface, which is still more than the average wetland coverage of 4.7% across the entire Thukela Catchment. The higher lying areas of this IUA fall within the Grasslands IBA (IBA #SA020).

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018) the most extensive wetlands within IUA 3 are Seep wetlands, which make up 64.7% of the wetland area and cover 11 245 ha. Channelled Valley Bottom and Unchannelled Valley Bottom wetlands are the next most extensive wetland types at 17.5% and 14.7% respectively. The least common wetlands within the IUA are Depression wetlands which cover only 526 hectares and make up 3% of the wetland area within the IUA. No Floodplain wetlands are indicating as occurring within this IUA.

<u>Priority Systems in IUA 3</u>

Boschoffsvlei is the only Priority Wetland that has been identified in IUA 3 at this stage. Boschoffsvlei is approximately 1 850 ha in extent (Begg, 1989). According to Begg (1989), the substrate of the upper reaches of the system along the floodplain of the Wasbankspruit is dominated by clays of the Rensburg soil form while the lower reaches including the eastward extension of the system along the Dorpspruit comprise alluvial soils. Begg (1989) indicates that the hydrology of the wetland is affected by the Buffalo River due to backing up of water from the Buffalo River when it is in flood. According to Begg (1989) the road bridge on the R34 confined flow in Wasbankspruit leading to erosion of the river and a reduction in the frequency of the flooding of the system. Begg (1989) reported that a weir upstream of this was constructed to try to prevent the erosion and desiccation of the system.

From a vegetation perspective, Begg (1989) reported that the vegetation in the system varies considerably due to factors such as erosion, different land-use practices, and localised differences in hydrology and soil structure in the system. He indicated that much of the system was degraded at the time but that some wetter areas do occur characterised by sedge communities. He further reported that in less disturbed sections of the system reeds do occur. Begg (1989) indicated that the system is likely to be important for flood attenuation, sediment trapping and agriculture.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 48, 73.9% of wetlands within IUA 3 are considered to be Largely to Critically Modified (wetland condition D/E/F), with 12.1% of wetlands in a Natural to Largely Natural condition (wetland condition A/B). Channelled Valley Bottom wetlands are especially affected by degradation with 98.6% of these systems considered Largely to Critically Modified. Depression wetlands were generally in the best condition with 49.7% of these wetlands falling within the A/B category.

Boschoffsvlei Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer *et al*. 2018), though the NFEPA wetland attribute data (Nel *et al*., 2011) indicates the main body of the wetland to be in a wetland condition of C.

Table 48: Wetland condition summary for IUA 3 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 3	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	1 666	1 980	7 603	1	41	3 009	172	343	2 050				261	78	187
%	14.8	17.6	**67.6**	0.0	1.3	**98.6**	6.7	13.4	**79.9**				**49.7**	14.8	35.6

Threats/Impacts

IUA 3 includes the urban centres of Osizweni and Dundee. Landuse includes extensive areas of urban villages and subsistence agriculture associated with Osizweni, while the Dundee area supports commercial agriculture with extensive cultivation. Both commercial and subsistence agriculture have resulted in draining and clearing of wetland habitat with erosion and channel incision also being of significant concern (as noted by the high level of degradation in Valley Bottom wetland systems). 5 WWTW are known to occur.

Begg (1989) reported that Boschoffsvlei had been impacted by road crossings, furrowing, alien vegetation encroachment, and cultivation at the time. Evidence of draining, cultivation, damming, and alien vegetation invasion impacts to the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

Groundwater

The groundwater characteristics in IUA 3 are as follows:

- Geology: Karoo Supergroup –
  - Vryheid (arenite, coal and shale)
- Dolerite intrusions: dykes and sills limited to the southern part of the area (potential contact zone aquifer systems)
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging (high) ~45 $mm \cdot a^{-1}$
- Groundwater quality ($mS \cdot m^{-1}$): <70 (~45% of area) and 70-300 (55% of area) – highly impacted by redundant coal mines generating acid rock drainage. Hot spot (high TDS) areas noted in upstream area of V32E. Expect groundwater quality deterioration around the Dundee developments.
- Groundwater Reserve status (allocations): High risk (SI = 96%).
- Wetland(s) present along the Wasbankspruit (V32B). Dependence on groundwater source to be investigated.

9.2.4 IUA 4: Lower Buffalo

IUA 4 is delineated from the confluence of the Blood River confluence to the confluence of the Thukela River.

Rationale

Logical catchment entity unit from the confluence of the Blood River based on more mountainous area with geomorphology alternating between upper and lower foothills. Similar land use (rural, some irrigation and larger conservation/ tourism areas. Mainstem Buffalo and tributaries in good ecological condition due to less intensive developments.

Overview

IUA 4, the Lower Buffalo, includes the Msinga, Nqutu and Endumeni local municipalities (Figure 68). The IUA does not have large settlements with the largest being the village of Nqutu. The towns in the catchment include Vant's Drift, Rorke's Drift, Elandskraal, Mangeni and Helpmekaar. There are no protected areas or significant ecological features.

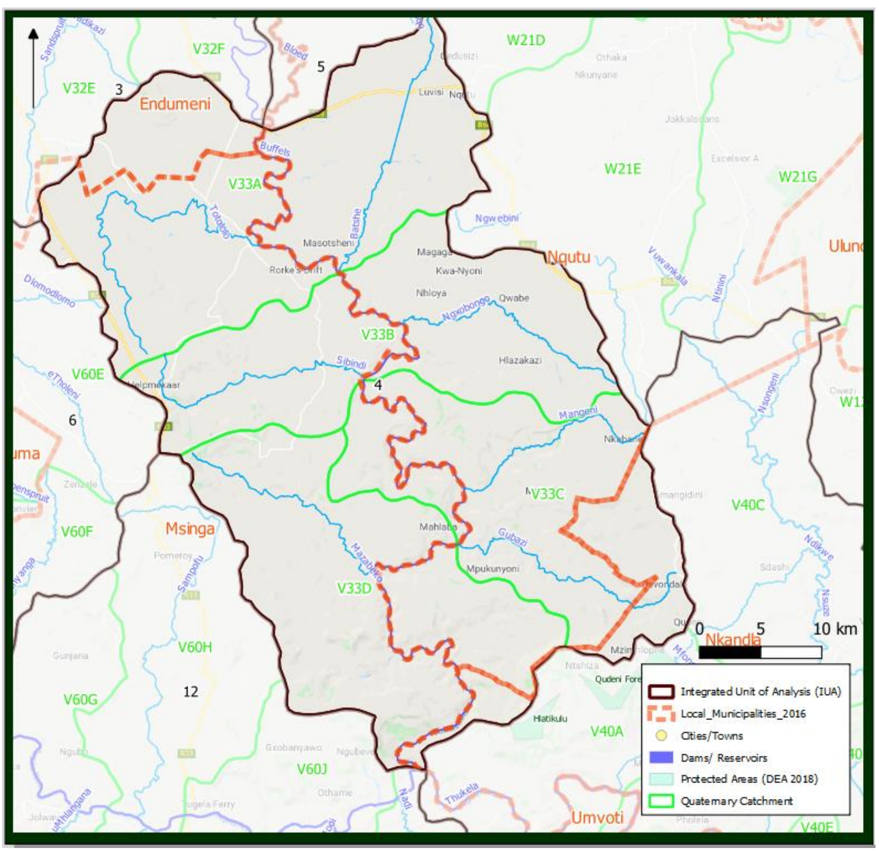


Figure 68: Overview of boundaries and features in IUA 4

Water Resources

Water resources in the IUA include the Lower Buffalo River and its tributaries (Table 49).

Table 49: Water resources and catchments of IUA 4

IUA	Main Rivers	Tributaries	Quaternaries
4	Lower Buffalo	Totololo River; Batshe River; Sibindi River; Ngxobongo River; Mangeni River; Mazabeko River; Gubazi River	V33A; V33B; V33C; V33D

The region falls into the Rural Socio-Economic Zone with land uses transforming 26% of the landscape. Agricultural land uses represent 20% and residential 6% (Figure 69).

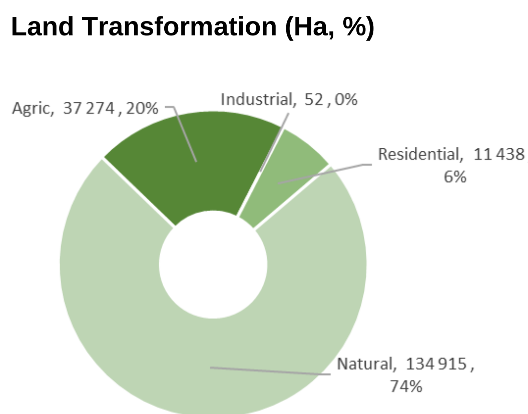
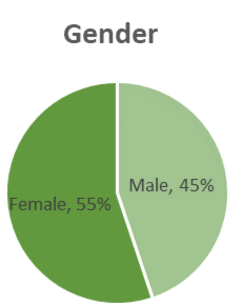
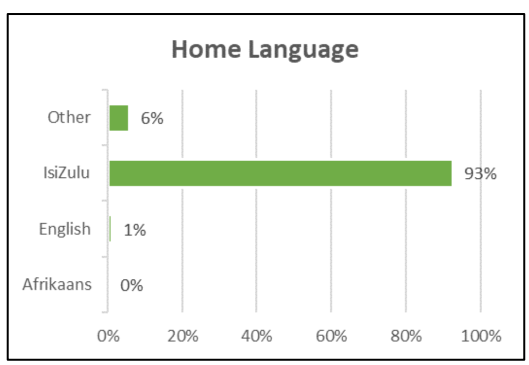


Figure 69: Land transformation per category in IUA 4 (Ha, %)

Socio-Economic Profile

The population of IUA 4 is approximately 100 993 with approximately 19608 households. Most residents in IUA 4, 93%, speak IsiZulu, 1% speak English and no residents speak Afrikaans (Figure 70). Only 23% of residents completed secondary school.





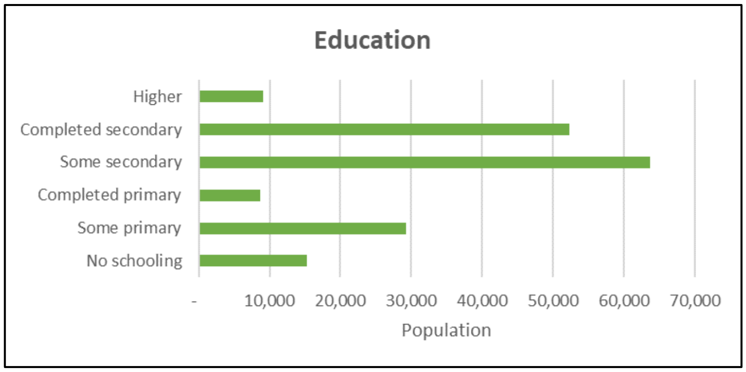


Figure 70: Demographic profile of residents in IUA 4 (Stats SA-Census 2011)

A very small proportion, 13%, of economically active residents are employed with only 69% employed in the formal sector (Figure 71). A relatively small, 7% of residents earn below the minimum wage (<R4800) (Stats SA-Census 2011).

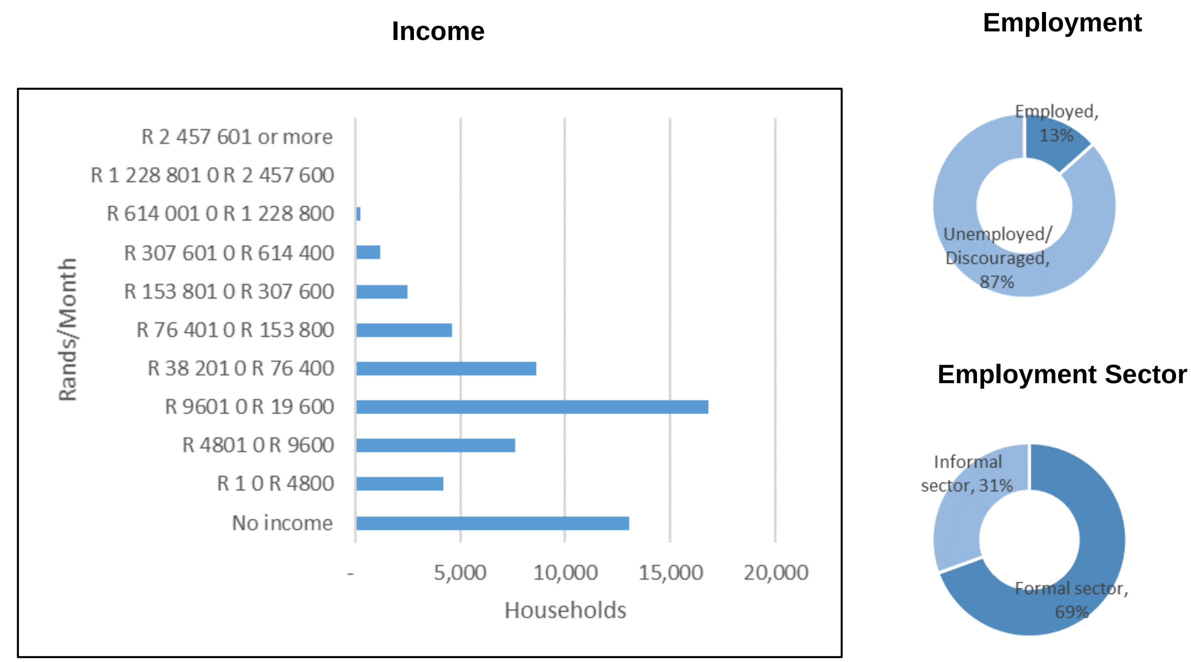


Figure 71: Economic profile of residents in IUA 4 (Stats SA-Census 2011)

Land tenure is represented by predominantly traditional owned land and communally owned land and privately owned land to a lesser degree (Figure 72).

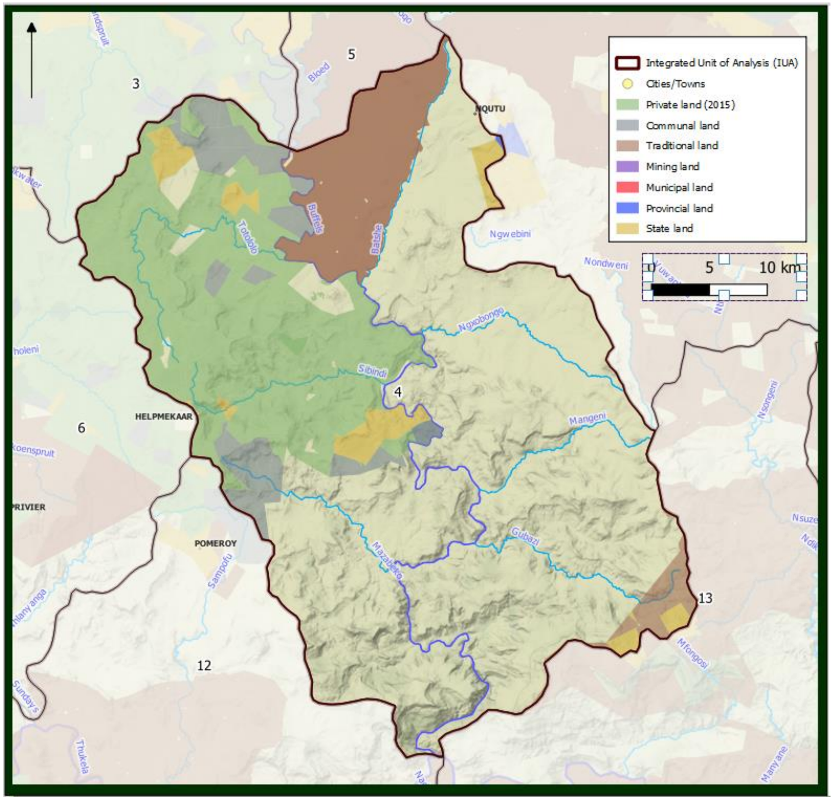


Figure 72: Land ownership within IUA 4 (DRDLR 2015)

Access to services varies greatly among residents with a large proportion, 71%, having limited access to piped water (>50m away from their dwelling), 92% having no access to refuse disposal services, 91% with no flush toilets and only a small proportion,12%, having 24 hour access to the internet. A high, 35%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and a large number, 49% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent) (Figure 73).

This IUA consists mainly of subsistence agriculture. Although no particularly high-water consumption activities are based in this IUA, the rural communities rely heavily on the ecosystem services of the region (Figure 74).

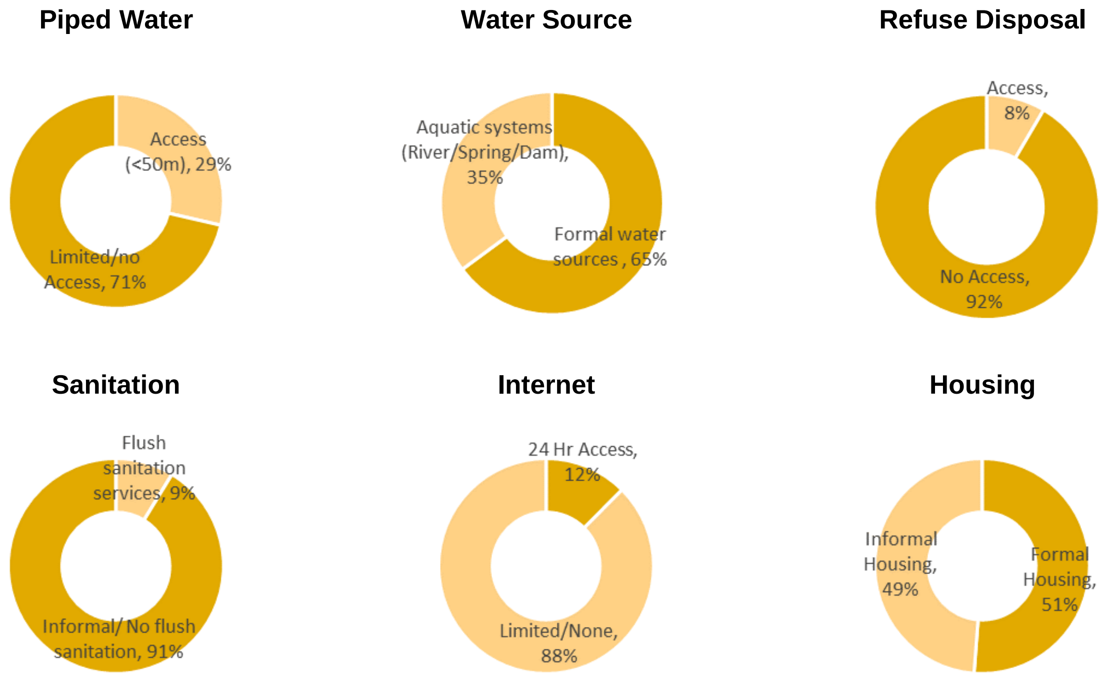


Figure 73: Access to services and indicators of wellbeing of residents in IUA 4 (StatsSA-Census 2011)

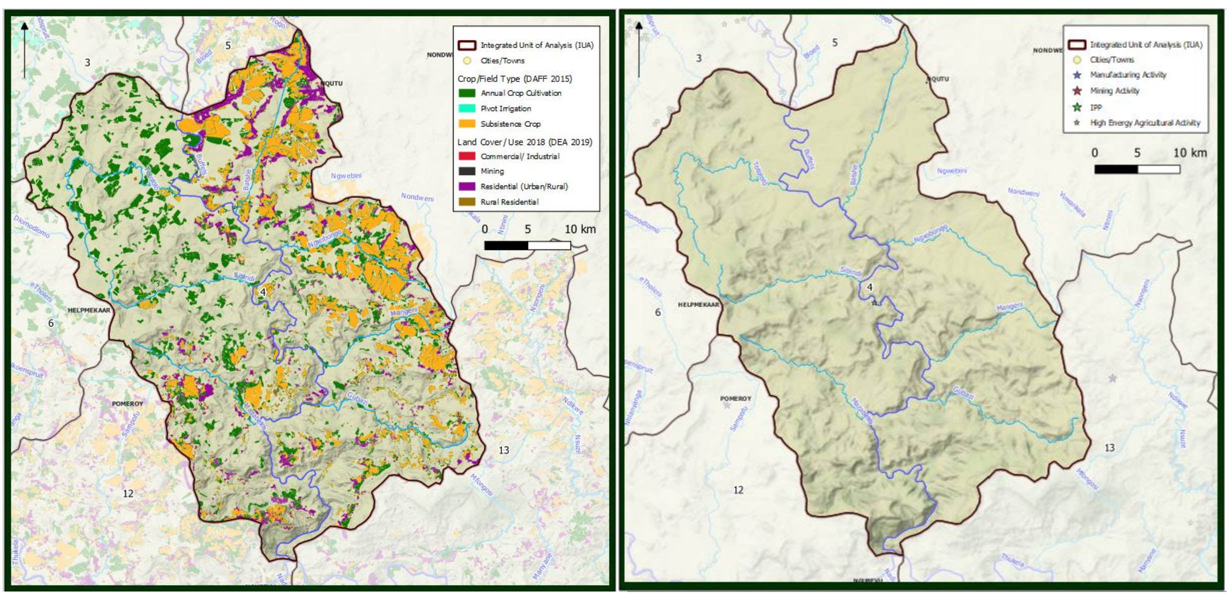


Figure 74: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 4

The land use is described in the charts below. IUA 4 exhibits some of the lowest intensity use of the whole region under study. The high proportion of subsistence agriculture, however, points to the vital importance of ecosystem services in this area. Negligible high intensity land cover is present in this IUA (Figure 75).

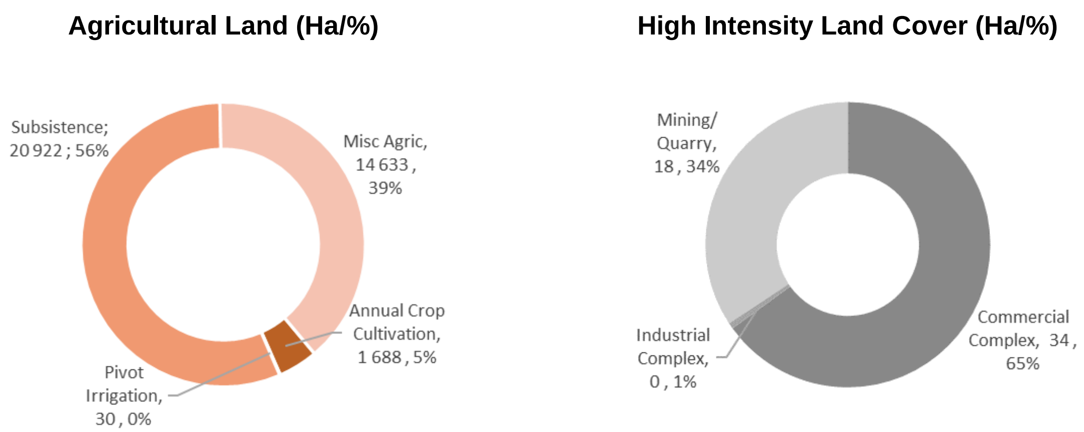


Figure 75: Classification of Agricultural Land and of High Intensity Land Cover in IUA 4

Table 50 below provides details on the municipalities which form part of IUA 4, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 50: Municipalities located within IUA 4

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 4
Nqutu LM	• Wholesale & retail trade • Government • Finance • **Agriculture** • Manufacturing • Community • Transport • **Mining & quarrying** • Construction • **Electricity**	Wards: 1, 2, 9, 10, 12, 11, 13, 14, 15 & 16 The main town of this municipality, Nqutu, falls within the north east boundary of IUA 4. Subsistence agriculture is the main economic driver of this area. Although accounting for a significant portion of this IUA, this region has no high intensity water use, aside from the rural residential and subsistence agricultural use.
Msinga LM	• Community Services • Trade • Construction • Transport	Wards: 12, 15, 16 & 18 The main settlements in the area are Rorke's Drift, and Mthaleni. Scattered annual crop cultivation is the primary consumer of water in this area. No significant high water consumption operations take place in the region. The agricultural potential of the area is very low, given the mountainous terrain.
Endumeni LM	• Trade • Private household/domestic workers • **Farming** • Manufacturing • Business services • Construction • Transport • Social services • **Mining**	Ward: 1 Similar to Nqutu, only scattered annual crop cultivation takes place here. There are no significant water consumers.

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 4
	• **Utilities**	
Nkandla LM	• Subsistence Agriculture • Informal sector	Wards: 2, 8 & 9 Making up a tiny sliver of the south eastern portion of IUA 4, this municipality has little bearing on the economic functioning of the IUA. Some scattered rural settlements with subsistence agriculture, and an insignificant amount of annual crop cultivation exist.

Water Resource Use

A dam below the confluence of the Buffalo and the Blood Rivers has been identified as a possible regional scheme for long term water supply to the region. Bulk water users include the Umzinyathi District Council.

Ecosystem Services

Situated in the central-eastern extent of the catchment IUA 4 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Totololo, Batshe, Sibindi, Ngxobongo, Mangeni, Mazabeko and Gubazi Rivers which flow into the Lower Buffalo river (Figure 76).

The landscape is characteristic of a variety of wetland systems, predominantly seeps (76%) and unchannelled-valley bottoms (11%) (Figure 77). Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 51).

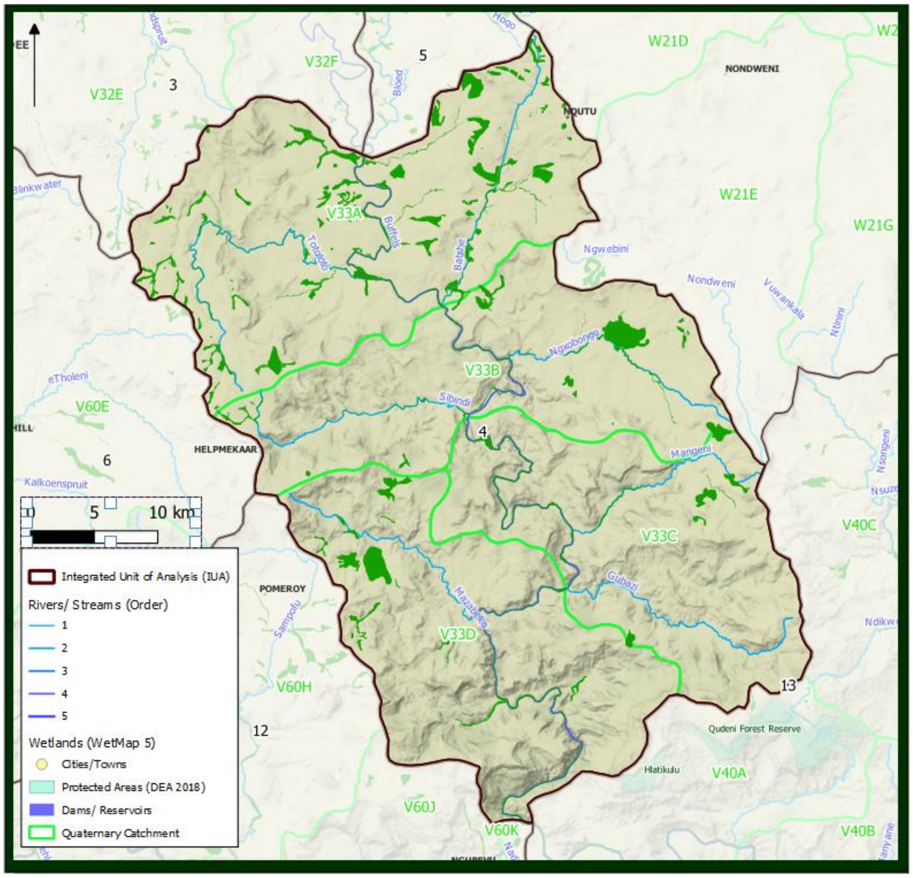


Figure 76: Locality of water resources in IUA 4

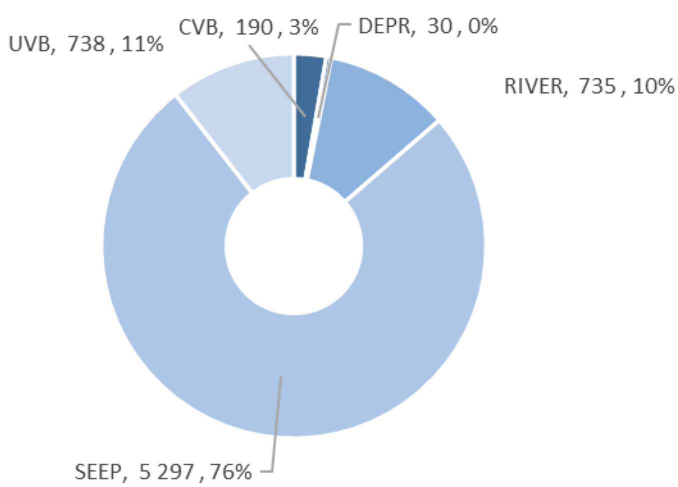


Figure 77: Wetland extent and type in IUA 4 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 51: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 4 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 4	Sector (12 Sectors)
Provisioning	**Food**	Low wetland extent	Major Significance: Highly rural undeveloped catchment; High level of subsistence agriculture.	Higher	**Households**
	Fresh Water	Rivers; Lower extent of wetlands	Major Significance: Highly rural undeveloped catchment; High level of subsistence agriculture; 35% of residents rely directly on natural sources of water; Some annual crops (potentially commercial)	Higher	**Households; Agriculture**
	Raw materials	Low wetland extent	Major Significance: Highly rural undeveloped catchment; High level of subsistence agriculture.	Higher	**Households**
	Medicinal resources	Low wetland extent	Significance- No direct data- Highly rural undeveloped catchment; High level of subsistence agriculture.	Lower	
Regulating	**Climate regulation**	Low wetland extent	Minor significance to global beneficiaries; Perceived low terrestrial quality likely reduces flow	Lower	
	Water quantity regulation	Low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service	Lower	
	Water purification & waste management	Low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
	Erosion control/ Soil stability	Low wetland extent; Poor condition of terrestrial habitat structure	Observed high extent of erosion likely further reduces flow of services	Lower	
	Biological control	Low wetland extent	Minor significance to rural communities: relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
Cultural	**Landscape & amenity values**	Rivers; Low wetland extent; no protected areas	Major Significance to highly rural landscape. The high reliance on natural systems likely translates into increased value and cultural connection; Limited identified tourism or recreational services.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The water quality in IUA 4 has tolerable levels of electrical conductivity and orthophosphate and high pH. Impacts from agricultural activity is evident. Additional monitoring is required in this lower reach to obtain a better perspective of water quality. No water quality hotspots have been identified. A data gap exists for V33C andV33D the lower Buffalo and tributaries, as no monitoring is undertaken.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 4 - Lower Buffalo														
102749	V33A	26.8	24.3	239.0	63.5	0.9	6.8	16.8	42.5	2.49	1.1	8.6	0.100	103.0
189586	V33A				63.4					2.43	1.5	8.5	0.103	
195401	V33B											8.0		

River Ecological information and PES

Rivers are largely in a B and C PES ecological category. The upper reach of the Buffalo (B33A), Batse and Ngxobongo tributaries are in a D PES category, driven by flow and non-flow impacts, with localised water quality issues and from the upstream catchment. This IUA includes an EWR site (EWR 14) at the outlet. The lower portion of the Buffalo before its confluence with the Thukela is in a good ecological condition.

Wetlands

IUA 4 is located in the central reach of the Thukela Catchment within the Grassland and Savanna Biomes, and falls mostly within the Sub-Escarpment Grassland Bioregion, though a significant portion of the lower reaches in the IUA extends into the Sub-Escarpment Savanna Bioregion. Wetlands cover only 6 181 ha of IUA 4, or 3.4% of the land surface, which is less than the average wetland coverage of 4.7% across the entire Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018) the most extensive wetlands within IUA 4 are again Seep wetlands, which make up 84.4% of the mapped wetland area and cover 5 216 ha. Unchannelled Valley Bottom and Channelled Valley Bottom wetlands are the next most extensive wetland types at 12.1% and 3.1% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 28 hectares and make up less than 1% of the wetland area within the IUA. The National Wetland Map 5 (Van Deventer *et al.,* 2018) identified no Floodplain wetlands within this IUA.

Priority Systems in IUA 4

No Priority Wetlands have been identified in IUA 4 at this stage.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 52, 72.9% of wetlands within IUA 4 are considered to be Largely to Critically Modified (wetland condition D/E/F), with 11% of wetlands in a Natural to Largely Natural condition (wetland condition A/B). Seep wetlands are especially affected by degradation with 79% of these systems considered Largely to Critically Modified. Depression wetlands were generally in the best condition with 60.8% of these wetlands falling within the A/B category.

Table 52: Wetland condition summary for IUA 4 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al.,* 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 4	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	450	646	4 121		162	28	210	189	347				17	6	5
%	8.6	12.4	**79.0**		**85.5**	14.5	28.1	25.4	**46.5**				**60.8**	20.9	18.3

<u>Threats/Impacts</u>

Large parts of IUA 4 are characterised by urban villages and subsistence agriculture associated with the greater Nqutu area and other rural areas. Threats to wetlands are related to clearing and transformation of wetland habitat and erosion.

Groundwater

The groundwater characteristics in IUA 4 are as follows:

- Geology: Karoo Supergroup –
  - Pietermaritzburg (shale)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
  - Dwyka (arenite, tillite, mudstone and shale)
- Dolerite intrusions: Only sills (cap rocks)
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging (high): 45 $mm \cdot a^{-1}$
- Groundwater quality ($mS \cdot m^{-1}$): <70.
- Groundwater Reserve status (allocations): No risk (SI = 22%)

9.2.5 IUA 5: Blood River

The Blood River drainage region is delineated as IUA 5.

Rationale

Logical entity around catchment boundary, limited land use and biophysical characteristics of the area. This IUA is mainly a wetland system with extensive rural areas in the lower reaches. Subsistence farming with high dependence on the natural water resources.

Overview

IUA 5, the Blood River IUA, includes the Emadlangeni, Abaqulusi, Nqutu and Endumeni local municipalities (Figure 78) and the small towns of Kingsley, Ntabebonvu and Bloedrivier. The IUA is not characteristic of any major communities or protected areas.

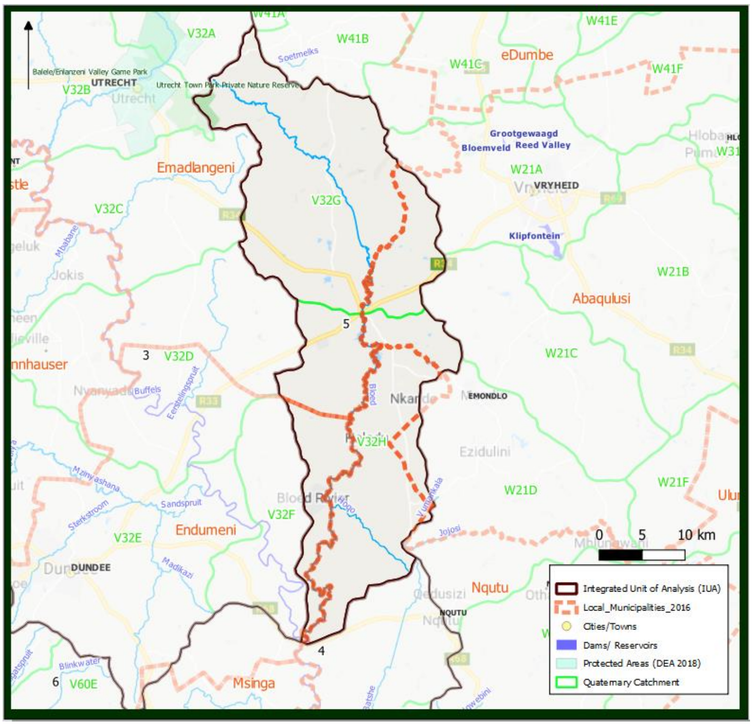


Figure 78: Overview of boundaries and features in IUA 5

Water Resources

Water resources in the IUA include the Blood River and its tributary the Hoqo River (Table 53). Key ecological features in the catchment are the extensive wetland systems midway down the Blood River.

Table 53: Water Resources and catchments of IUA 5

IUA	Main River	Tributaries	Quaternaries
5	Blood River	Hoqo River	V32G; V32H

The IUA straddles the Mixed-Use and Rural Socio-Economic Zone with land uses transforming 37% of the landscape. Agricultural land uses represent 33% and industrial and residential the remaining 4% (Figure 79).

Land Transformation (Ha, %)

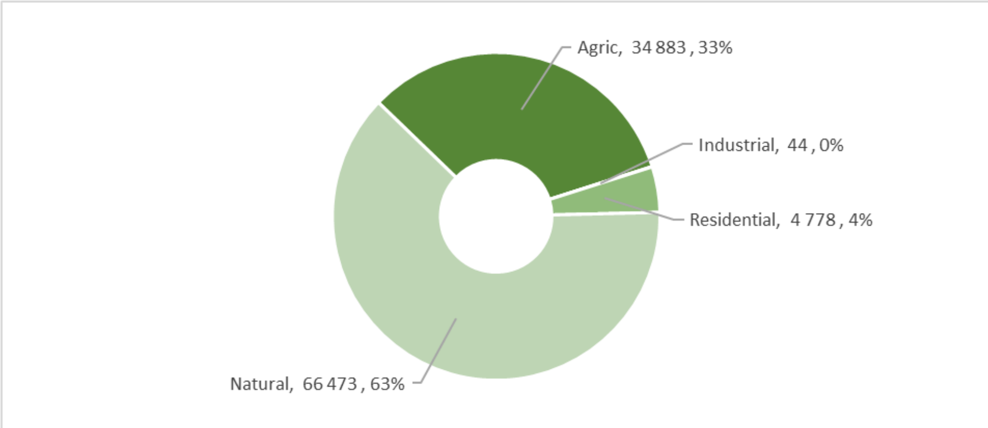


Figure 79: Land transformation per category in IUA 5 (Ha, %)

Socio-Economic Profile

The population of IUA 5 is approximately 41 759 with approximately 8 305 households. 80% of residents speak IsiZulu, 2% English and 1% Afrikaans (Figure 80). Only 24% of residents completed secondary school.

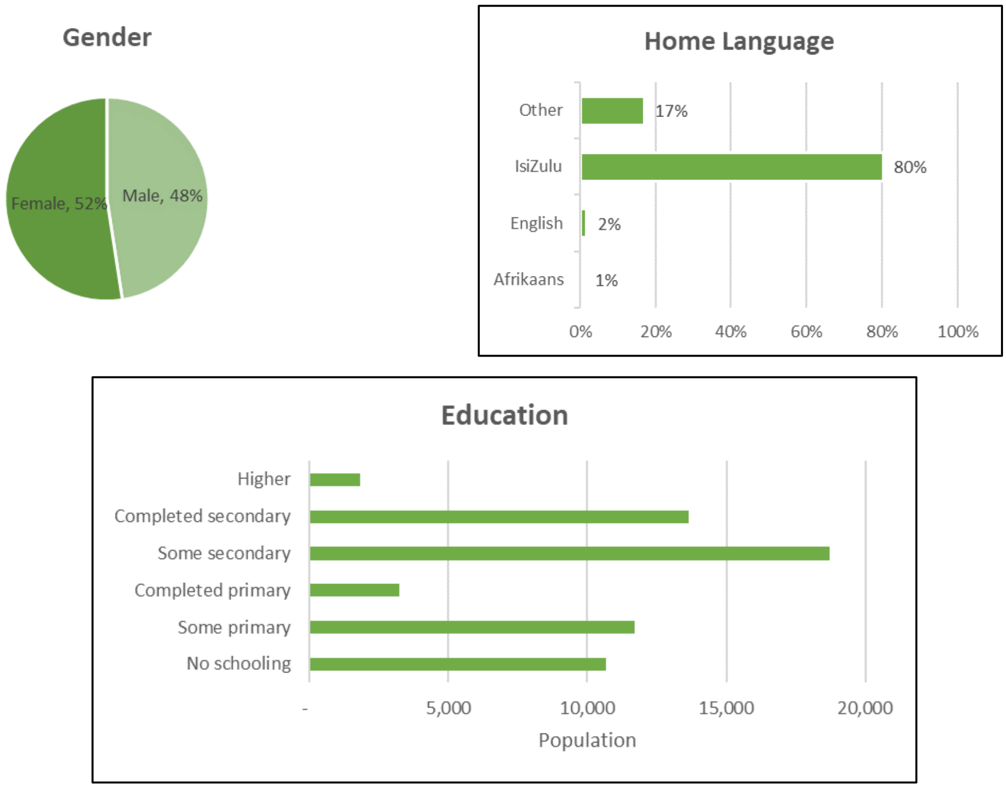


Figure 80: Demographic profile of residents in IUA 5 (StatsSA-Census 2011)

A very small number 16% of economically active residents are employed with only 61% being employed in the formal sector (Figure 81). A relatively small proportion, 6%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

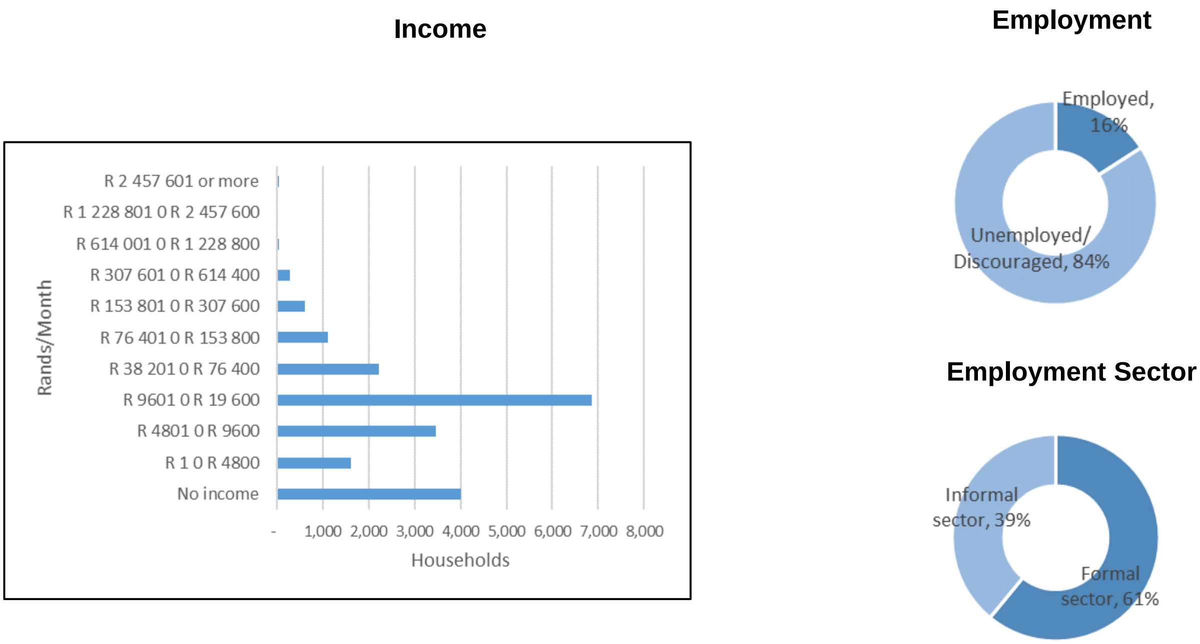


Figure 81: Economic profile of residents in IUA 5 (StatsSA-Census 2011)

Land tenure is represented by a large portion of Traditional owned land and Communal owned land followed by privately owned land. There is a small portion of State-owned land (Figure 82).

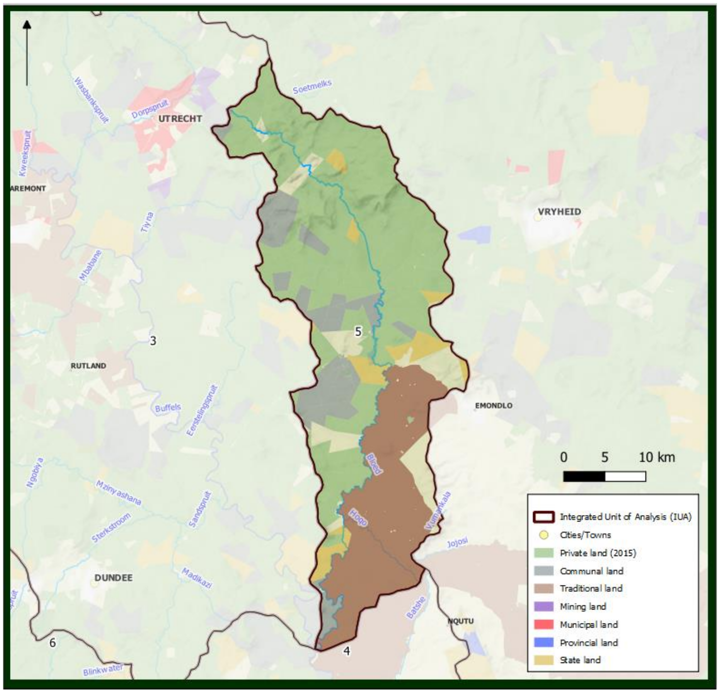


Figure 82: Land ownership within IUA 5 (DRDLR 2015)

Access to services varies greatly among residents with 60% having limited access to piped water (>50m away from their dwelling), 90% having no access to refuse disposal services, 89% with no flush toilets and only 23% having 24 hour access to the internet (Figure 83). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high,19%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 19% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

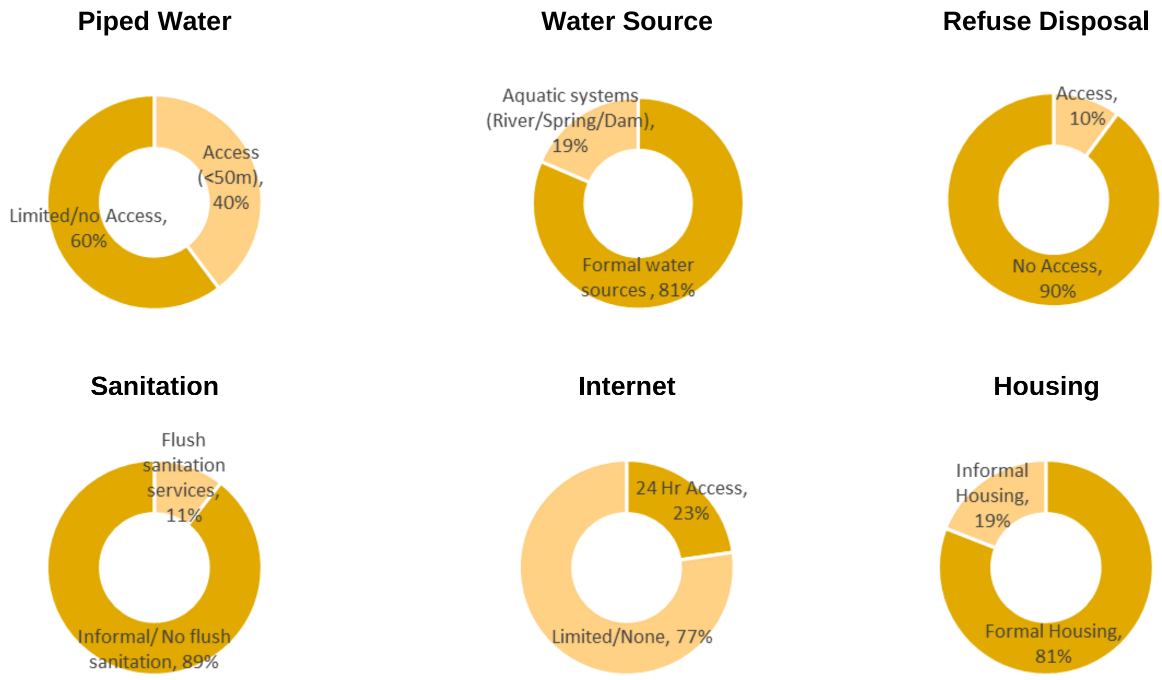


Figure 83: Access to services and indicators of wellbeing of residents in IUA 5 (StatsSA-Census 2011)

Mixed commercial dryland and irrigated agriculture dominate the land use within the IUA, with subsistence agriculture also being a major feature (Figure 84).

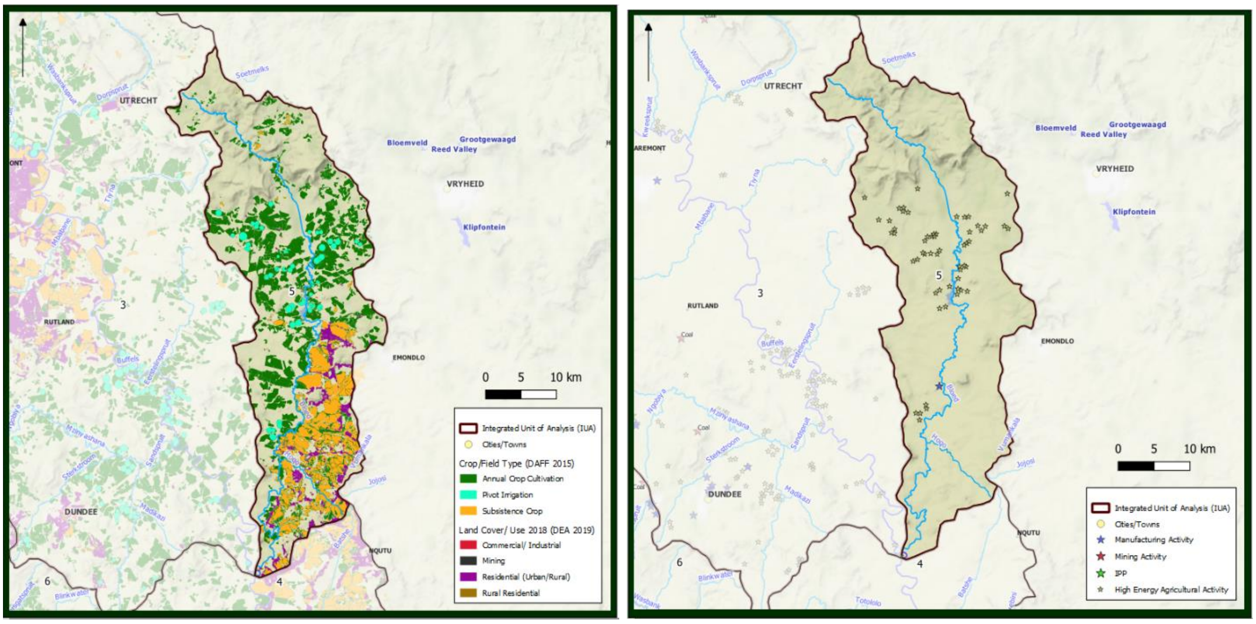


Figure 84: Land use by land cover in (DEA 2019/DAFF 2015) B) and locality of high energy industries in IUA 5

Commercial and subsistence agriculture dominate the landscape in IUA 5, pointing to the balancing between the economic roles of the commercial farming sector, as well as the informal sector in this area. Overall this IUA fits the general classification of the area as being highly rural, with negligible high intensity land cover (Figure 85).

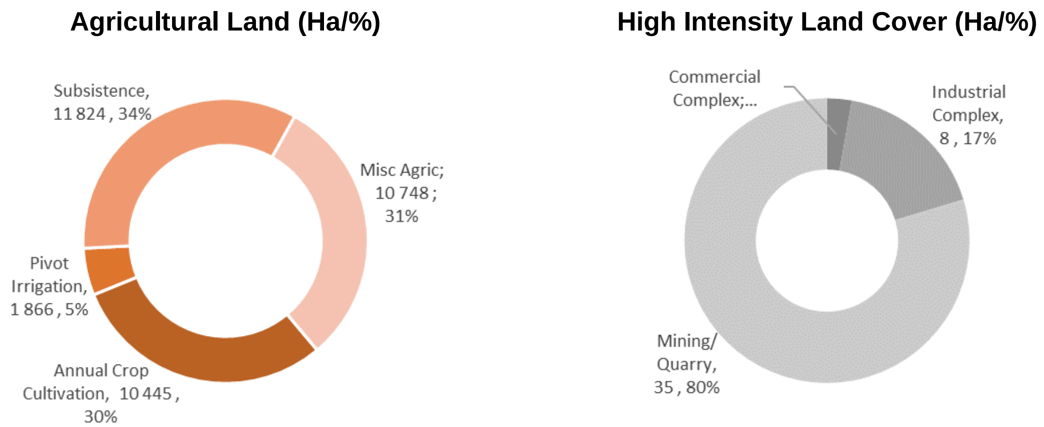


Figure 85: Classification of Agricultural Land and of High Intensity Land Cover in IUA 5

Table 54 below provides details on the municipalities which form part of IUA 5, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 54: Municipalities located within IUA 5

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 5
Emadlangeni LM	• **Agriculture;** • Trade;	Wards: 1 & 6

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 5
	• Finance; • Government services; • **Mining;** • Tourism.	Consisting mainly of ward 6, this area is characterised by high intensity annual crop cultivation and pivot agriculture. No major settlements or other high water use operations can be seen in this area.
Abaqulusi LM	• Wholesale and retail trade • Manufacturing • Finance • General government • **Agriculture and forestry** • Transport, storage and communication • Community and social services	Wards: 13, 17 & 22 Similar to Emadlangeni, this is a small area characterised by high intensity annual crop cultivation and pivot agriculture. No major settlements or other high water use operations can be seen in this area.
Endumeni LM	• Trade • Private household/domestic workers • **Farming** • Manufacturing • Business services • Construction • Transport • Social services • **Mining** • **Utilities**	Ward: 6 This area is mainly characterised by dryland annual crop cultivation, with a small amount of pivot irrigation.
Nqutu LM	• Wholesale & retail trade • Government • Finance • **Agriculture** • Manufacturing • Community • Transport • **Mining & quarrying** • Construction • **Electricity**	Wards: 15, 16 & 17 Dense subsistence agriculture is the main economic driver of this area. Water consumption in this area is driven by the rural residential and subsistence agricultural use.

Water Resource Use

This tributary has some upstream development, but the lower reaches are more rural. A dam below the confluence of the Buffalo and the Blood Rivers has been identified as a possible regional scheme for long term water supply to the region. Bulk water users include the Umzinyathi District Council.

Ecosystem Services

Situated in the north-eastern extent of the catchment IUA 5 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Hoqo River which flows into the Blood River (Figure 86).

The landscape is characteristic of a high wetland extent predominantly channelled-valley bottoms (69%) and seeps (25%) (Figure 87).

Regionally significant water resources include the expansive wetland systems in the northern regions of the IUA. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 55).

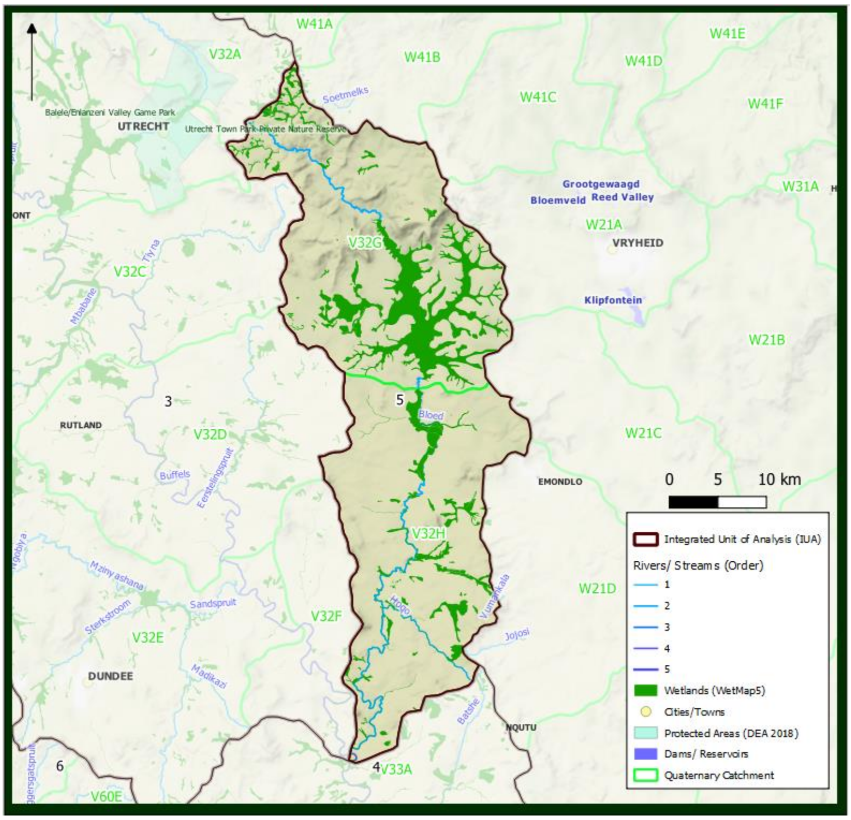


Figure 86: Locality of water resources in IUA 5

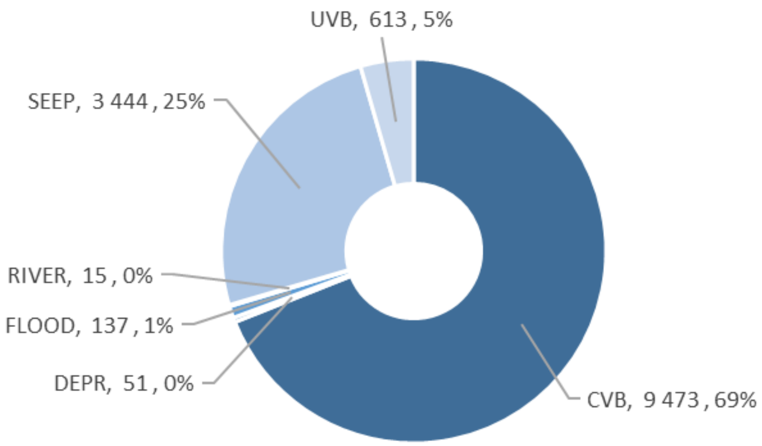


Figure 87: Wetland extent and type in IUA 5 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 55: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 5 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 5	Sector (12 Sectors)
Provisioning	**Food**	Wetlands and rivers	Major significance: Predominantly in southern reaches due to high presence of rural communities	Higher	**Households**
	Fresh Water	Rivers	Major Significance: Commercial agriculture and irrigation within the northern reaches; Southern reaches due to high presence of rural communities and subsistence agriculture. 19% of residents rely directly on natural systems as their primary water source	Higher	**Households; Agriculture**
	Raw materials	Wetlands and rivers	Major significance: Predominantly in southern reaches due to high presence of rural communities	Higher	**Households**
	Medicinal resources	Wetlands and rivers	Major significance: Predominantly in southern reaches due to high presence of rural communities	Higher	**Households**
Regulating	**Climate regulation**	Wetland	Major significance to global beneficiaries due to large wetland complex	Higher	**Society**
	Water quantity regulation	Wetland	Major Significance due to high presence of agriculture including commercial (irrigation), and subsistence and high presence of rural communities	Higher	**Agriculture; Households**
	Water purification & waste management	Wetland	Major Significance due to high presence of agriculture including commercial (irrigation), and subsistence and high presence of rural communities	Higher	**Agriculture; Households**
	Erosion control/ Soil stability	Wetlands	Significant flow of services, however observed high extent of erosion likely further reduces flow of services to rural communities in southern region	Lower	
	Biological control	Wetlands	Significance to high level of agricultural activities	Lower	
Cultural	**Landscape & amenity values**	Wetlands, Rivers	Major Significance to rural landscape in southern region. The high reliance on natural systems likely translates into increased value and cultural connection; Limited identified tourism or recreational services.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Water quality data availability for IUA 5 is limited to catchment V32H and to electrical conductivity and nutrients, both of which are elevated depicting non-compliance. Water quality is impacted by the agricultural practices and the sewage discharges from the Ncome Prison. There is gap with regard to water quality data for V32G. No monitoring data is available for the period assessed.

Monitoirng Point ID	Drainage Region	EC (mS/m) 95	NH4-N (mg/l) 95	NO3-N (mg/l) 50	pH (pH units) 95	PO4-P (mg/l) 50
IUA 5 - Blood River						
188946	V32H	65.3	2.19	1.7	8.9	0.150
194844	V32H				8.2	
188947	V32H	66.0	3.10	2.6	8.8	0.336
188945	V32H	90.7	11.80	13.0	7.8	2.100

River Ecological information and PES

Rivers are in C PES ecological category. The upper quaternary V32G includes very large vlei areas that are wetland driven. There are no EWR sites in the IUA, however a rapid assessment is proposed for the biophysical node at Ncone on the Blood River.

Wetlands

IUA 5 is located along the north eastern watershed of the Thukela Catchment within the Grassland Biome, and falls mostly within the Sub-Escarpment Grassland Bioregion, though a small portion of the upper reaches extend into the Mesic Highveld Grassland Bioregion. Wetlands cover 13 110 ha of IUA 5, or 12.4% of the land surface, which is the second highest percentage wetland coverage for the IUA's within the Thukela Catchment. The higher lying areas of this IUA fall within the Grasslands IBA (IBA #SA020).

Based on the National Wetland Map 5 (Van Deventer et al., 2018), the most extensive wetlands within IUA 5 are Channelled Valley Bottom wetlands, which make up 72.3% of the mapped wetland area and cover 9 473 ha. Seep and Unchannelled Valley Bottom wetlands are the next most extensive wetland types at 22.1% and 4.2% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 51 hectares and make up less than 1% of the wetland area within the IUA. Floodplain wetlands make up 1% of wetland habitat in the IUA.

<u>Priority Systems in IUA 5</u>

Blood River Vlei is the only Priority Wetland that has been identified in IUA 5 at this stage. Blood River Vlei is a large wetland system approximately 6 540 ha in extent. There are two main arms to the wetland with the system becoming relatively wide and flat in the middle and lower reaches along the Blood River. It is largely unchannelled in the middle reaches becoming channelled with well-developed meanders and, cut-off meanders and ox-bows in the lower reaches where it forms a distinct floodplain. A sill of dolerite forms the keypoint of the system just upstream of the R33 road bridge (Begg, 1989).The wetland comprises various vegetation communities which vary from hygrophilous grassland on the outer margins of the system to sedge meadows and reed swamp in the lower lying wetter areas of the system (Begg, 1989). Reeds (Phragmites australis) dominate the middle reaches of the wetland while patches of bulrush (Typha capensis) also occur (Begg, 1989). Rooted and floating leaved aquatic plants also occur in the main river channels, ox-bows and patches of open water in the system.

The system and surrounds is also considered to support at least 5 species of fish, 18 species of frogs, 41 species of reptiles and 49 species of mammals (Begg, 1989). Blue and Crowned cranes as well as numerous waterbird species are known to occur in or utilise the wetland system and surrounding habitat including large numbers of waterfowl (Begg, 1989). The system is therefore likely to have a very high ecological value. While fire (burning) is likely to play an important role in the vegetation dynamics of the system, the timing of burning may have serious negative consequences for the fauna that utilise the system (Begg, 1989). Begg (1989) rated water storage, streamflow regulation and wildlife protection as very important functions of the system with flood attenuation, sediment trapping, recreation and agricultural use as important. Working for Wetlands (WfW) have carried out rehabilitation work in both the main system as well as the eastern arm of the system, including, but not restricted to, gabion and concrete weirs as well as earthwork berms and fencing (SANBI, Wetland Interventions 2012).

<u>Baseline Ecological State</u>

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 56, 86.5% of wetlands within IUA 5 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 3.7% of wetlands in a Natural to Largely Natural condition (wetland condition A/B). Channelled Valley Bottom wetlands are especially affected by degradation with 97.6% of these systems considered Largely to Critically Modified. Floodplain wetlands were generally in the best condition with 100% of these wetlands falling within the C category. Blood River Vlei Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer *et al*. 2018), though the NFEPA wetland attribute data (Nel et al., 2011) indicates the main body of the wetland to be in a wetland condition of A/B to C.

Table 56: Wetland condition summary for IUA 5 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 5	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F

Wetland Extent (ha)	385	717	1 794		227	9 246	82	203	268		137		20	6	26
%	13.3	24.8	**61.9**		2.4	**97.6**	14.9	36.7	**48.4**		**100.0**		38.2	11.4	**50.4**

Threats/Impacts

Wetlands within the northern and central portions of this IUA have been significantly impacted by commercial agriculture which includes extensive cultivation and construction of numerous farm dams, including large farm dams within the main body of the Blood River Vlei Priority Wetland. Southern reaches of the IUA are characterised by urban villages and subsistence agriculture that result in heavy direct utilisation of wetland resources, most notably through heavy livestock grazing. Erosion is a significant problem affecting wetlands within the IUA, as reflected by the high levels of degradation within Valley Bottom wetlands.

Begg (1989) reported that many small farm dams had already been built in the tributaries of the Blood River Vlei such as the Lynspruit, Spartelspruit and Bloubankspruit at the time. Begg (1989) also reported that water had been pumped from the system for many years for irrigation purposes. A number of centre-pivot irrigation systems are still present in and adjacent to the lower reaches of the system. In addition, there is evidence of draining, road crossings, cultivation, damming, and alien vegetation invasion impacts to the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

The Working for Wetlands (WfW) rehabilitation work would likely have addressed some of these impacts and the success of the interventions, and whether or not new impacts and the threats identified previously still exist today, or have increased, are unknown and will, if existing information allows, be investigated further as this study progresses and more information is collected on the Priority Wetland systems.

Groundwater

The groundwater characteristics in IUA 5 are as follows:

- Geology: Karoo Supergroup –
  - Pietermaritzburg (shale)
  - Vryheid (arenite, coal and shale)
  - Dwyka (arenite, tillite, mudstone and shale)
- Dolerite intrusions: Occasional dikes, large sills (cap rocks)
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging (high): 45 $mm \cdot a^{-1}$
- Groundwater quality ($mS \cdot m^{-1}$): <70.
- Groundwater Reserve status (allocations): Moderate risk (SI = 70%).
- Priority wetland (depression type wetland) present in the middle section of the Blood River (KZN North Wetland).

9.2.6 IUA 6: Sundays River

The IUA is delineated from the source of the Sundays River to its confluence with the Thukela River (watershed boundary of the Sundays River catchment).

Rationale

This IUA is based on the similar land use, mainly extensive irrigation in the tributaries and mainstem. Large rural areas with subsistence farming in the middle reaches of the IUA. The water resources are mainly in a moderately modified present state with high ecological sensitivity to changes. It defines a logical entity for management and classification.

Overview

IUA 6, the Sundays River IUA, includes the local municipalities of Alfred Duma, Endumeni and Msinga (Figure 88). The IUA includes the smaller towns and communities of Kliprivier, Elandslagte, Wasbank and Etholeni. The region has no proclaimed protected areas.

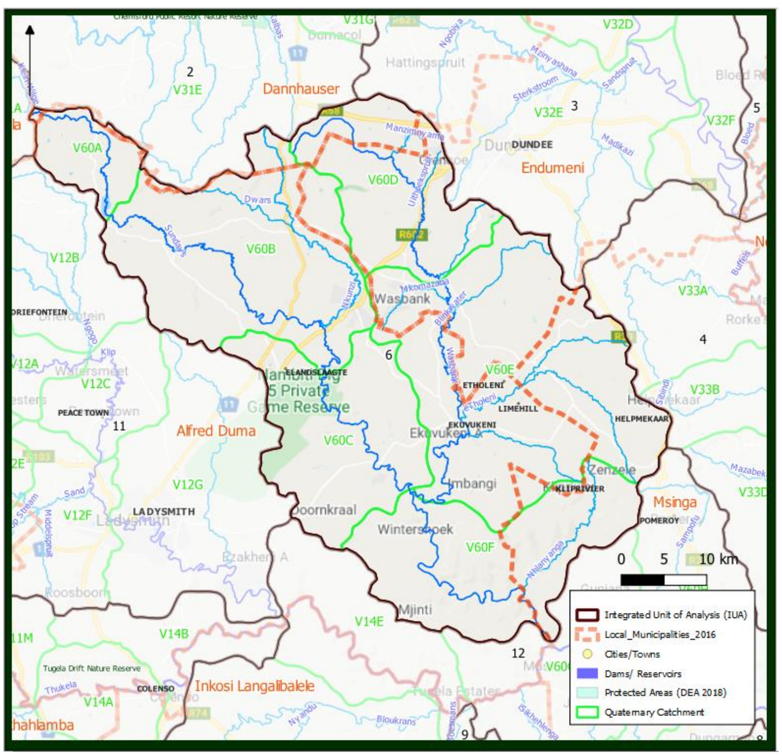


Figure 88: Overview of boundaries and features in IUA 6

Water Resources

Water resources in the IUA include the Sundays River and tributaries (Table 57). A small portion of the upper IUA on the escarpment represents a SWSA, especially that of catchment V60A. The region falls into the Mixed-Use Socio-Economic Zone with land uses transforming 24% of the landscape. Agricultural land uses represent 19% and residential the remaining 5% (Figure 89).

Table 57: Water resources and catchments of IUA 6

IUA	Main Rivers	Tributaries	Quaternaries
6	Sundays River	Dwars River; Nkunzi River; Manamntana River; Biggersgatspruit; Mkomazana River; Binkwater River; Dlomodlomo River; eTHoleni River; Kalkoenspruit; Nhlanyanga River	V60A; V60B; V60D; V60C; V60E; V60F

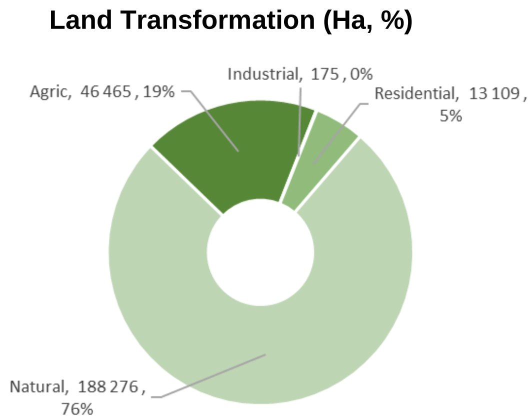
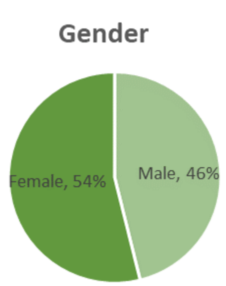
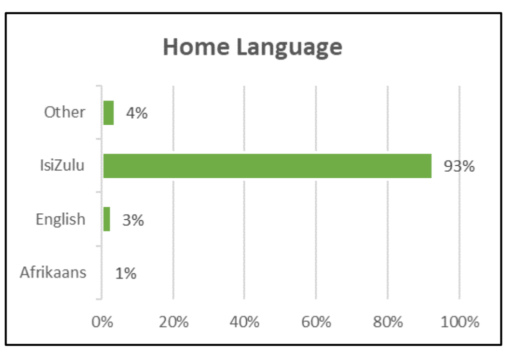


Figure 89: Land transformation per category in IUA 6 (Ha, %)

Socio-Economic Profile

The population of IUA 6 is approximately 131 642 with approximately 26 492 households. Most residents, 93%, speak IsiZulu, 3% speak English and 1% Afrikaans (Figure 90). 26% of residents completed secondary school.





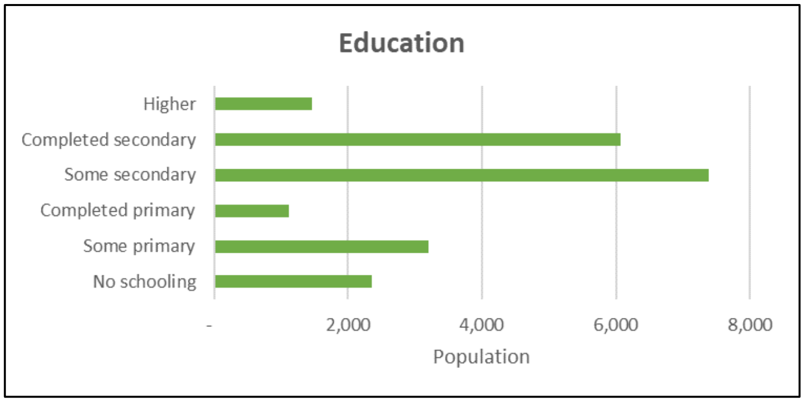


Figure 90: Demographic profile of residents in IUA 6 (StatsSA-Census 2011)

A very small number 13% of economically active residents are employed with 70% being employed in the formal sector (Figure 91). A relatively small proportion, 7%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

Land tenure is represented by a large portion privately owned land and State owned land, followed by traditional owned land and communal land (Figure 92).

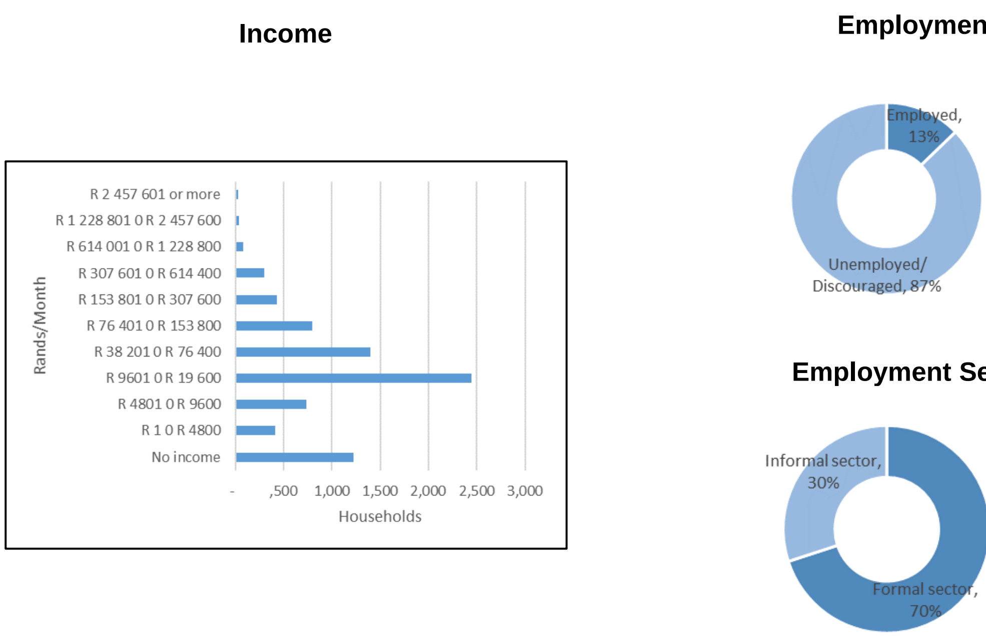


Figure 91: Economic profile of residents in IUA 6 (StatsSA-Census 2011)

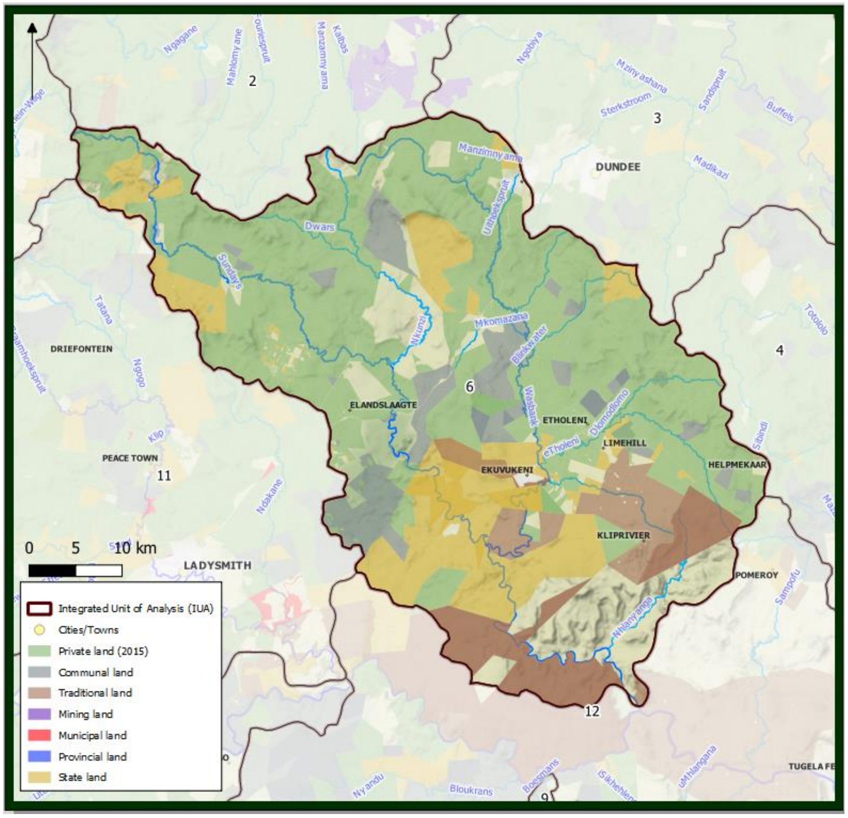
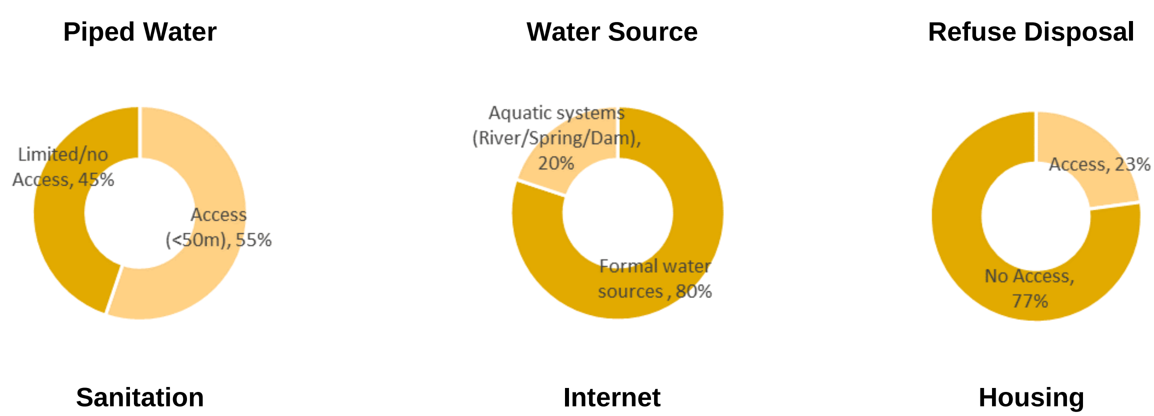


Figure 92: Land ownership within IUA 6 (DRDLR 2015)

Access to services varies greatly among residents with 45% having limited access to piped water (>50m away from their dwelling), 77% having no access to refuse disposal services, 77% with no flush toilets and only 18% having 24 hour access to the internet (Figure 93). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 20%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 33% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).



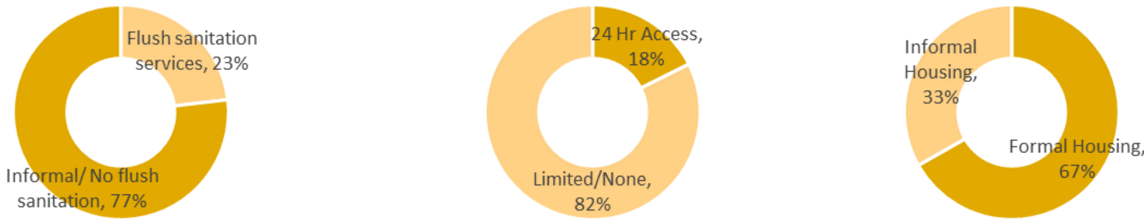


Figure 93: Access to services and indicators of wellbeing of residents in IUA 6 (StatsSA-Census 2011)

This IUA places relatively low demand on water resources, being characterised by scattered dryland agriculture, rural settlements, and subsistence agriculture (Figure 94).

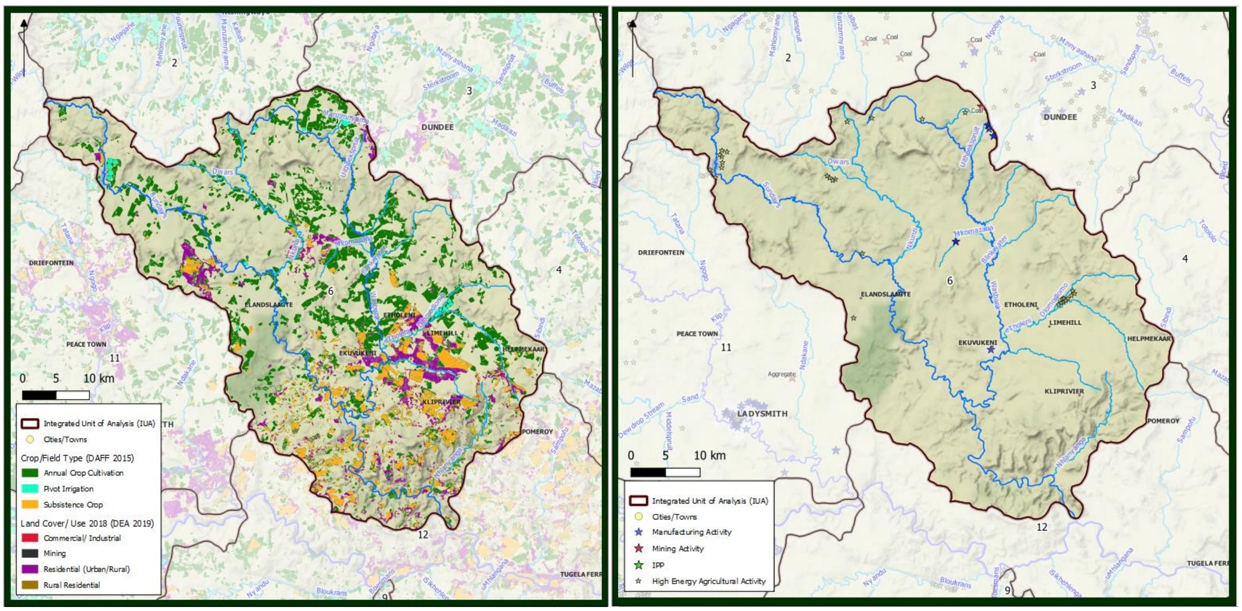
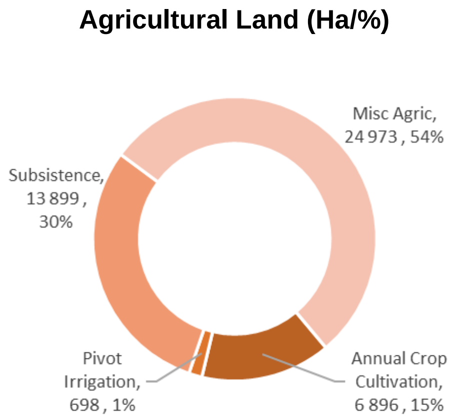


Figure 94: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 6

Miscellaneous agriculture, mostly in the form of rangelands dominates the landscape of IUA 6, followed by subsistence agriculture, with a small amount of commercial agriculture. This IUA also conforms to the general character of this region, exhibiting negligible levels of high intensity land cover (Figure 95).



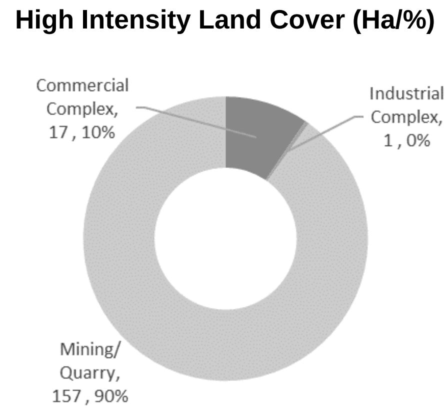


Figure 95: Classification of Agricultural Land and of of High Intensity Land Cover in IUA 6

Table 58 below provides details on the municipalities which form part of IUA 6, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 58: Municipalities located within IUA 6

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)-(IUA relevant sector in bold)	Relevance to IUA 6
Alfred Duma LM	• **Agriculture, fishing and forestry** • **Mining and quarrying** • Manufacturing • Construction • Wholesale and retail trade • Tourism	Wards: 7, 14, 23, 24, 28, 29, 30, 31, 32, 33, 34, 35 & 36 The main settlement of this area is the greater Ekuvukeni area, which is characterised by sparse rural residence with concurrent subsistence agriculture. In the north western part of the area, some annual crop cultivation and pivot irrigation is evident.
Endumeni LM	• Trade • Private household/domestic workers • **Farming** • Manufacturing • Business services • Construction • Transport • Social services • **Mining** • **Utilities**	Wards: 1 & 7 This area is mainly characterised by annual crop cultivation. The relatively small Corobrik mining operation falls on the north eastern edge of the watershed.
Msinga LM	• Community Services • Trade • Construction • Transport	Wards: 1, 2 & 12 This area is sparsely populated, with some annual crop cultivation taking place.
Danhauser LM	• Community Services • **Mining** • Manufacturing • Trade • **Agriculture** • Finance • Transport • Construction	Wards: 1 & 3 Accounting for a small area of IUA 6, this area is mainly characterised by annual crop cultivation.

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 6
	• **Electricity**	

Water Resource Use

This area has mostly rural and agricultural development with an irrigation scheme. The water balance and extent to which the existing users have exceeded the water balance with the inclusion of EWRs will need to be established, as there is limited potential for EWR releases.

Ecosystem Services

Situated in the centre of the Thukela catchment IUA 6 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by various tributaries which flow into the Sundays River (Figure 96).

The landscape is characteristic of a variety of wetland systems, predominantly seeps (51%) and depressions (21%) (Figure 97). Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 59).

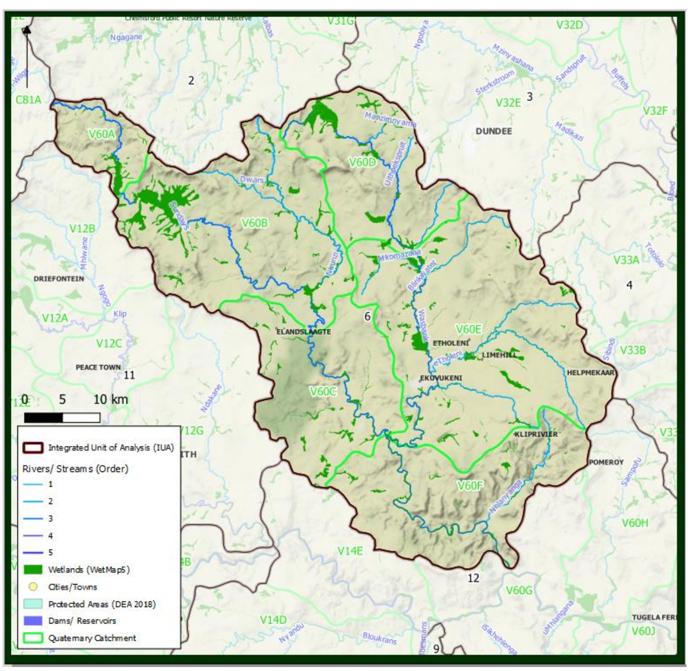


Figure 96: Locality of water resources in IUA 6

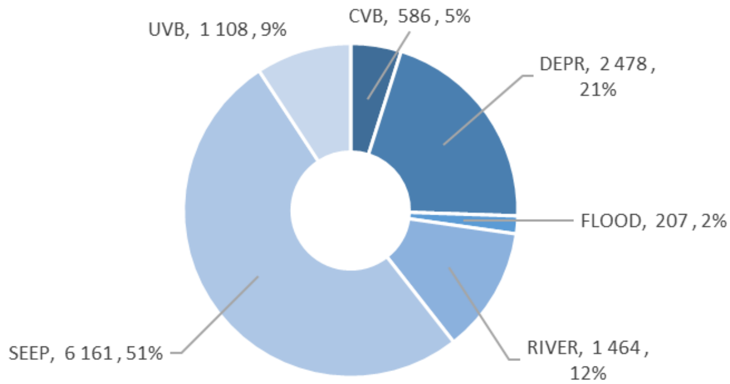


Figure 97: Wetland extent and type in IUA 6 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 59: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 6 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 6	Sector (12 Sectors)
Provisioning	**Food**	Wetlands and rivers	Major significance: Predominantly in high subsistence density regions	Higher	**Households**
	Fresh Water	Rivers	Major Significance to mixed use landscape: Commercial agriculture and irrigation within the northern reaches; Southern reaches due to high presence of rural communities and subsistence agriculture. 20% of residents rely directly on natural systems as their primary water source	Higher	**Agriculture; Households**
	Raw materials	Wetlands and rivers	Major significance: Predominantly in high subsistence density regions	Higher	**Households**
	Medicinal resources	Wetlands and rivers	Major significance: Predominantly in high subsistence density regions	Higher	**Households**
Regulating	**Climate regulation**	Wetland complex in upper reaches	Major significance to global beneficiaries	Higher	**Households**
	Water quantity regulation	Wetland and SWSA in upper catchment	Major Significance due to high presence of agriculture including commercial (irrigation), and subsistence and high presence of rural communities	Higher	**Agriculture; Households**
	Water purification & waste management	Wetland	Major Significance due to high presence of agriculture including commercial (irrigation), and subsistence and high presence of rural communities	Higher	**Agriculture; Households**
	Erosion control/ Soil stability	Wetlands	Significant flow of services, high level of agricultural activities	Lower	
	Biological control	Wetlands	Significant flow of services, high level of agricultural activities	Lower	
Cultural	**Landscape & amenity values**	Wetlands, Rivers	Major Significance to rural landscape in southern region. The high reliance on natural systems likely translates into increased value and cultural connection; Limited identified tourism or recreational services.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The water quality in the upper Sundays River at Waterfall and Kleinfontein is good with low salts and low nutrients concentrations and ideal pH. Some localised non-compliance to ionised ammonia is observed in this catchment. Unacceptable levels of electrical conductivity, sodium, sulphate, and non-compliant pH levels were found in V60B in the Nkuzi catchment, and V60D and V60E, the Wasbank catchment. The poor water quality is a result of coal mining decants (acid mine drainage) in the Nkuzi and upper Wasbank, as well as from agricultural activity and local towns. Further investigation is required to ascertain actual impact of acid mine drainage as compared to farming and other activities within V60B, D and E.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 6 - Sundays River														
102783	V60B	27.8	7.6	247.3	37.7	0.6	3.2	18.2	15.8	0.14	0.05	8.2	0.01	91.6
102784	V60B	7.7	6.0	80.4	11.8	0.6	2.8	4.3	8.9	0.14	0.14	7.9	0.01	13.0
187716	V60B	485.5	30.7	5124.4	549.0	0.2	8.8	382.5	375.9	7.14	0.05	8.7	0.03	3904.5
187722	V60B	377.7	26.3	3836.3	444.2	0.5	7.0	256.3	321.2	7.17	0.05	8.6	0.01	2614.5
187726	V60B	126.5	22.3	1083.2	133.5	0.7	5.4	82.0	77.2	0.64	0.05	8.4	0.01	726.7
188372	V60B				49.8					0.81		8.3	0.05	
188772	V60B				50.9					1.33		8.1	0.05	
188773	V60B				49.9					0.93		8.1	0.05	
188843	V60B				67.1					0.58		8.0	0.05	
102786	V60D	38.8	20.9	318.9	44.4	0.3	4.2	14.0	23.8	0.12	0.06	8.5	0.01	73.4
102787	V60D	46.7	41.1	1512.3	159.5	0.4	6.6	23.5	348.1	0.08	0.32	8.7	0.02	239.6
102788	V60D	25.5	20.5	623.8	100.4	1.1	4.0	15.4	194.3	0.16	0.04	8.8	0.03	129.8
102789	V60D	37.1	42.0	343.9	53.2	0.3	3.5	36.7	34.6	0.19	0.94	8.5	0.02	75.4
102790	V60D	29.7	28.3	576.1	86.7	0.7	3.8	17.5	154.5	0.07	0.04	8.8	0.01	111.7
102791	V60D	50.6	364.0	3326.4	472.5	0.8	12.8	101.5	930.3	0.17	0.04	9.0	0.01	1578.1
187700	V60D	117.5	574.8		655.5		19.2	73.2	1761.6			8.8		1525.2
187701	V60D	141.1	36.9	1852.0	217.2	3.2	6.4	97.1	526.1	0.51	0.05	9.1	0.26	1514.4
187702	V60D	33.8	34.6	480.5	155.7	0.8	4.9	27.2	199.2	0.05	0.35	8.7	0.01	141.0
187705	V60D	39.8	37.3	1905.8	190.5	3.0	7.0	28.9	505.4	0.12	0.15	9.0	0.22	179.4
187709	V60D	69.3	580.9	5368.2	686.1	1.3	22.5	101.8	1722.1	0.14	0.10	8.8	0.01	1814.8
189041	V60D				99.8				34.8	3.02		8.9	0.11	
189043	V60D				158.0				24.8	0.79		8.4	0.05	
189045	V60D				63.0				52.9	3.59		10.1	0.70	
102792	V60E	36.5	18.4	231.6	51.8	0.4	3.3	21.2	35.2	0.15	0.03	8.5	0.01	65.6
102793	V60E	36.7	15.5	302.9	45.2	0.4	2.7	28.6	18.5	0.19	0.03	8.5	0.01	16.4
102795	V60E	24.5	35.1	925.7	102.1	1.2	5.4	21.2	181.8	0.07	0.05	8.8	0.01	90.9
102782	V60E	22.3	44.9	1785.2	186.3	2.4	7.0	17.3	473.4	0.13	0.05	9.2	0.01	143.2

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V60B	Nkunzi	Serious	High salts and nutrients; WWTWs discharges (Biggarsberg); piggery, erosion – sediments, coal mining and acid mine drainage in lower reaches
V60D	Wasbank (upper)	Large	Elevated nutrients, high salinity; coal mining and acid mine drainage decant
V60E	Wasbank (lower)	Moderate	Elevated nutrients, high salinity; upstream impacts; sand-mining, over-grazing, erosion; rural communities

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V60E	eTholeni	Large	WWTWs discharges (Tholeni); sand-mining, over-grazing, erosion;

River Ecological information and PES

The ecological condition of this sub-catchment is largely, moderately modified, with most river systems with a PES of a C ecological category. Land use, wetland modifications and instream dams (flow and non-flow) are largely drivers of ecological condition. The D ecological condition of the Wasbank River V60D is driven by poor water quality due to mining; of the Kalkoenspruit and Wasbank (V60E) by serious instream habitat and wetland continuity modifications impacted by sand mining, cultivation, erosion. The PES of the only seriously modified river is the eTholeni which is in an E ecological category. The IUA includes 2 Comprehensive Reserve EWR sites, EWR 7 and 8 very close to the outlet.

Wetlands

IUA 6 is located in the central reach of the Thukela Catchment within the Grassland and Savanna Biomes, and falls mostly within the Sub-Escarpment Grassland Bioregion, though the Sub-Escarpment Savanna Bioregion also extends into the IUA. Wetlands cover 10 643 ha of IUA 4, or 4.3% of the land surface, which is near the average wetland coverage of 4.7% across the entire Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al.*, 2018), the most extensive wetlands within IUA 6 are again Seep wetlands, which make up 58.8% of the mapped wetland area and cover 6 254 ha. Depression wetlands are indicated in the National Wetland Map 5 (Van Deventer et al., 2018) as the next most extensive wetland type within this IUA, making up 23.3% of the wetland area, though this is considered a significant overestimation and likely based on incorrect typing of wetlands within the National Wetland Map 5. Unchannelled Valley Bottom and Channelled Valley Bottom wetlands are the next most extensive wetland types at 10.4% and 5.5% respectively. The least common wetlands mapped within the IUA are Floodplain wetlands which cover only 207 hectares and make up less than 2% of the wetland area within the IUA.

<u>Priority Systems in IUA 6</u>

Two Priority Wetlands, being Paddavlei and Boschberg Vlei, have been identified in IUA 6. Paddavlei is located in the upper reaches of the Wasbank River and is between approximately 912 and 1 662 ha in extent (Begg, 1989). According to Begg (1989) the system is dominated by clays of the Rensburg soil form. Begg (1989) indicates that the keypoint of the system is a dolerite dyke which intersects the Wasbank River at the outlet of the wetland and which has resisted downcutting. From a vegetation perspective, Begg (1989) reported that the system is dominated by hygrophilous grassland and that there was an apparent lack of reed habitat (Phragmites australis) in the system at the time. Begg (1989) reported that Blue and Crowned cranes as well as Secretary birds were recorded in the system at the time. He further indicated that the system is likely to be important for water storage, streamflow regulation, flood attenuation and agriculture.

Boschberg Vlei is located in the upper reaches of the Sundays River and is approximately 1 400 ha in extent (Begg, 1989). Cut-off meanders have given rise to several ox-bows along the floodplain sections of the wetland, while depressions in the system support permanently waterlogged backwater areas (Begg, 1989). Begg (1989) indicates that the keypoint of the system is also a dolerite dyke which intersects the Sundays River at the outlet of the wetland and which has resisted downcutting. According to Begg (1989), the substrate of the main body of the system is comprised of alluvium with the arms comprising predominantly clays of either the Rensburg or Katspruit soil forms. From a vegetation perspective, Begg (1989) reported that the system is dominated by sedge meadows and hygrophilous grassland and that the reed (Phragmites australis) was largely absent from the system at the time. Begg (1989) indicated that the system is likely to be important for water storage, streamflow regulation, flood attenuation, sediment trapping, water purification, wildlife and agriculture.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 60, 54.7% of wetlands within IUA 6 are considered to be Largely to Critically Modified (wetland condition D/E/F), which is the lowest percentage of all of the IUA's within the Thukela Catchment, though only 7.7% of wetlands were placed in a Natural to Largely Natural condition (wetland condition A/B). All of the Valley Bottom wetland systems, including Floodplains, are especially affected by degradation with over 80% of these systems considered Largely to Critically Modified. Depression wetlands were generally in the best condition with 98.9% of these wetlands falling within the C category.

Paddavlei Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel *et al*., 2011) indicates the main body of the wetland to be in a wetland condition of A/B to C.

Boschberg Vlei Priority Wetland is indicated as having a wetland condition of C (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel *et al*., 2011) indicates the main body of the wetland to be in a wetland condition of A/B.

Table 60: Wetland condition summary for IUA 6 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al*., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 6	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	694	1 382	4 178	60	17	511	60	139	912		1	205	9	2 457	18
%	11.1	22.1	**66.8**	10.1	2.9	**86.9**	5.4	12.5	**82.1**		0.6	**99.4**	0.3	**98.9**	0.7

Threats/Impacts

IUA 6 is a largely rural IUA and characterised by land uses including both commercial and subsistence agriculture. 2 WWTWs are known to occur within the IUA. Slangdraai Dam upstream of Boshberg Vlei potentially poses a threat to the water supply to the wetland. Numerous small dams have also been built in the wetland and sections of the system appear to be impacted by cultivation. Begg (1989) reported that Padddavlei had been impacted by roads crossings, furrowing and cultivation at the time. Evidence of draining, cultivation, damming, flow modification and alien vegetation invasion impacts to the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

Groundwater

The groundwater characteristics in IUA 6 are as follows:

- Geology: Karoo Supergroup –
  - Beaufort (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
  - Dwyka (arenite, tillite, mudstone and shale)
- Dolerite intrusions: Limited.
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~15 $mm \cdot a^{-1}$ (northern ½) to 45 $mm \cdot a^{-1}$ (southern ½).
- Groundwater quality ($mS \cdot m^{-1}$): <70 (upstream 80% area) and 70-300 (V60F). Isolated water quality hot spot on eastern boundary of V60B (to be investigated), V60E and V60F. Potential coal field present – future mining and impacts on groundwater-surface water quality expected.
- Groundwater Reserve status (allocations): Moderate risk (SI = ~72%).
- Wetlands present in V60A and V60B (to be classified as groundwater dependant system).

9.2.7 IUA 7: Upper Mooi

The IUA is delineated from Nsonge, Klein Mooi and Mooi rivers outflows below the uKhahlamba Drakensberg to Mooi River at the outlet of quaternary catchment V20E.

Rationale

The IUA delineation is based on the moderate to high relief terrain mostly in the lower foothills geomorphological zone. It is a hard-working area with extensive irrigation, town development with some industrial activities. Water transfer from the system to the Mngeni from Spring Grove Dam and Mearns Weir.

Overview

IUA 7, the Upper Mooi IUA, includes the local municipalities of Mpofana and Umgeni and includes the towns of Mooi River and Bruntville (Figure 98).

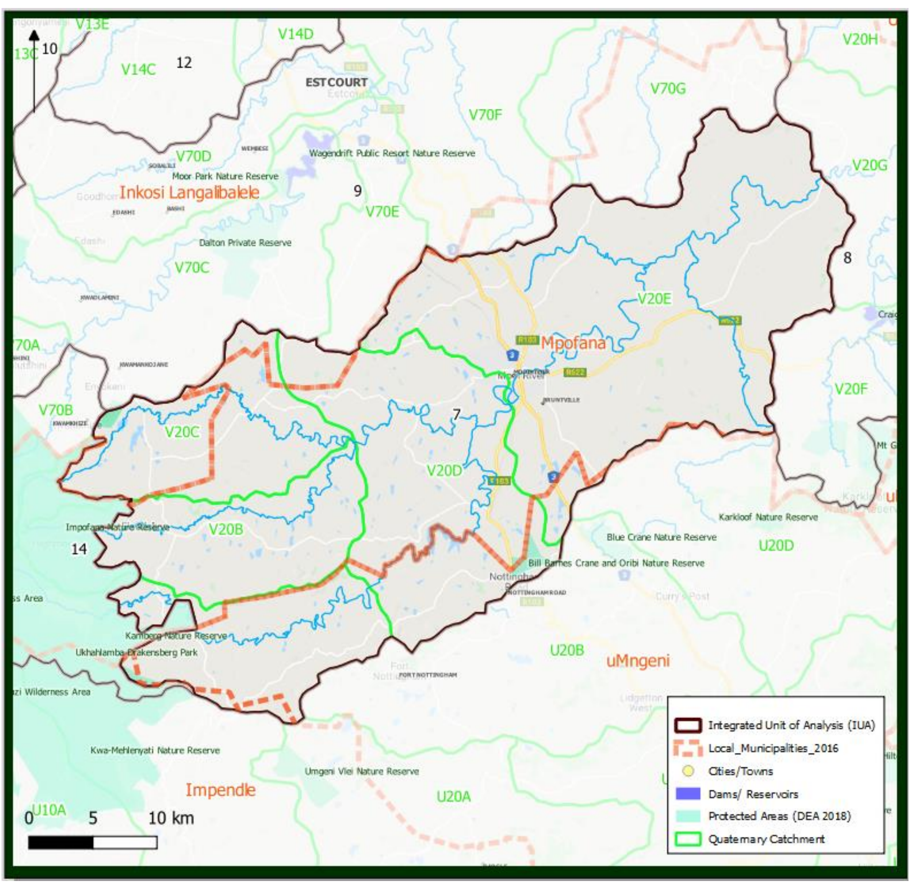


Figure 98: Overview of boundaries and features in IUA 7

Water Resources

Water resources in the IUA include the Upper Mooi River and tributaries (Table 61) The IUA incudes Spring Grove Dam from where the Mooi to Mgeni Transfer Scheme operates to provide water to Midmar Dam. The region falls into the Agricultural Socio-Economic Zone with land uses transforming 36% of the landscape. Agricultural land uses represent 32% and residential the remaining 2% (Figure 99).

Table 61: Water resources and catchments of IUA 7

IUA	Main Rivers	Tributaries	Quaternaries
7	Upper Mooi River	Nsonge River; Klein-Mooi River; Katspruit; Joubertsvlei se Loop	V20A (lower portion); V20B (lower portion); V20C; V20D; V20E

Land Transformation (Ha, %)

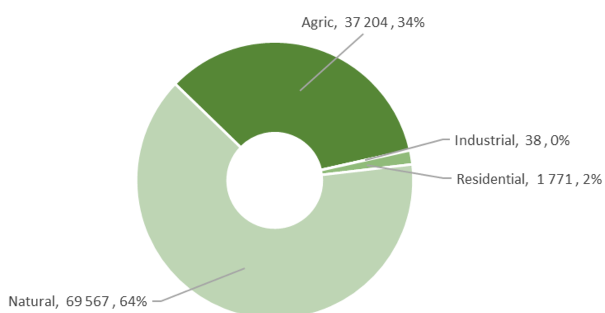


Figure 99: Land transformation per category in IUA 7 (Ha, %)

Socio-Economic Profile

The population of IUA 7 is approximately 31 715 with approximately 8 913 households. 82% of residents speak IsiZulu, 9% speak English and 1% Afrikaans (Figure 100). 35% of residents have completed secondary school.

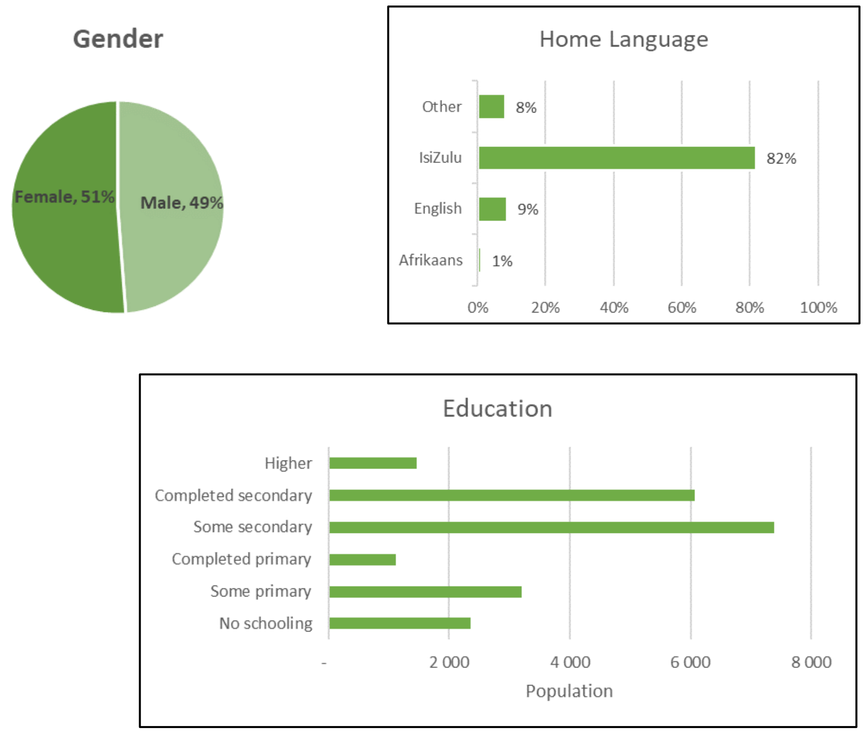


Figure 100: Demographic profile of residents in IUA 7 (StatsSA-Census 2011)

There are 44% of economically active residents that are employed with 63% being employed in the formal sector (Figure 101). A relatively small proportion, 4%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

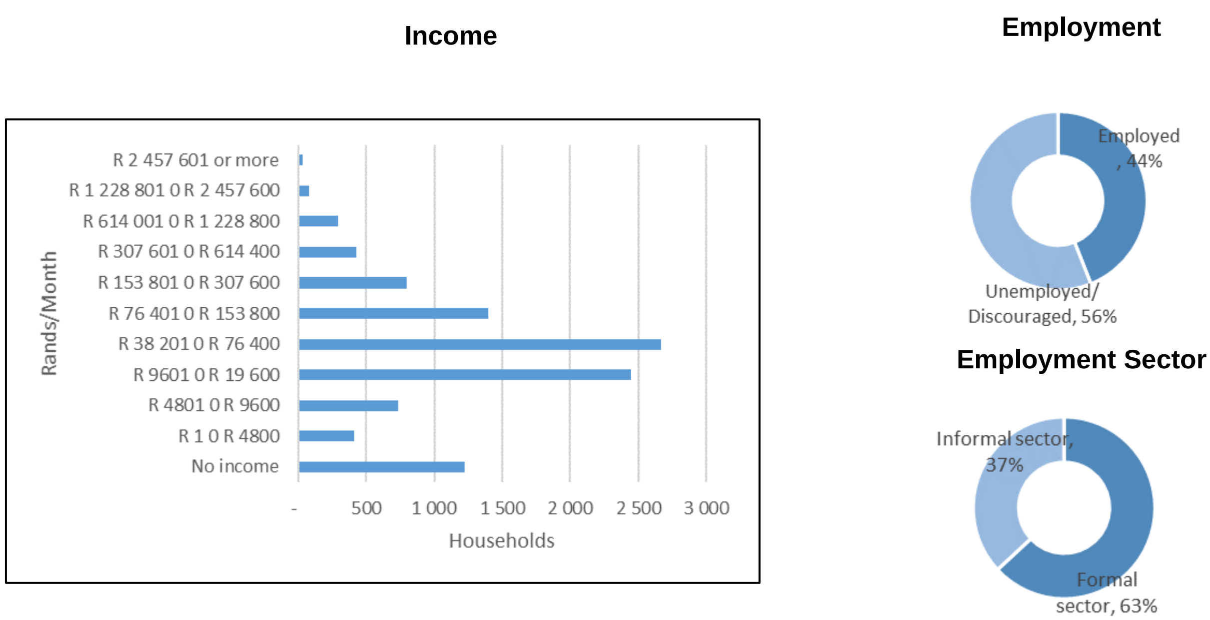


Figure 101: Economic profile of residents in IUA 7 (StatsSA-Census 2011)

Land tenure is represented by predominantly privately owned land and with communally owned land and state-owned land to a lesser degree (Figure 102).

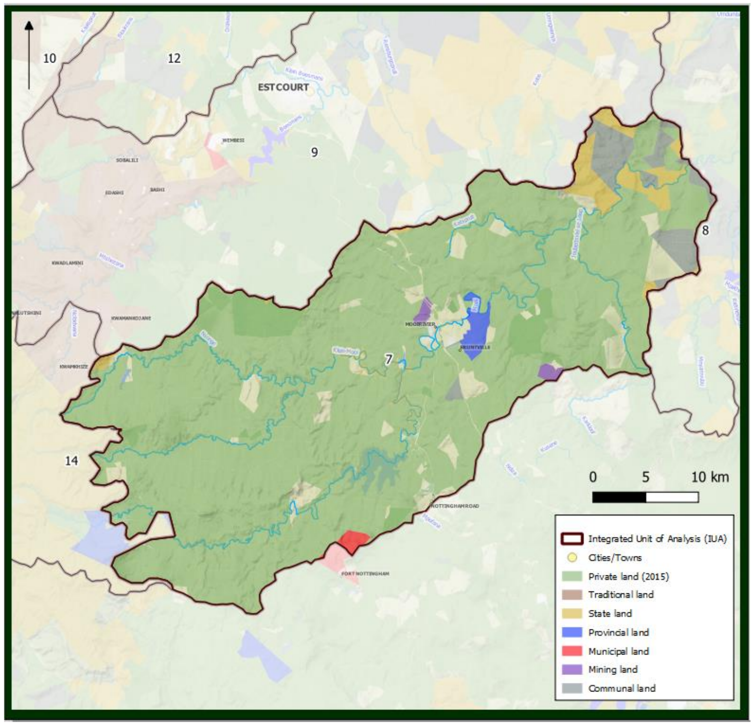
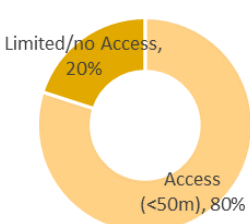


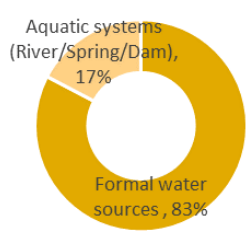
Figure 102: Land ownership within IUA 7 (DRDLR 2015)

Access to services varies greatly among residents with 20% having limited access to piped water (>50m away from their dwelling), 42% having no access to refuse disposal services, 35% with no flush toilets and only 21% having 24 hour access to the internet (Figure 103). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 20%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 16% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

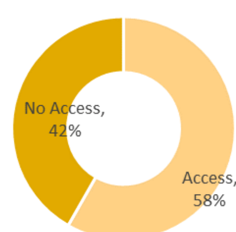
Piped Water



Water Source



Refuse Disposal



Sanitation

Internet

Housing

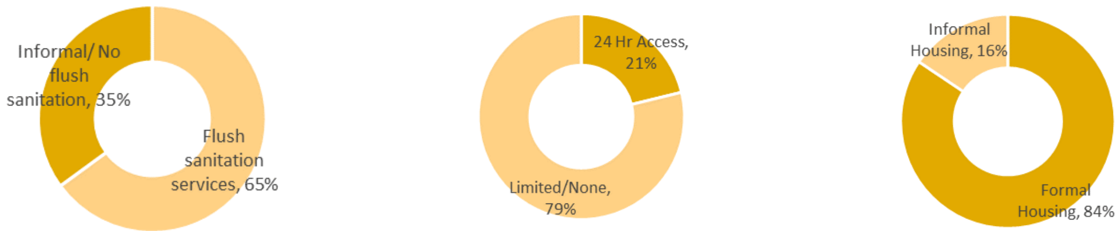


Figure 103: Access to services and indicators of wellbeing of residents in IUA 7 in (StatsSA- Census 2011)

Irrigation agriculture places considerable demand on water resources in this IUA, while a large portion of the land cover consists of dryland agriculture (Figure 104).

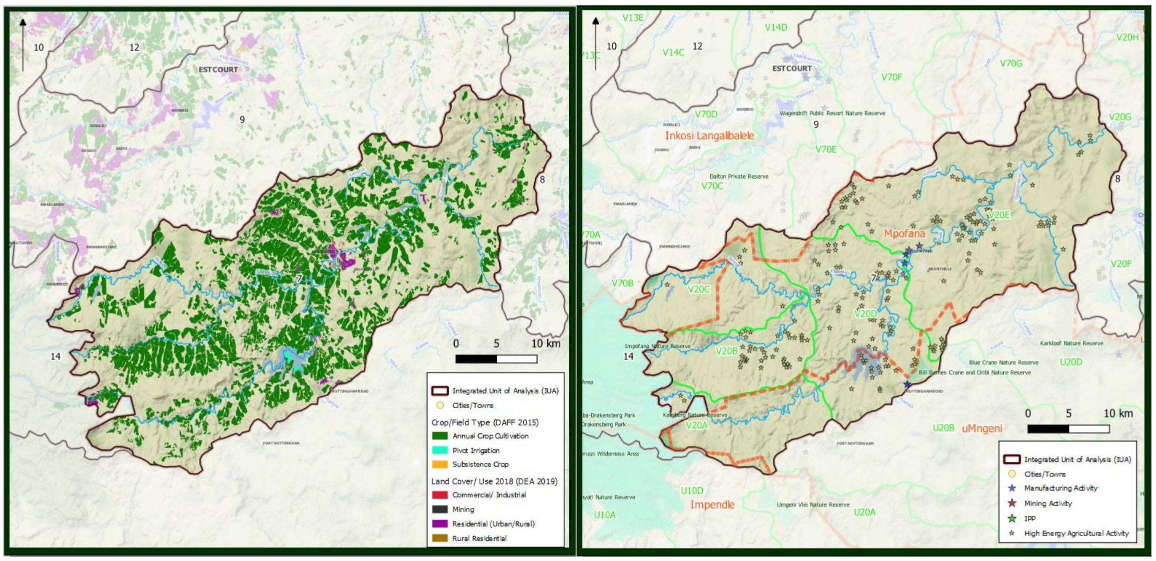
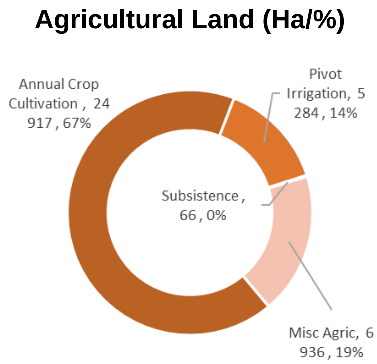


Figure 104: Land use by land cover in IUA 7 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 7

The economy of IUA 7 exhibits a high level of reliance on high intensity commercial agriculture, including irrigated agriculture (Figure 105). The town of Mooi River has a small commercial hub, which mainly services the surrounding farmlands. Tourism also plays a role in the local economy of the area.



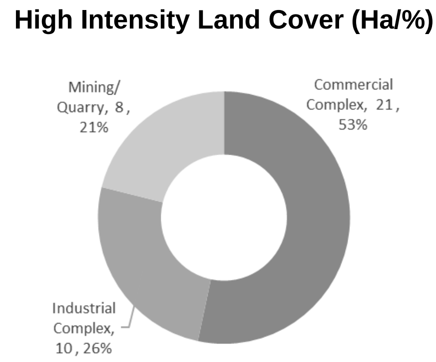


Figure 105: Classification of Agricultural Land and Classification of High Intensity Land Cover in IUA 7

Table 62 below provides details on the municipalities which form part of IUA 7, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 62: Municipalities located within IUA 7

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 7
Mpofana LM	• **Agriculture** • Tourism • SMMEs • Co-ops • **(Water Transfer)**	Wards: 1, 2, 3, 4 & 5 The main economic hub of this area is Mooi River. The main economic driver of the region is high intensity annual crop cultivation and pivot irrigation. Some forestry is also present in the area. Tourism also plays a role in the region's economy. The western tip of this Municipality falls within the Impofana Nature reserve. The Spring Grove Dam, fed by the Mooi River system, provides the bulk of the water requirements of the area. This dam is also part of the Mooi to Mgeni Transfer Scheme, which transfers water out of this catchment into the Mgeni basin to supply the area around the city of Durban.
uMngeni	• **Agriculture (36.9%)** • Wholesale/retail • Business / real estate • Manufacturing	Ward: 3 The southern tip of IUA falls into ward 3 of this municipality. It encompasses the small town of Nottingham Road. Considerable high intensity agriculture is central to this region's economy.
Inkosi Langalibalele LM	• **Agriculture** • Manufacturing • Tourism • Industry • Services	Ward: 11 Some annual crop cultivation and forestry occurs here, with the bulk of this area appearing to act as grazing land.

Water Resource Use

This IUA is driven by the presence of the Spring Grove and Mearns dams and associated Mgeni. Recent studies have considered preliminary EWR's when assessing the transfer volumes available. Some compensation releases have been made to date from the Spring Grove and

Mearns dams, but mostly with a focus on downstream users. There are also considerable irrigation developments, and the balance between these users and the EWRs will need to be reviewed. Bulk water industrial users include Mooi River, Bruntville and Rosetta.

Ecosystem Services

Situated in the centre of the uThukela tertiary catchment IUA 7 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Nsonge, Klein-Mooi and Joubertsvlei Rivers which flow into the Upper-Mooi River (Figure 106).

The landscape is characteristic of a variety of wetland systems, predominantly channelled-valley bottoms (55%) and seeps (28%) (Figure 107). Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 63).

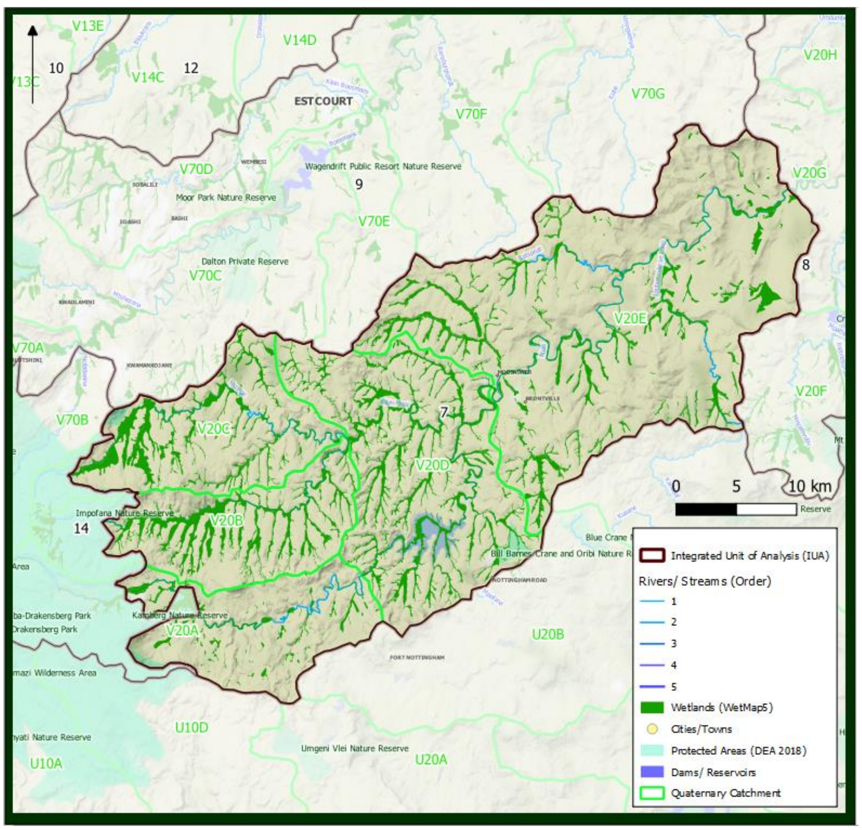


Figure 106: Locality of water resources in IUA 7

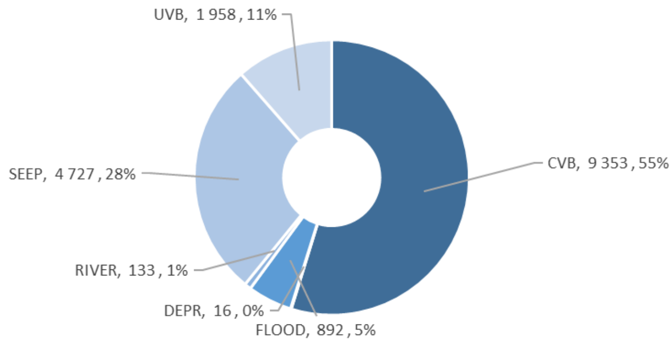


Figure 107: Wetland extent and type in IUA 7 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 63: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 7 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 7	Sector (12 Sectors)
Provisioning	**Food**	Wetlands	Minor significance- low level of rural communities/subsistence farming	Lower	
	Fresh Water	Rivers; Spring Grove Dam	Major significance: Due to high level of commercial agriculture and high extent of irrigational activity. 17% of residents rely directly on natural systems as primary water source; Transfers to Midmar Dam	Higher	**Agriculture**
	Raw materials	Wetlands	Minor significance- low level of rural communities/subsistence farming	Lower	
	Medicinal resources	Wetlands	Minor significance- low level of rural communities/subsistence farming	Lower	
Regulating	**Climate regulation**	High wetland extent	Major significance to global beneficiaries	Higher	**Society**
	Water quantity regulation	High wetland extent	Major Significance due to high presence of agriculture including commercial and irrigation	Higher	**Agriculture**
	Water purification & waste management	High wetland extent	Major Significance due to high presence of agriculture including commercial and irrigation	Higher	**Agriculture**
	Erosion control/ Soil stability	High wetland extent	Significance due to high presence of agriculture including commercial and irrigation. Gradual topography however limits requirement for regulation of erosion.	Lower	
	Biological control	High wetland extent	Major Significance due to high presence of agriculture including commercial and irrigation	Higher	**Agriculture**
Cultural	**Landscape & amenity values**	Wetlands, Rivers; Spring Grove Dam	Major Significance: Upper reaches and midlands provides regionally significant tourism industry	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The upper Mooi River catchment exhibits to good quality. The compliance assessment indicates that for almost all variables water quality is at for the most part ideal and acceptable levels. Slightly elevated pH is observed in quaternary catchment V20D and at the outlet upstream of confluence with the Thukela. Intensive agricultural activity does occur in quaternary catchment V20B (lower reaches), V20D and V20E but there is little evidence of salinity or nutrients in the monitoring data. Increase use of fertilizers and high irrigation return flows is however becoming a concern.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 7 - Upper Mooi River														
102737	V20A	7.8	5.2	59.6	9.5	0.5	2.2	3.9	5.5	0.11	0.10	8.1	0.005	3.0
188045	V20A	7.0	3.9	55.8	9.4	0.4	2.8	2.9	4.6	0.24	0.05	8.0	0.010	3.0
102738	V20B	7.9	11.1	80.5	12.7	0.5	2.6	4.3	7.3	0.11	0.26	8.1	0.010	3.7
102739	V20C	7.3	6.0	61.3	9.1	0.5	2.3	3.1	5.2	0.08	0.05	7.9	0.010	3.0
177645	V20D	11.5	19.7	173.1	22.3	0.2	3.1	6.2	20.6	0.05	0.05	7.9	0.010	10.0
195005	V20D	8.9	3.0		8.5	0.1	1.7	4.0	6.9	0.18	0.10	8.1	0.003	1.1
195006	V20D	11.5	10.5		12.5	0.1	2.2	7.6	9.3	0.18	0.31	8.5	0.006	2.0
195007	V20D	7.2	3.2		9.2	0.1	1.6	3.4	4.9	0.16	0.25	8.6	0.003	1.4
195008	V20D	7.0	5.3		8.4	0.1	2.2	3.3	4.4	0.15	0.14	8.5	0.003	2.2
195009	V20D	7.0	5.9		8.7	0.1	2.0	3.5	5.9	0.08	0.10	8.7	0.003	1.8
195010	V20D	9.7	3.5		9.2	0.1	2.5	3.9	5.5	0.17	0.14	8.1	0.003	1.4
177646	V20D	8.6	11.6	75.7	11.8	0.4	2.7	5.5	8.3	0.20	0.13	8.0	0.010	2.3
87982	V20D	4.9	6.3	51.1	7.6	0.1	1.7	3.6	5.5	0.05	0.09	7.6	0.018	1.5
188882	V20E				209.0					18.72	0.16	7.9	1.770	
102735	V20E	8.6	8.5	68.6	11.2	0.5	2.5	3.7	6.8	0.40	0.11	8.0	0.010	3.2
102736	V20E	13.5	14.1	224.7	25.3	0.5	4.8	8.2	34.2	0.09	0.08	8.2	0.010	35.2
189112	V20E				67.8					2.30	0.71	8.1	0.191	

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V20D	Mooi/Klein Mooi	Moderate	elevated nutrients, irrigated agriculture
V20E	Mooi	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Mooi River)

River Ecological information and PES

The upstream rivers in the IUA are in a C ecological category. The lower reach of the Mooi in V20E and the Katspruit are largely modified in a D ecological condition, while the Joubertsvlei se Loop is seriously modified, in an E category. The present ecological condition is driven by flow and non-flow impacts in these rivers. The IUA includes a Rapid EWR site the on the N3 close to outlet of IUA. The inclusion of a new rapid assessment site upstream Mooi River Town will be evaluated as part of the EWR quantification step.

Wetlands

IUA 7 is located along the southern watershed of the Thukela Catchment within the Grassland Biome, and falls mostly within the Sub-Escarpment Grassland Bioregion, though a small portion of the upper reaches extends into the Drakensberg Grassland Bioregion. Wetlands cover 17 326 ha of IUA 5, or 12.6% of the land surface, which is the highest percentage wetland coverage for the IUA's within the Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 7 are Channelled Valley Bottom wetlands, which make up 53.5% of the mapped wetland area and cover 9 276 ha. Seep and Unchannelled Valley Bottom wetlands are the next most extensive wetland types at 27.5% and 14.1% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 17 hectares and make up less than 1% of the wetland area within the IUA. Floodplain wetlands make up 4.7% of wetland habitat in the IUA.

<u>Priority Systems in IUA 7</u>

Hlatikulu is the only Priority Wetland that has been identified in IUA 7 at this stage. The Hlatikulu Priority Wetland is approximately 733 hectares in extent (Begg, 1989) and is situated in the foothills of the Drakensberg. According to Guthrie (1996), the importance of the Hlatikulu wetland lies in its functions related to water storage, streamflow regulation and flood attenuation, as well as providing suitable habitat for wildlife and grazing for livestock. The western arm of the wetland contains the main stream with the result that the flow in this portion of the system is largely confined to meanders of the river channel (Begg, 1989). In contrast the flow of water in the eastern arm of the system is diffuse and drainage channels are indistinct, particularly in the lower reaches of the wetland (Begg, 1989). According to Guthrie (1996), forty-nine percent of the wetland has been classified as disturbed, mainly due to the construction of two large dams and historical drainage of system to facilitate pasture planting. The author suggests that grazing and fire have had less of an effect on the plant communities in the wetland. According to Guthrie (1996), the vegetation communities of the Hlatikulu wetland have similarities with those at Ntabamhlope Vlei. The wetland habitats apparently include wet grassland, sedge meadows, bulrushes and reedswamp (Guthrie (1996).

According to Guthrie (1996), all three southern African crane species (Blue, Wattled and Crowned Crane), and fourteen species of waterfowl, have been recorded in the Hlatikulu Crane and Wetland Sanctuary. Begg (1989) also reported two pairs of Wattled crane were known to breed in the wetland and he reported Crowned crane as also having been recorded visiting the system. According to Guthrie (1996), a wetland rehabilitation programme had also been implemented in the system at the time. Nxele (2007) used the Hlatikulu wetland as a case study to research public participation in wetland rehabilitation considering the Working for Wetlands (WfW) rehabilitation undertaken in the wetland.

The Hlatikulu wetland also has socio-economic importance (Nxele, 2007). According to Nxele (2007), in addition to supplying water for human and livestock consumption, ingcobosi (Schoenoplectus brachycerus) harvested from the wetland is used for making sleeping mats, with other wetland plants also harvested to make brooms and other craft items. Nxele (2007) also reported some local residents use medicinal plants from the wetland. Begg (1989) indicated that the wetland was also important for water storage, streamflow regulation, flood attenuation, wildlife and agriculture at the time.

Working for Wetlands (WfW) have carried out rehabilitation work in both the arms of the system, including, but not restricted to, concrete weirs and earthwork berms (SANBI, Wetland Interventions 2012).

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 64, 78.5% of wetlands within IUA 7 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 6.3% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B). Channelled Valley Bottom wetland systems are especially affected by degradation with over 90% of these systems considered Largely to Critically Modified. Depression wetlands were generally in the best condition with 74.1% of these wetlands falling within the A/B category.

Hlatikulu Priority Wetland is indicated as having a wetland condition of mostly D/E/F with one tributary A/B (Van Deventer *et al*. 2018), though the NFEPA wetland attribute data (Nel *et al.,* 2011) indicates the main body of the wetland to be in a wetland condition of C.

Table 64: Wetland condition summary for IUA 7 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 7	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	706	1 508	2 559	173	491	8 612	118	399	1 921	85	239	497	12	1	3
%	14.8	31.6	53.6	1.9	5.3	92.8	4.8	16.3	78.8	10.4	29.2	60.5	74.1	8.2	17.7

Threats/Impacts

IUA 7 includes the town of Mooi River and is characterised by extensive commercial cultivation, including widespread irrigation. Wetlands have been extensively transformed by draining and clearing of vegetation. Some of the higher-lying areas of the IUA also support commercial forestry operations.

In terms of the Hlatikulu Priority Wetland, according to Begg (1989) parts of the western arm of the wetland had been impacted by draining at the time. Begg (1989) also pointed out the erosion as a result of a road crossing in the vicinity of the outlet of the system posed a threat to the keypoint of the wetland. Dams were also considered to pose a potential threat to the system in the late 1980's as Begg (1989) indicated that storage dams had been built in the wetland. Begg (1989) also indicated agriculture alongside the upper reaches of the wetland at the time including centre-pivot irrigation between the two arms of the wetland and the establishment of pastures at the head of the western arm at the system. Evidence of existing and historical draining and cultivation in the wetland as well as a threat of alien vegetation encroachment into the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

The Working for Wetlands (WfW) rehabilitation work would likely have addressed some of these impacts and the success of the interventions, and whether or not new impacts and the threats identified previously still exist today, or have increased, are unknown and will, if existing information allows, be investigated further as this study progresses and more information is collected on the Priority Wetland systems.

Groundwater

The groundwater characteristics in IUA 7 are as follows:

- Geology: Karoo Supergroup –
  - Beaufort (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
- Dolerite intrusions: Limited (if any)
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~15 mm·a-1 (eastern ½) to 45 mm·a-1 (western ½).
- Groundwater quality (mS·m-1): <70 (upstream 80% area).
- Groundwater Reserve status (allocations): High risk (SI = 65% to 82%).
- Wetlands present in V20E.

9.2.8 IUA 8: Middle/Lower Mooi River

IUA 8 is delineated as the Mooi River at the outlet of quaternary catchment V20E to the confluence of the Mooi River with the Thukela River (below) Keate's Drift.

Rationale

This IUA is based on similar ecoregion (lowlands, hills and mountains with moderate and high relief). Extensive irrigation in the catchment (mainstem and tributaries). Although the present state of most of the systems in this IUA are moderately modified, the EIS range from high to very high.

Overview

IUA 8, the Lower Mooi IUA, includes portions of the Umvoti, Mpofana and Msinga local municipalities (Figure 108). The IUA includes the towns of Muden and Keates Drift. Protected areas include Mt Gilboa Nature Reserve and Craigie Burn Nature Reserve.

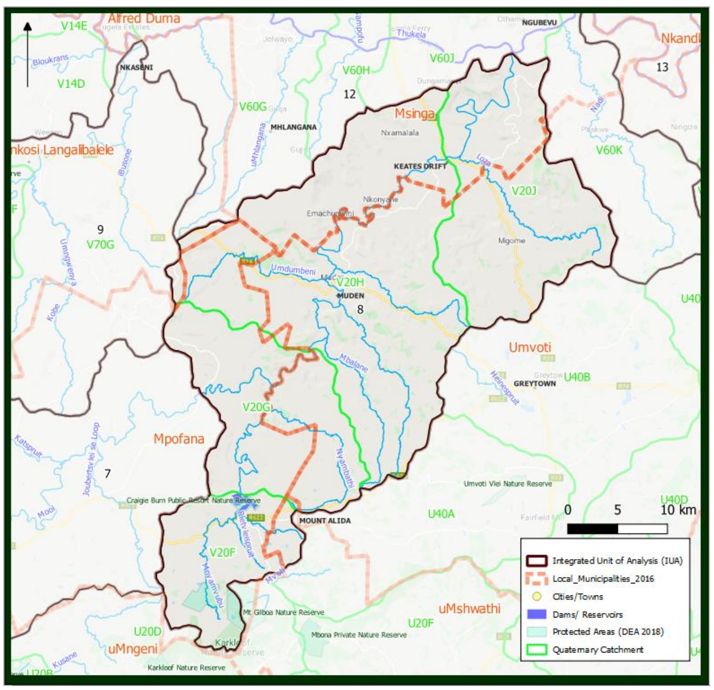


Figure 108: Overview of boundaries and features in IUA 8

Water Resources

Water resources in the IUA include the Mooi River and tributaries (Table 65) as well as the Craigie Burn dam. The region falls into the Agricultural Socio-Economic Zone with land uses transforming 19% of the landscape. Agricultural land uses represent 13% and residential the remaining 6% (Figure 109).

Table 65: Water resources and catchments of IUA 8

IUA	Main Rivers	Tributaries	Quaternaries
8	Mooi River	Mpatheni River; Nyambathi River; Mnyamvubu River; Mbalane River; Mhlopeni River; Umdumbeni River; iTshekana River; Loza River	V20F; V20G; V20H; V20J

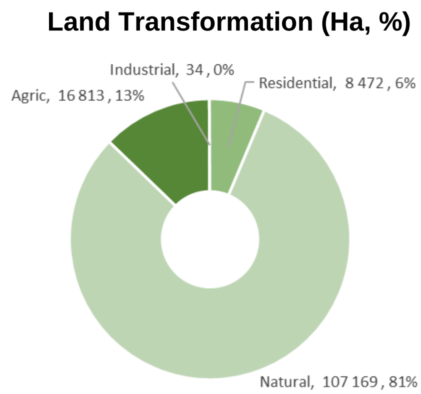
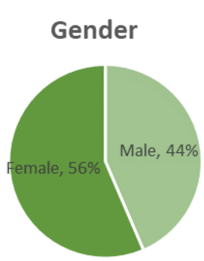
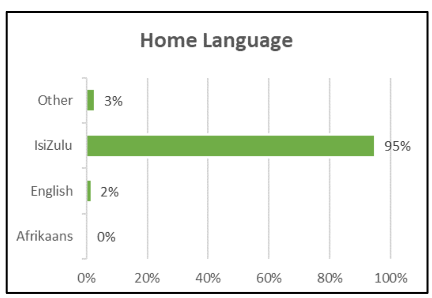


Figure 109: Land transformation per category in IUA 8 (Ha, %)

Socio-Economic Profile

The population of IUA 8 is approximately 56 074 with approximately 12 841 households. The majority of residents, 95%, speak IsiZulu, and 2% speak English (Figure 110). Only 18% of residents completed secondary school.





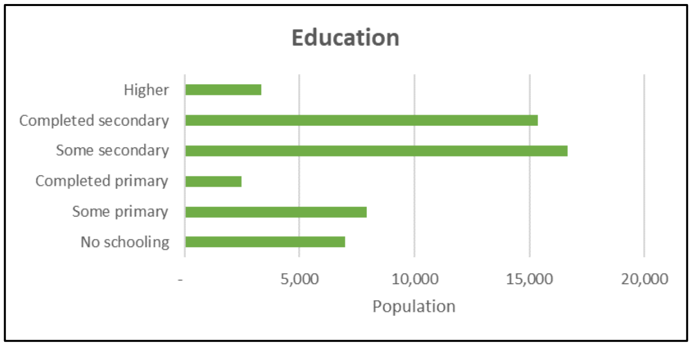


Figure 110: Demographic profile of residents in IUA 8 (StatsSA-Census 2011)

There are only 18% of economically active residents that are employed with 64% being employed in the formal sector (Figure 111). A relatively small proportion, 8%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

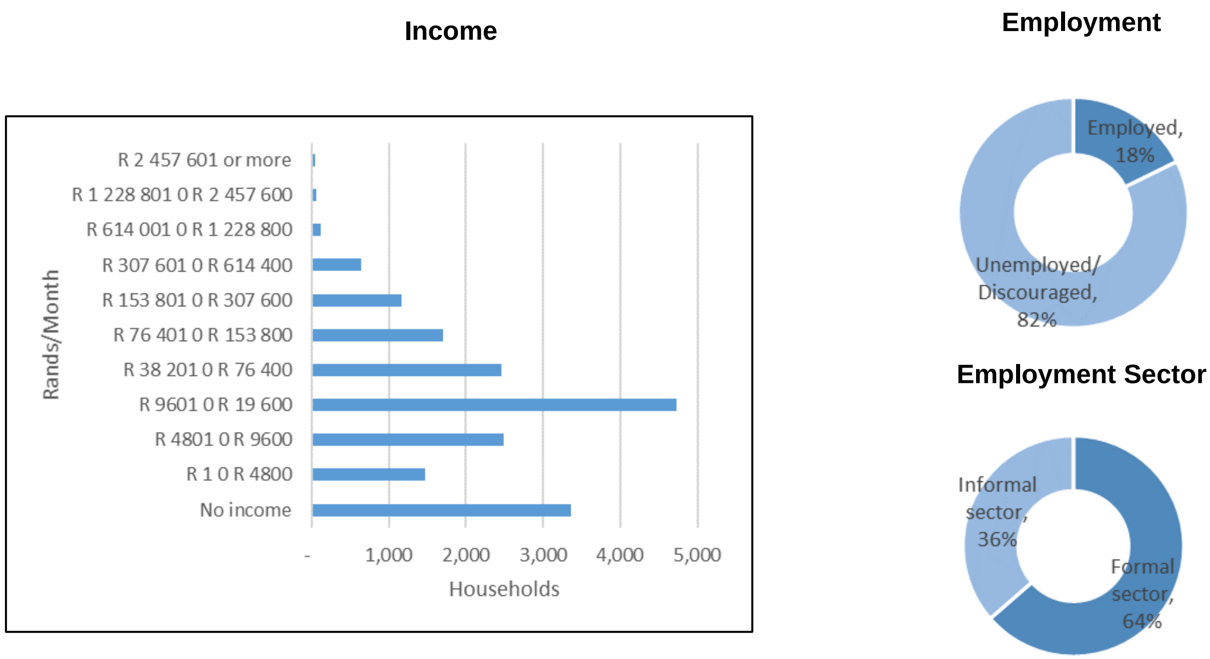


Figure 111: Economic profile of residents in IUA 8 (StatsSA-Census 2011)

Land tenure is represented by a large proportion of Communal owned land, followed by privately owned land and State-owned land. There is also an area of traditional owned land in the north-eastern part of IUA 8 (Figure 112).

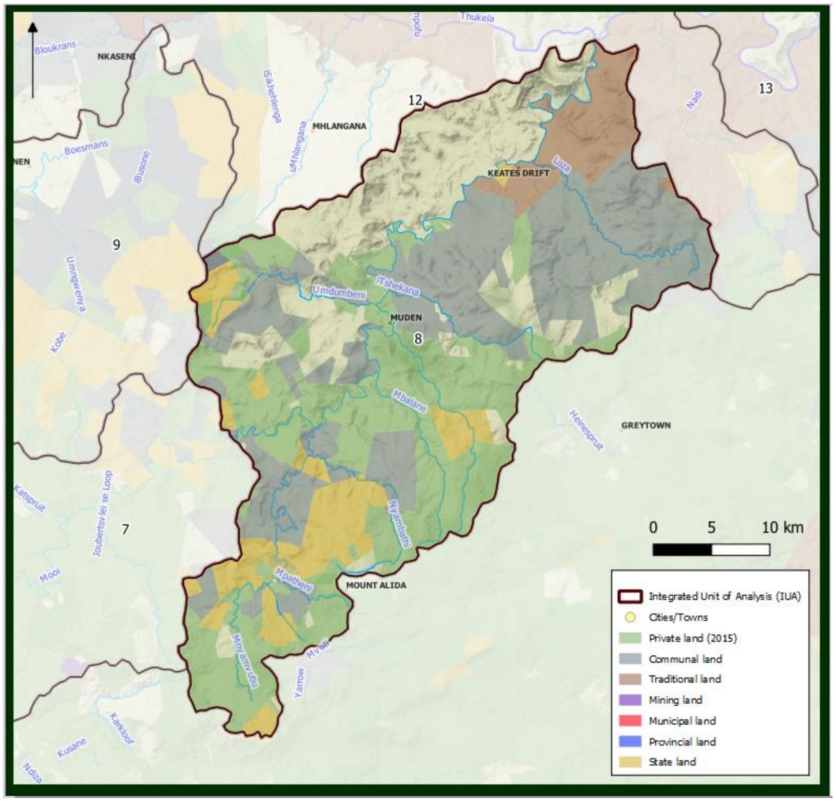


Figure 112: Land ownership within IUA 8 (DRDLR 2015)

Access to services varies greatly among residents with high proportion, 84%, having limited access to piped water (>50m away from their dwelling), 92% having no access to refuse disposal services, 92% with no flush toilets and only 9% having 24 hour access to the internet (Figure 113). Varied access to services indicates varied levels of wellbeing throughout the catchment.

A very high, 30%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 62% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

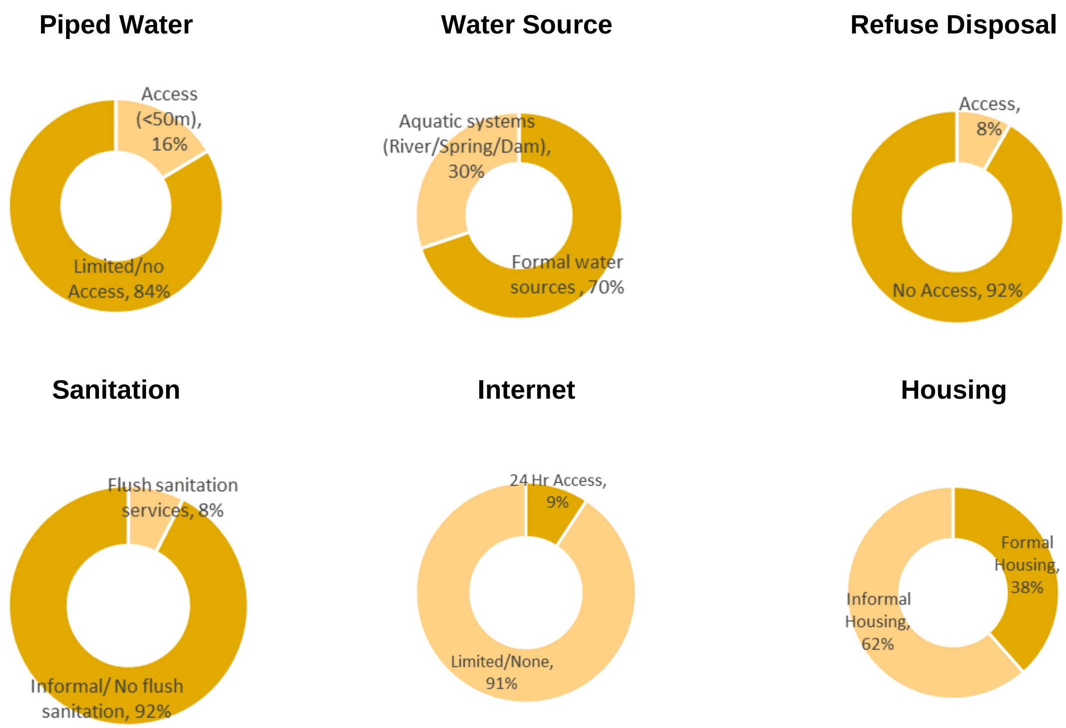


Figure 113: Access to services and indicators of wellbeing of residents in IUA 8

This IUA consists mainly of rangeland, with some irrigation agriculture present (Figure 114). Demand on water resources is relatively low.

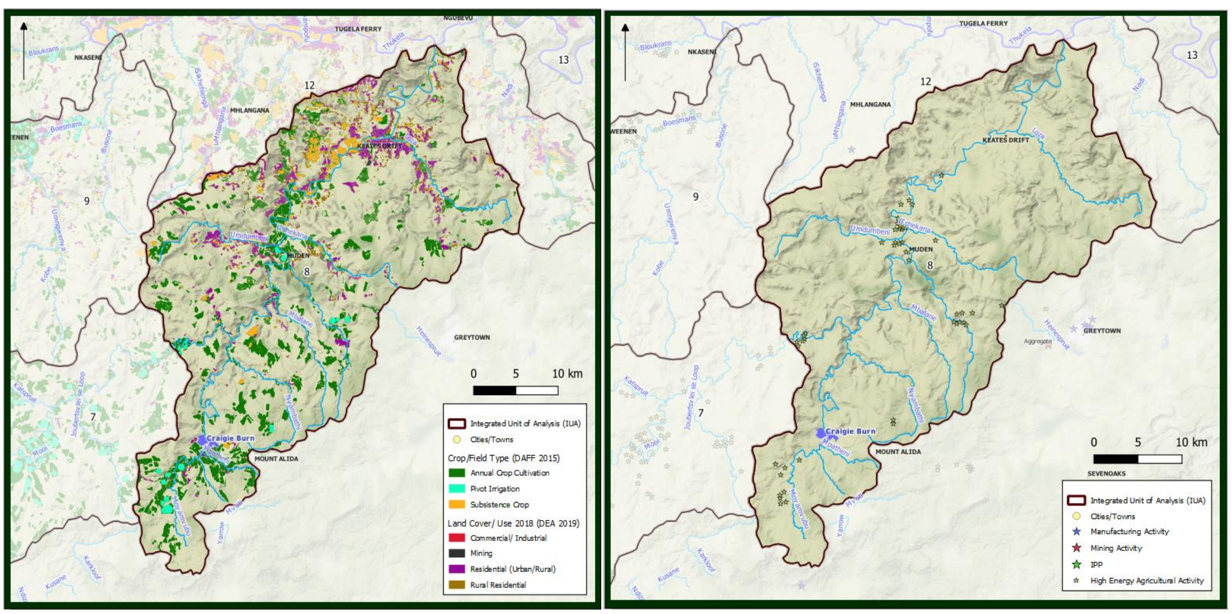
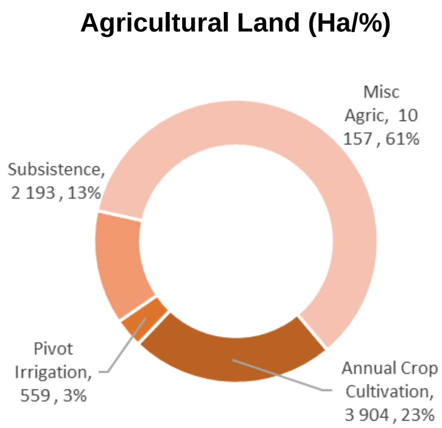


Figure 114: Land use by land cover in IUA 8 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 8

The mountainous terrain of this IUA does not lend itself to agricultural development, as such commercial agriculture accounts for a relatively low proportion of land cover, while the local economy appears to rely on subsistence agriculture. Miscellaneous agriculture, most likely rangeland, accounts for the most of the land cover, while high intensity land cover is almost non-existent (Figure 115).



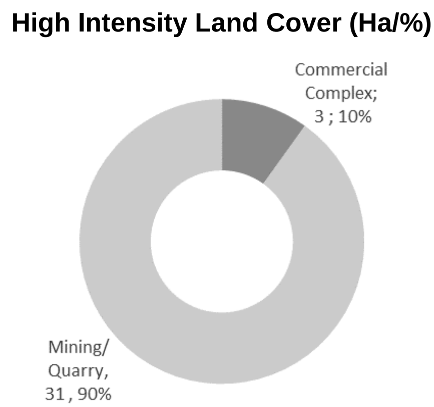


Figure 115: Classification of Agricultural Land and of High Intensity Land Cover in IUA 8

Table 66 below provides details on the municipalities which form part of IUA 8, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 66: Municipalities located within IUA 8

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 8
Umvoti LM	• General government services • Wholesale & retail trade, catering & accommodation • Manufacturing • Finance, Insurance, Real estate & Business Services • **Agriculture forestry & fishing**	Wards: 8, 11 & 14 Accounting for the bulk of this IUA, with the town of Muden representing its main economic centre. This area is characterised by sparse annual crop cultivation. Tourism also plays a role in this area, with the Mhlopeni Nature Reserve and Imbalala Game Lodge falling into IUA 8.
Msinga LM	• Community Services • Trade • Construction • Transport	Wards: 8, 9, 10, 11 & 13 The town of Keates Drift is the main settlement in this area. The area is mainly characterised by rural residential settlement, with concurrent subsistence farming.
Mpofana LM	• **Agriculture** • Tourism • SMMEs • Co-ops	Ward: 4 Agriculture is the main focus of this region, seconded by forestry. The Craigie Burn Dam, fed by the Mnyamvubu and Mpatheni Rivers, is the main source of water for the area.

Water Resource Use

This IUA is driven by the incremental flows in entering the system, and the releases and spills from the dams upstream. Considerable irrigation occurs along the main stem. The Craigieburn Dam is also being earmarked for water supply to Greytown, so any surplus in that dam appears to have been allocated. The volume available for supply to Greytown may need to be reviewed with EWRs.

Ecosystem Services

Situated in the south-central extent of the catchment IUA 8 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Mpatheni, Nyambathi, Mnyamvubu, Mbalane, Mhlopeni, Umdumbeni, iTshekana and Loza Rivers which flow into the Mooi River (Figure 116). The landscape is characteristic of a variety of wetland systems, predominantly seeps (40%) and unchannelled-valley bottoms (35%) (Figure 117). Regionally significant aquatic resources include the Craigie Burn Dam. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 67).

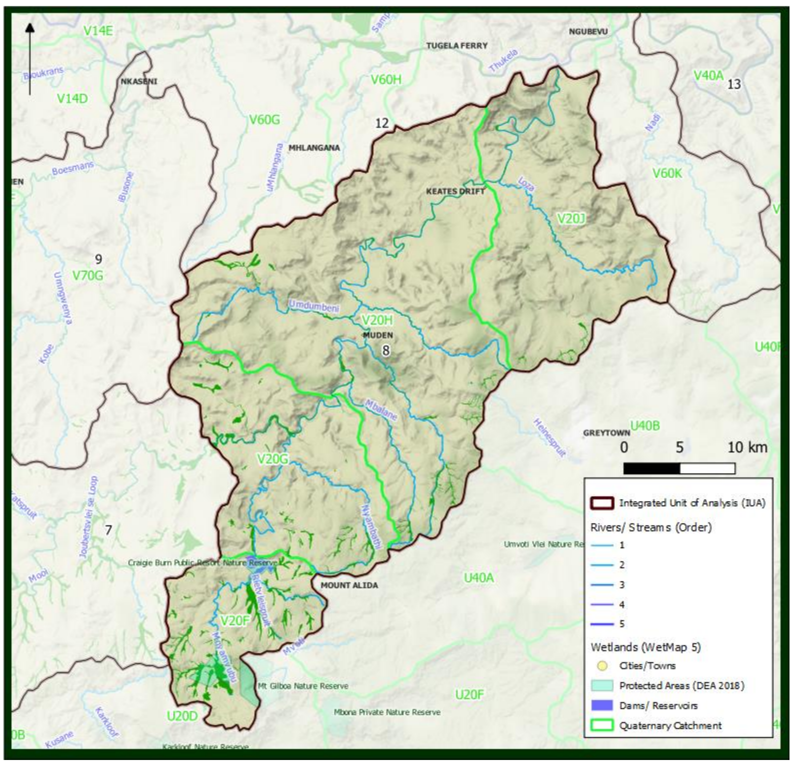


Figure 116: Locality of water resources in IUA 8

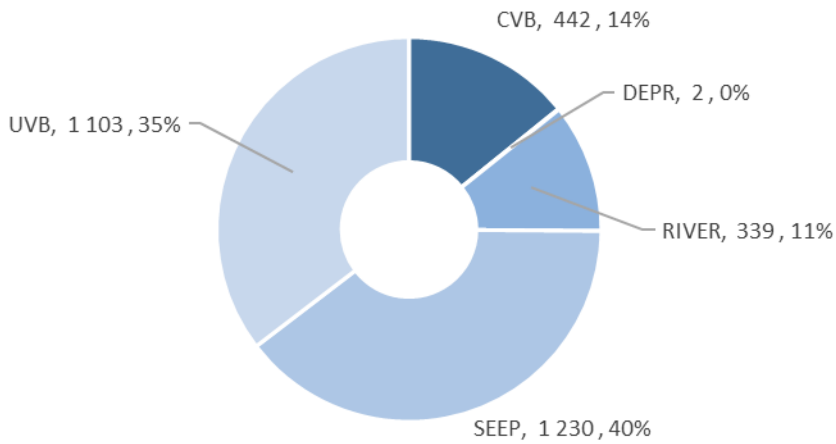


Figure 117: Wetland extent and type in IUA 8 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 67: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 8 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 8	Sector (12 Sectors)
Provisioning	**Food**	Relatively low wetland extent	Major Significance- relative high densities of rural communities and subsistence livelihoods	Higher	**Households**
	Fresh Water	Craigie Burn Dam, Rivers	Major significance: Presence of significant commercial agriculture both annual crop cultivation and irrigation activities; Rural communities have a significant presence downstream in the catchment.	Higher	**Households; Agriculture**
	Raw materials	Relatively low wetland extent	Major Significance- relative high densities of rural communities and subsistence livelihoods	Higher	**Households**
	Medicinal resources	Relatively low wetland extent	Significance- relative high densities of rural communities and subsistence livelihoods	Higher	**Households**
Regulating	**Climate regulation**	Relatively low wetland extent	Significance to global beneficiaries	Lower	
	Water quantity regulation	Relatively low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service	Lower	
	Water purification & waste management	Relatively low wetland extent	Significant to rural communities and limited commercial agriculture however relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
	Erosion control/ Soil stability	Relatively low wetland extent	Significant to rural communities and limited commercial agriculture however relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
	Biological control	Relatively low wetland extent	Minor significance to rural communities- relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
Cultural	**Landscape & amenity values**	Protected areas/Reserves; Wetlands and rivers	Significance to tourism industry and to rural communities through cultural value	Lower	
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The compliance assessment of the Lower Mooi River reflects good quality water. However very limited data is available for the lower catchment. The data in V20F is at the outflow from Craigie Dam thus water quality is good. The only other site is at the outlet quaternary catchment at Keates Drift in V20H. Water quality here is impacted in terms of salinity and elevated pH indicative of the upstream agricultural activity.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 8 - Middle/Lower Mooi River														
102744	V20F	6.9	8.8	79.4	11.6	0.6	2.7	4.6	7.5	0.11	0.05	8.0	0.010	3.0
102745	V20F	6.4	7.5	70.5	10.8	0.5	2.4	4.5	7.2	0.12	0.03	7.9	0.005	3.5
102748	V20F	6.4	9.0	71.9	11.5	0.5	2.5	4.7	7.2	0.11	0.06	8.0	0.010	2.4
102740	V20H	36.4	23.4	407.8	48.6	0.7	3.7	24.4	38.6	0.10	0.07	8.7	0.010	19.1

River Ecological information and PES

The rivers in the IUA are largely in a modified ecological condition (C PES category). The Mbalane and short reaches of the Mooi River below the confluence of the Nyambathi River and at Muden are in a largely natural condition, i.e. a B ecological category. The IUA includes EWR site 11 in V20G on the Mooi River. An additional site in this IUA is being considered on Mooi River below Keats Drift or additionally on the Mnyamvubu River downstream Craigie Burn Dam.

Wetlands

IUA 8 is located in the southern watershed of the Thukela Catchment within the Grassland and Savanna Biomes, and falls within the Sub-Escarpment Grassland Bioregion and the Sub-Escarpment Savanna Bioregion, though the bulk (>90%) of mapped wetland habitat within the IUA falls within the Sub-Escarpment Grassland Bioregion. Wetlands cover only 1 103 ha of IUA 4, or 2.4% of the land surface, which is significantly less than the average wetland coverage of 4.7% across the entire Thukela Catchment. A small portion of the IUA falls within the Karkloof IBA (IBA #SA129), with all three Priority Wetlands also falling within the IBA.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 8 are again Seep wetlands, which make up 42.6% of the mapped wetland area and cover 1 371 ha. Unchannelled Valley Bottom and Channelled Valley Bottom wetlands are the next most extensive wetland types at 34.7% and 22.7% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 2 hectares and make up less than 1% of the wetland area within the IUA. The National Wetland Map 5 (Van Deventer et al., 2018) identified only 1 ha of Floodplain wetland habitat within this IUA.

Priority Systems in IUA 8

IUA 8 includes three Priority Wetlands associated with the headwaters of the Mnyamvubu River being the Dartmoor, Melmoth and Scawby wetlands. According to Edwards (2009), the Dartmoor wetland is approximately 42 ha in extent and is an Unchannelled Valley Bottom wetland system characterised by diffuse flow conditions and extensive peat deposits. Begg (1989) indicates that the wetland is approximately 70 ha in extent. According to Edwards (2009) the wetland and its catchment are entirely underlain by a large dolerite sill that forms the Karkloof escarpment and plateau and the wetland terminates against a dolerite dyke ridge that has intruded into the sill. Edwards (2009) indicates that the wetland has evolved from a floodplain wetland characterised by laterally migrating meanders to a valley-bottom wetland characterised by discontinuous streams and peat accumulation.

According to Bowd, Kotze, Morris and Quinn (2006), the Melmoth wetland is one of the area's least impacted wetlands. The wetland is approximately104 ha in extent (Begg, 1989; Bowd, et. al., 2006) and forms part of the headwaters of the Mnyamvubu River. As is the case with the Dartmoor and Scawby wetlands the Melmoth wetland system is dominated by hygrophilous plant communities (Begg, 1989). The system supports a wide variety of wildflowers and is regularly burnt during the dry season (Begg 1989). In 1989, the wetland became part of the Karkloof Nature Reserve and thus is formally protected from degradation and modification (Bowd, *et. al*., 2006).

The Scawby wetland is indicated as being approximately 460 ha in extent (Begg, 1989). As such is the largest of the three Priority systems in this IUA. Begg (1989) indicated that wildlife protection (ecological importance) was the most important function of these systems at the time with water storage and streamflow regulation also being important.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 68, 67.8% of wetlands within IUA 8 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 9.5% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B). Unchannelled Valley Bottom wetland systems are especially affected by degradation with over 87% of these systems considered Largely to Critically Modified.

Melmoth Priority Wetland is indicated as having a wetland condition of A/B (Van Deventer et al. 2018), with the NFEPA wetland attribute data (Nel *et al.,* 2011) also indicating the main body of the wetland to be in a wetland condition of A/B.

Dartmoor Priority Wetland is indicated as having a wetland condition of C (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel *et al.*, 2011) indicates the main body of the wetland to be in a wetland condition of A/B.

Scawby Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel *et al*., 2011) indicates the main body of the wetland to be in a wetland condition of C. Wattled cranes have apparently been recorded in the Scawby wetland (Begg, 1989).

Table 68: Wetland condition summary for IUA 8 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al.*, 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 8	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	133	449	789	153	155	420	16	126	972	1			0	1	
%	9.7	32.8	**57.5**	21.1	21.3	**57.6**	1.5	11.3	**87.2**	**100.0**			20.4	**79.6**	

Threats/Impacts

Extensive commercial plantations occur along the upper edge of this IUA with some commercial cultivation also present. The lower reaches of the IUA are characterised by extensive areas of subsistence agriculture. Limited commercial sugar cane farming occurs along the Mooi River in the centre of the IUA.

Damming, plantations and the spread of alien invasive plant species as well as regular burning were listed by Begg (1989) as posing a potential threat to the three Priority Wetlands at the time. According to Begg (1989), both the Scawby and Dartmoor wetland systems had been impacted by furrowing/draining at the time. Whether these impacts and threats still exist today, or have increased, are unknown and will be investigated further as this study progresses and more information is collected on the Priority Wetland systems. Evidence of what appears to be either existing or historical draining in the Dartmoor and Scawby wetlands and draining and cultivation in the wetland systems between these and in the latter, as well as a threat of alien vegetation encroachment into the latter, can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

Groundwater

The groundwater characteristics in IUA 8 are as follows:

- Geology: Karoo Supergroup –
  - Pietermaritzburg (shale)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)

  - Dwyka (arenite, tillite, mudstone and shale
- Dolerite intrusions: Limited .
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~15 $mm \cdot a^{-1}$ (eastern ½) to 45 $mm \cdot a^{-1}$ (western ½).
- Groundwater quality (mS·m-1): <70 (~25% of area), 70-300 (65% of area) and >300 (10% of area). Regional groundwater quality deterioration in V20H, and V20J.
- Groundwater Reserve status (allocations): Moderate risk (SI = 35% to 50%).

9.2.9 IUA 9: Middle/Lower Bushmans River

IUA 9 is delineated from the outflow of the Bushmans River from the UKhahlamba Drakensberg National Park to its confluence with the Thukela River.

Rationale

The IUA delineation is based on the land use impacts in the catchment area due to towns, settlements and extensive irrigation. The present state of the mainstem Bushmans is moderately modified with the tributaries still in a good state. It is a hardworking catchment area with industrial, agriculture and urban development. The delineation creates a logical entity for management.

Overview

IUA 9, the Middle/Lower Bushmans River IUA, encompasses the Inkosi Langalibalele and Mpofana local municipalities (Figure 118). The IUA includes the larger city of Estcourt and smaller towns and communities of Wembezi, Bashi and Weenen. The regions of the IUA are protected through Weenen Game Reserve, Wagendrift Nature Reserve and Dalton Private Reserve.

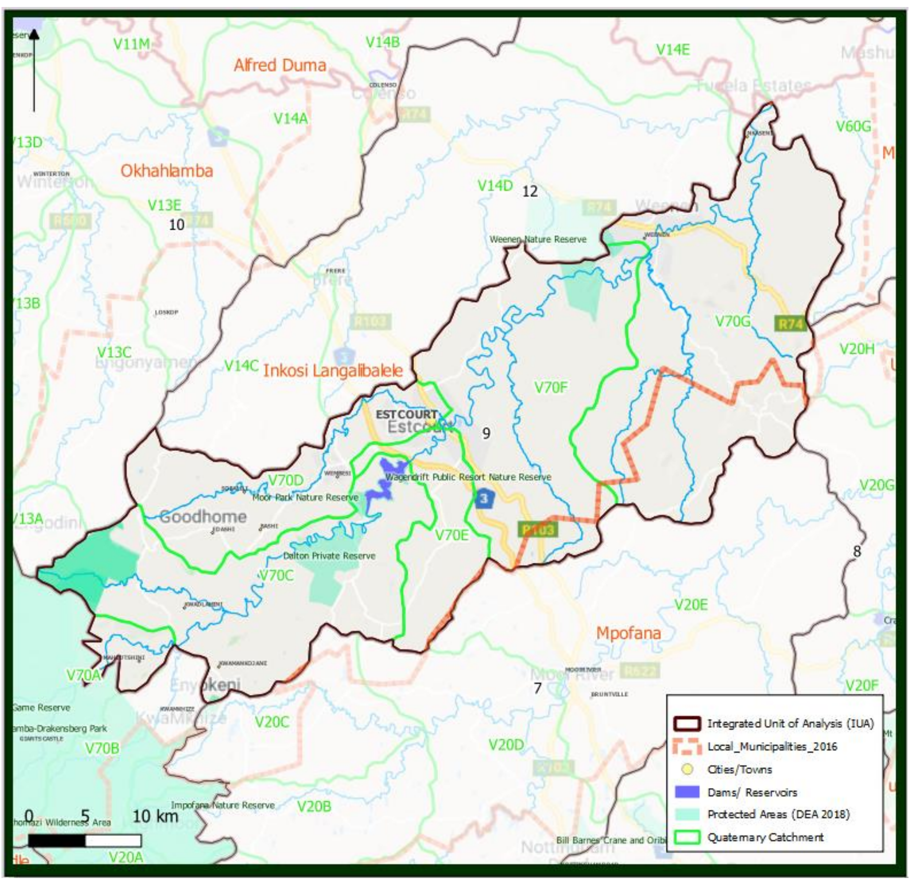


Figure 118: Overview of boundaries and features in IUA 9

Water Resources

Water resources in the IUA include the Middle/Lower Bushmans River and tributaries (Table 69) as well as the Wagendrift dam. The proposed Mielietuin Dam site is proposed on the Bushman's River between Estcourt and Weneen.

Table 69: Water resources and catchments of IUA 9

IUA	Main Rivers	Tributaries	Quaternaries
9	Middle/Lower Bushmans River	Klein Boesmans River; Rensburgspruit; uMngwenya River; Kobe River; iBusone River	V70A (lower portion); V70C; V70D; V70E; V70F; V70G

The region falls into the Agricultural Socio-Economic Zone with land uses transforming only 17% of the landscape. Agricultural land uses represent 11% and residential the remaining 6% (Figure 119).

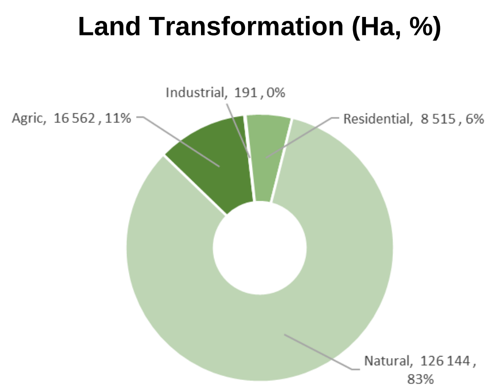
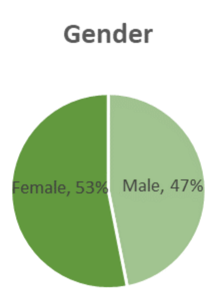
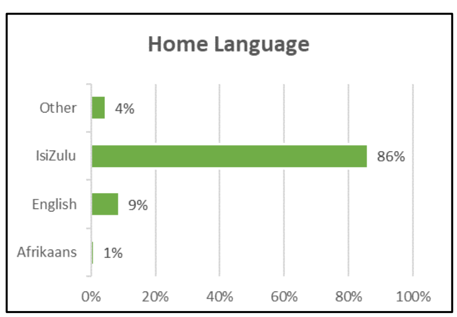


Figure 119: Land transformation per category in IUA 9 (Ha, %)

Socio-Economic Profile

The population of IUA 9 is approximately 97 958 with approximately 22 801 households. 86% of the residents of IUA 9 speak IsiZulu, 9% speak English and 1% Afrikaans (Figure 120). 35% of residents completed secondary school.





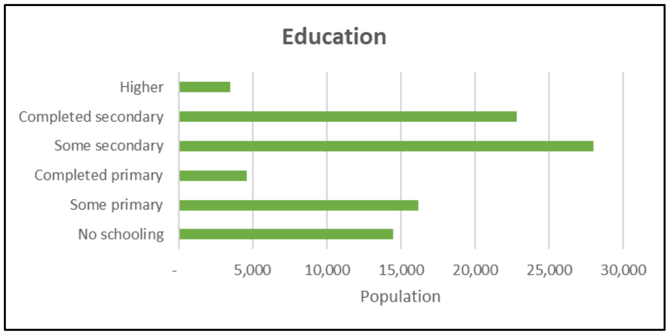


Figure 120: Demographic profile of residents in IUA 9 (StatsSA-Census 2011)

There are only 25% of economically active residents that are employed with 75% being employed in the formal sector (Figure 121). A relatively small proportion, 8%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

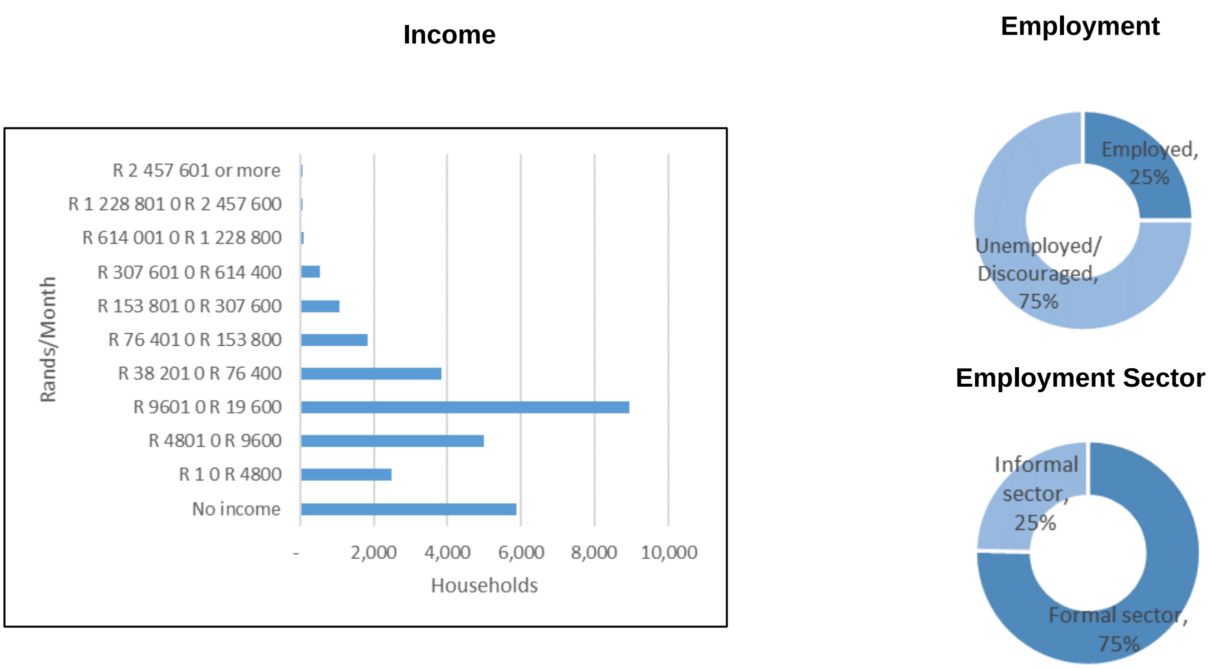


Figure 121: Economic profile of residents in IUA 9 (StatsSA-Census 2011)

Land tenure is represented predominantly by State owned, Communal owned and Traditional owned land with privately owned land to a lesser extent in IUA 9 (Figure 122).

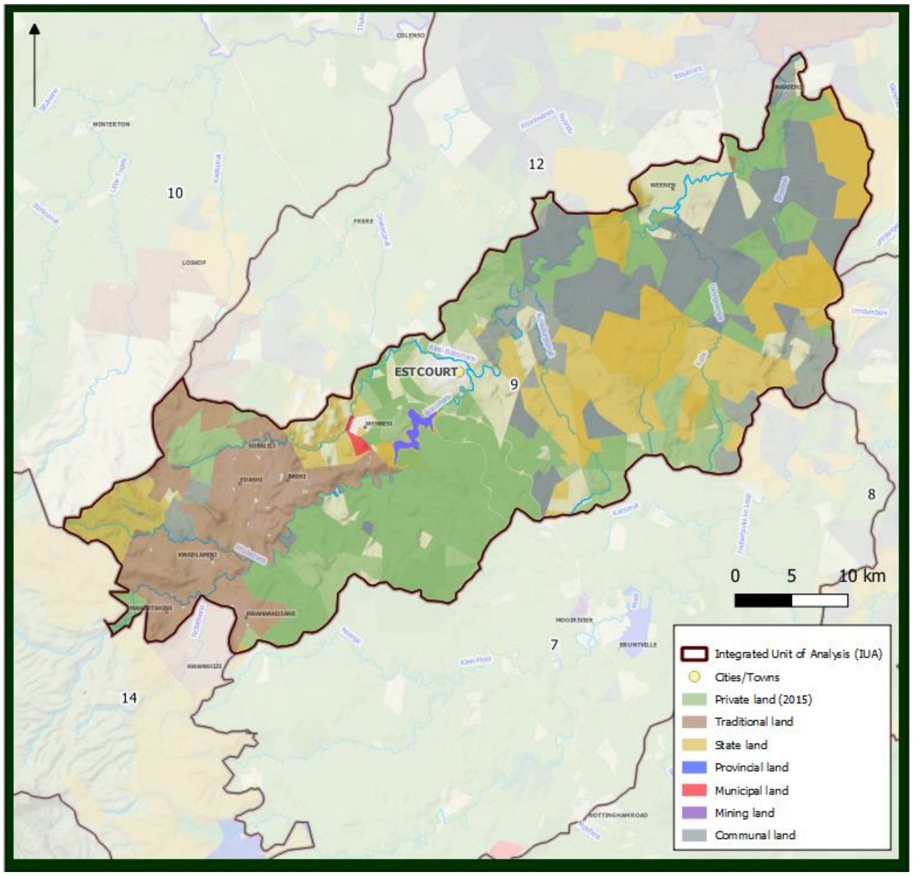


Figure 122: Land ownership within IUA 9 (DRDLR 2015)

Access to services varies greatly among residents with just under half the residents, 49%, having limited access to piped water (>50m away from their dwelling), 60% having no access to refuse disposal services, 59% with no flush toilets and 25% having 24 hour access to the internet (Figure 123) Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 18%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 29% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

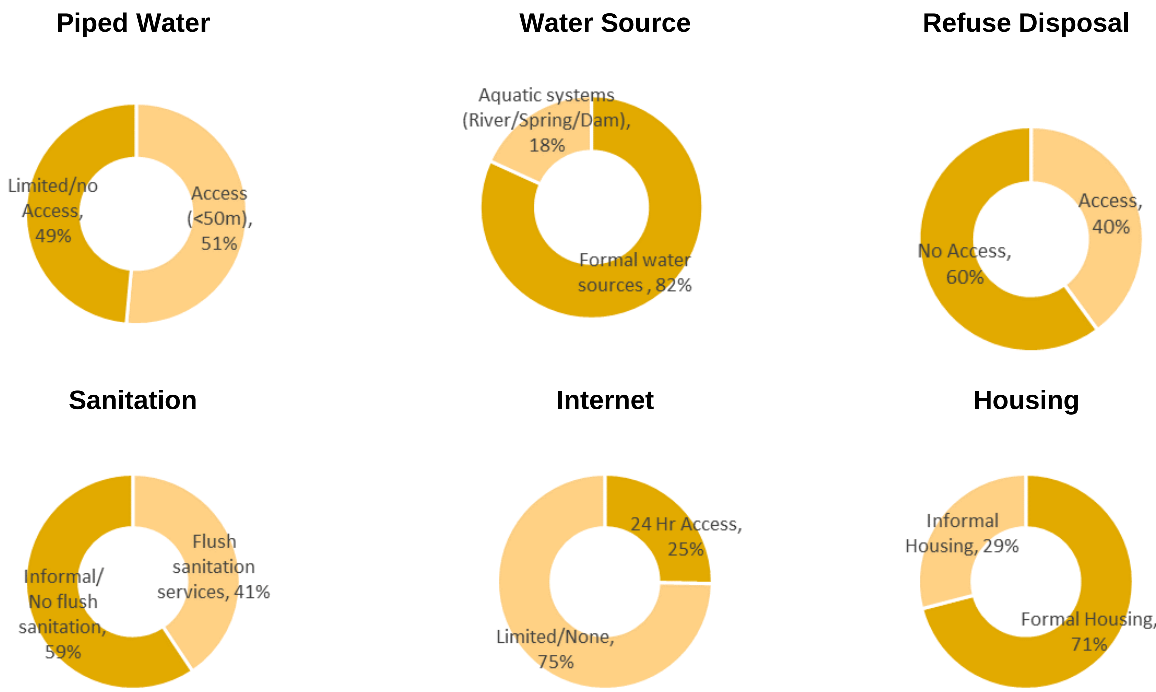


Figure 123: Access to services and indicators of wellbeing of residents in IUA 9 t (StatsSA-Census 2011)

This IUA contains a few high intensity irrigated agricultural hotspots which require a steady supply of water. Mostly it can be characterised by rangeland, with some light commercial activity around the central town of Estcourt (Figure 124).

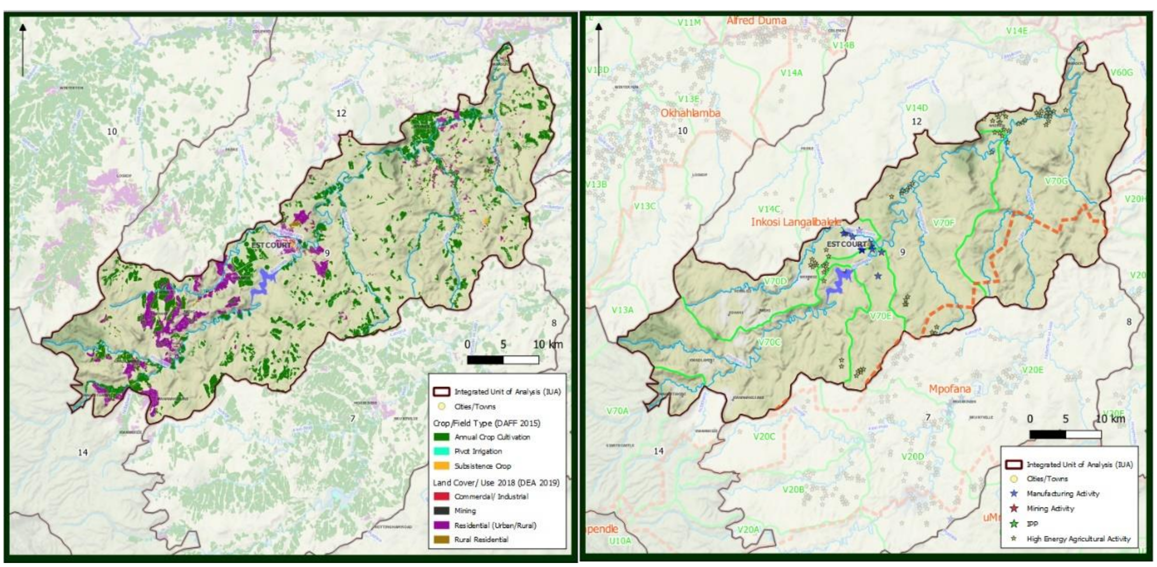


Figure 124: Land use by land cover in IUA 9 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 9

This IUA, at the head of the Thukela River, exhibits a mixed economy. A small commercial hub around the main town of Estcourt forms the backbone of the economy (Figure 125), supported by small areas of high intensity agriculture, while a large contingent of the population rely on subsistence agriculture and grazing.

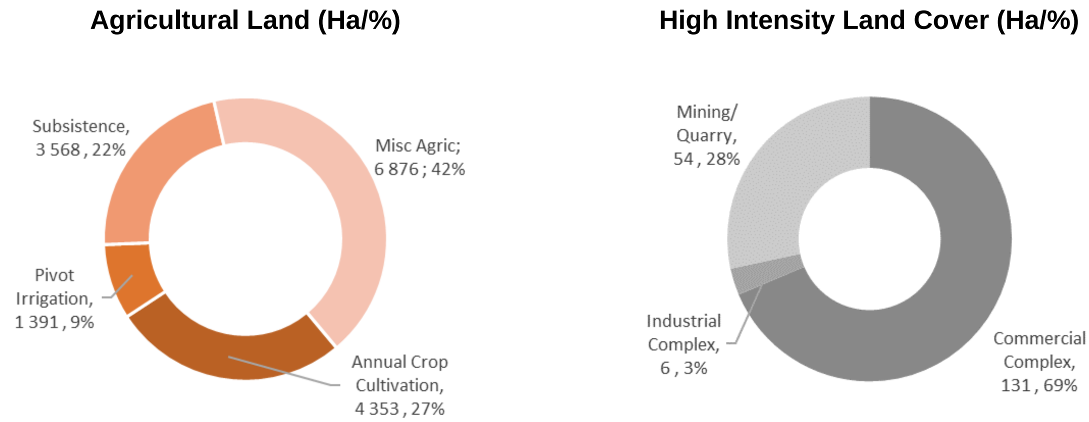


Figure 125: Classification of Agricultural Land and of High Intensity Land Cover in IUA 9

Table 70 below provides details on the municipalities which form part of IUA 9, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 70: Municipalities located within IUA 9

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 9
Inkosi Langalibalele LM	• **Agriculture** • Manufacturing • Tourism • Industry • Services	Wards: 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 With the main economic hub of the region being Estcourt, manufacturing forms the core of the region's economy, although it does not appear to be a high water intensity manufacturing. There is a large quarry near the town, which also contributes to the local economy. Two high intensity agricultural areas exist: one at Wembizi, just south west of Estcourt; and the other at Weenen, in the northern part of IUA 9. Tourism also plays a role in this area, as it encompasses at least part of 3 nature reserves – Weenen, Dalton, and Giants Castle. Residential usage likely accounts for the highest water consumption in the region. The Wagendrift Dam is the main reservoir for the area.
Mpofana LM	• **Agriculture** • Tourism • SMMEs • Co-ops	Wards: 1 & 4 There is no significant economic activity in this area.

Water Resource Use

This IUA is driven by the Wagendrift Dam and the centre of Estcourt and surrounding areas supply. The proposed Mielietuin Dam (part of a further phase of the TWP) is also situated in this IUA. Bulk water users include Estcourt, Wembezi, Craigtown Weenen, Noodkamp Kwadamini, Kwamazel and Sobabili.

Ecosystem Services

Situated in the south-central extent of the catchment IUA 9 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Klein Boesmans, Rensburgspruit, uMngwenya, Kobe and iBusone Rivers which flow into the Middle/Lower Bushmans River (Table 71). The landscape is characteristic of a variety of wetland systems, predominantly seeps (65%), channelled valley bottom (13%), riparian (12%) and unchannelled valley bottom (10%) (Figure 126).

Regionally significant aquatic resources include the Wagendrift Dam and various protected areas. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Figure 127).

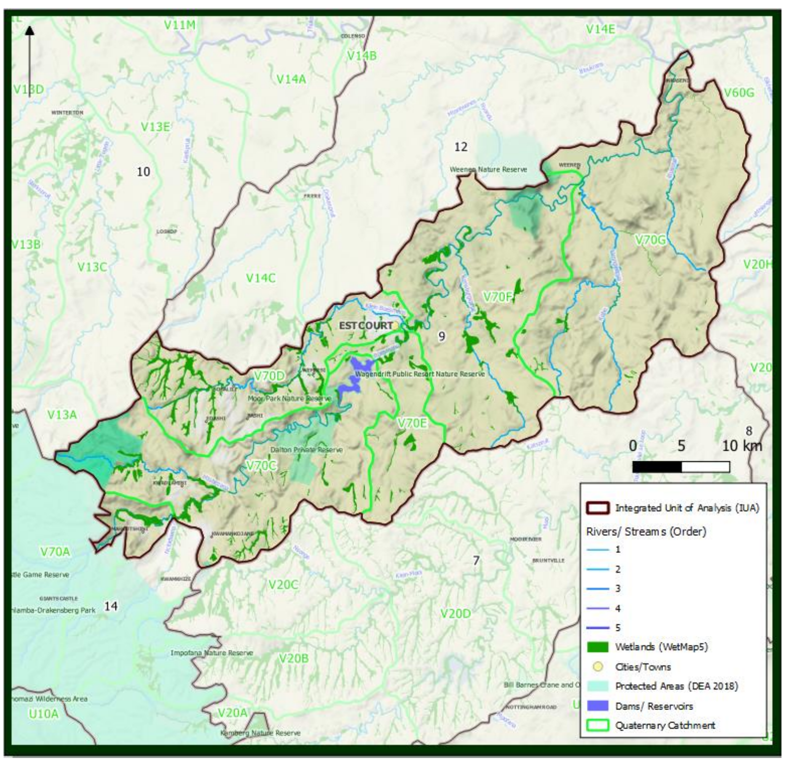


Figure 126: Locality of aquatic resources in IUA 9 in the uThukela Catchment

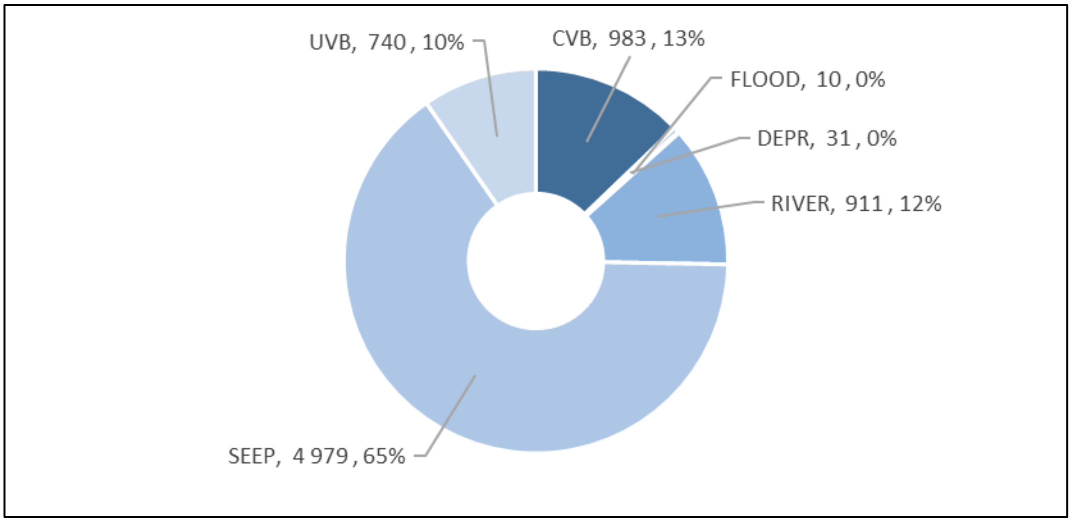


Figure 127: Wetland extent and type in IUA 9 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage

Table 71: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 9 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 9	Sector (12 Sectors)
Provisioning	**Food**	Wetlands-closely associated with rural communities	Major Significance- relative high densities of rural communities and subsistence livelihoods	Higher	**Households**
	Fresh Water	Rivers; Wagendrift Dam	Major significance: Presence of significant commercial agriculture both annual crop cultivation and irrigation (along the Boesmans River) activities; Industry/manufacturing at Estcourt; Rural communities have a significant presence upstream in the catchment.	Higher	**Households; Manufacturing; Agriculture**
	Raw materials	Wetlands-closely associated with rural communities	Major Significance: Relative high densities of rural communities and subsistence livelihoods	Higher	**Households**
	Medicinal resources	Wetlands-closely associated with rural communities	Significance- relative high densities of rural communities and subsistence livelihoods	Lower	
Regulating	**Climate regulation**	Wetlands	Significance to global beneficiaries	Lower	
	Water quantity regulation	Wetlands	Major Significance: Rural Communities associated with Sobalili and Edashi; Subsistence Agriculture (Livestock); Domestic water services at Estcourt, Industrial activities around Estcourt; Agricultural and irrigation throughout the catchment;	Higher	**Households; Manufacturing; Agriculture**
	Water purification & waste management	Wetlands	Major Significance: Rural Communities associated with Sobalili and Edashi; Subsistence Agriculture (Livestock); Domestic water services at Estcourt, Industrial activities around Estcourt; Agricultural and irrigation throughout the catchment;	Higher	**Households; Manufacturing; Agriculture**
	Erosion control/ Soil stability	Wetlands, Rivers	Significance due to high level of agricultural activities within catchment	Lower	
	Biological control	Wetlands, Rivers	Significance due to high level of agricultural activities within catchment	Lower	
Cultural	**Landscape & amenity values**	Protected areas/Reserves (Weenen; Moor Park, Wagendrift Nature Reserve); Upstream Wetlands and Rivers	Major significance to tourism industry and to rural communities through cultural value	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Based on the compliance assessment the water quality in Bushmans River catchment is good with ideal and acceptable levels of water quality variables present. High nutrients are evident in V70E, with elevated (tolerable and non-compliant) orthophosphate in V70D, V70E and 70F. Salinity impacts are observed in V70F downstream of the confluence of the Little Bushman's River. The sources of these nutrients are agricultural and the WWTW discharge, lack of management of sewer infrastructure and impacts from the Estcourt town and surrounding areas. There are also issues of poor quality sewage effluent from the Wembezi Ponds, the non-operational pump station and a leaking trunk sewer line in Wembezi which leads to localised water quality impacts. No data is available for quaternary catchment V70G, the impacts of the town of Weenen are thus not known. However, in terms of the Greendrop Report 2013, the WWTW discharge from Weenen was categorised as a high risk. Farmers and communities have raised concerns of poor water quality downstream of Estcourt.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 9 - Middle / Lower Bushmans River														
102799	V70A	9.5	2.6	77.3	11.0	0.5	2.1	4.2	5.3	0.10	0.05	8.1	0.010	3.0
102803	V70C	7.9	5.1	62.9	9.8	0.5	2.1	3.3	5.5	0.12	0.12	8.0	0.010	2.8
102802	V70C	8.6	4.6	71.9	10.9	0.5	2.3	3.8	5.1	0.10	0.11	8.0	0.010	3.1
102797	V70D	21.0	19.1	255.9	33.2	0.8	5.6	8.2	32.7	1.46	0.91	8.2	0.116	14.7
188808	V70E				29.7					2.55	0.10	7.9	0.100	
188807	V70F				36.0					6.80	0.10	7.6	0.360	
188370	V70F				101.0					23.00	0.60	7.4	3.845	

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V70D	Little Bushmans	Serious	WWTW discharges (Estcourt and Wembezi)); industrial area impacts; forestry in upper reaches; sand mining, agriculture; elevated nutrients
V70E	Bushmans	Moderate	Elevated nutrients; intensive irrigated agriculture
V70F	Bushmans	Moderate	Elevated nutrients, high salinity; intensive irrigated agriculture
V70G	Bushmans	Moderate	WWTW discharges (Weenen); extensive irrigation; erosion

River Ecological information and PES

A number of tributaries in the IUA are in a good ecological condition. The Mtshezana is in a natural state (A PES ecological category), while the Umngwenya (V70G) and iBusone (V70G) Rivers are in a B category. The remaining rivers in the IUA are in a moderately modified condition, a C PES ecological category. The IUA has two Comprehensive EWR sites, EWR5 at Weenen Nature Reserve and EWR 6 the outlet of the IUA (V70G) before the confluence with the Thukela River.

Wetlands

IUA 9 is located in the central reaches of the Thukela Catchment within the Grassland and Savanna Biomes, and falls within the Sub-Escarpment Grassland Bioregion and the Sub-Escarpment Savanna Bioregion, though the bulk (>75%) of mapped wetland habitat within the IUA fall within the Sub-Escarpment Grassland Bioregion. Wetlands cover only 6 813 ha of IUA 9, or 4.4% of the land surface, which is similar to the average wetland coverage of 4.7% across the entire Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 9 are again Seep wetlands, which make up 74.1% of the mapped wetland area and cover 5 047 ha. Channelled Valley Bottom and Unchannelled Valley Bottom wetlands are the next most extensive wetland types at 14.4% and 10.9% respectively. The least common wetlands mapped within the IUA are Floodplain and Depression wetlands which both make up less than 1% of the wetland area within the IUA.

<u>Priority Systems in IUA 9</u>

Ntambamhlope is the only Priority Wetland that has been identified in IUA 9 at this stage. Ntabamhlope is approximately 285 ha in extent (Oellerman *et. al.,* 1994). According to Begg (1989), Downing (1966) mapped, classified and described 17 different plant communities in the wetland with plant succession found to be determined by factors such as differences in soil moisture, the depth of the water table, organic content of the soil, and burning and grazing regimes. Seven vegetation types were defined by Oellerman *et. al.* (1994) for management. These were: reed marsh; Carex marsh: and bulrush marsh: which occur in semi-permanently flooded/saturated areas; sedge/Leersia marsh which occurs in permanently flooded to seasonally saturated areas; sedge meadows including hummocked wet meadows which are transitional between marsh vegetation and wet (hygrophilous) grassland; wet or hygrophilous grassland which forms the transition zone between the wetland and non-wetland (dryland) areas; and open water which occurs in the permanently flooded sections of the wetland.

According to Oellerman *et. al*. (1994), the wetland supports several Crowned crane breeding pairs as well as two pairs of Wattled crane. These authors also indicate that this is one of the few Priority Wetlands in the region that has deep (>3m) clear open water patches or pools. Access to these is made easy by their proximity to steeply sloped dry grassland. Oellerman et. al. (1994) also indicated that the wet meadows of flowering plants add to the aesthetic value of the system.

According to Oellerman *et. al*. (1994) the wetland is considered to have streamflow regulation and water purification value and because of the water users downstream who are dependent on assured yields of good quality water, the wetland is of regional significance. The wetland is also important as a research site due to the extensive long-term hydrological monitoring that has taken place in the catchment of the system (Begg, 1989; Oellerman *et. al*., 1994).

Working for Wetlands (WfW) have carried out rehabilitation work in both the upper northern and southern arms of the system as well as in the main system, including, but not restricted to, concrete weirs and earthwork berms (SANBI, Wetland Interventions 2012).

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 72, 74.1% of wetlands within IUA 9 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 8.2% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B). Channelled Valley Bottom wetland systems are especially affected by degradation with almost 100% of these systems considered Largely to Critically Modified.

Ntabamhlope Priority Wetland is indicated as having a wetland condition of D/E/F (Van Deventer et al. 2018), though the NFEPA wetland attribute data (Nel et al., 2011) indicates the main body of the wetland to be in a wetland condition of C.

Table 72: Wetland condition summary for IUA 9 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 9	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	389	996	3 662	2		981	146	203	392	4	1	5	21	1	11
%	7.7	19.7	72.6	0.2		99.8	19.7	27.4	52.9	37.5	13.2	49.4	63.9	3.1	33.0

Threats/Impacts

IUA 9 is characterised by a broad range of land uses including plantations, commercial agriculture and cultivation, urban villages and subsistence agriculture. With respect to the Ntabamhlope wetland, approximately 57 ha of the system has been altered by drainage channels and the system is traversed by roads in six places (Oellerman *et. al*., 1994). These authors indicate that the road embankments have had a damming effect on the system where these occur and in some of the crossings flow has been made more canalised downstream of the causeways. Oellerman *et. al.* (1994) also indicate that flow has been restricted by two small dams and measuring weirs but that the effects on the system are localised and did not constitute a threat to the system at the time. Evidence of a threat of alien vegetation encroachment into the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

The Working for Wetlands (WfW) rehabilitation work would likely have addressed some of these impacts and the success of the interventions, and whether or not new impacts and the threats identified previously still exist today, or have increased, are unknown and will, if existing information allows, be investigated further as this study progresses and more information is collected on the Priority Wetland systems.

Groundwater

The groundwater characteristics in IUA 9 are as follows:

- Geology: Karoo Supergroup –
  - Tarkastad (arenite and mudstone)
  - Beaufort (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
- Dolerite intrusions: Limited .
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~15 $mm \cdot a^{-1}$ (eastern ½) to 45 $mm \cdot a^{-1}$ (western ½).
- Groundwater quality (mS·m-1): <70 (in most of the western parts),70-300 (northern ½ of V70G).
- Groundwater Reserve status (allocations): No risk (SI = ~30%).

9.2.10 IUA 10: Upper Thukela

IUA 10 delineates the upper Thukela River catchment from its headwaters at the outflow of the uKhahlamba Drakensberg National Park to the confluence of the Klip River.

Rationale

This IUA is based on similar ecoregion (topography, vegetation, altitude, rainfall) It is a hardworking IUA with large dams to transfer water to the Vaal system, extensive irrigation, tourism and numerous rural settlements and some smaller urban areas.

Overview

IUA 10, the Upper Thukela IUA includes Okhahlamba, Alfred Duma and Inkosi Langalibalele local municipalities (Figure 128). The IUA includes the agricultural towns of Winterton, Bergville, Rookdale, Spioenkop and Loskop. Protected areas include Hlathikulu Nature Reserve towards the escarpment and the Spioenkop Nature Reserve.

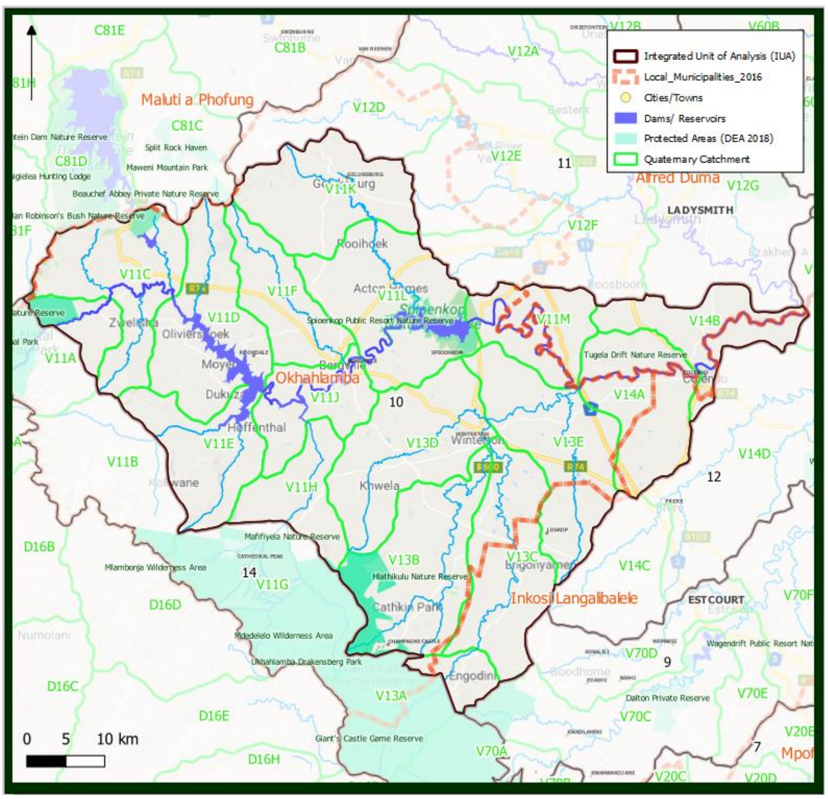


Figure 128: Overview of boundaries and features in IUA 10

Water Resources

Water resources in the IUA include the Upper Thukela River and tributaries (Table 73) as well as the Spioenkop and Woodstock dams. Key water transfers are from the Tugela-Vaal Transfer Scheme transferring water to the Sterkfontein dam and eventually to the Vaal system.

Table 73: Water resources and catchments of IUA 10

IUA	Main Rivers	Tributaries	Quaternaries
V10	Upper Thukela River	Putterill River; Khombe River; Mpandweni River; Nxwaye River; Mnweni River (lower); Sandspruit; Mlambonja River (lower); Njongola River; Venterspruit; Situlwane River; Sterkspruit; Little Thukela River; Kaalspruit	V11A (lower portion), V11C; V11D; V11E; V11F; V11H; V11J; V11K; V11L; V11M; 13A (lower reaches) V13B; V13C; V13D; V13E; V14A; V14B

The region falls into the Agricultural Socio-Economic Zone with land uses transforming 36% of the landscape. Agricultural land uses represent 30% and residential the remaining 6% (Figure 129).

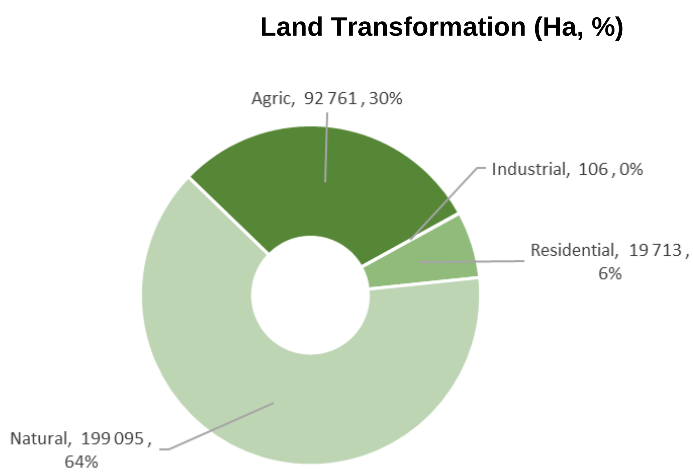


Figure 129: Land transformation per category in IUA 10 (Ha, %)

Socio-Economic Profile

The population of IUA 10 is approximately 166 615 with approximately 31 434 households. 92% of the residents of IUA 10 speak IsiZulu, 3% speak English and 1% Afrikaans (Figure 130). 29% of residents completed secondary school.

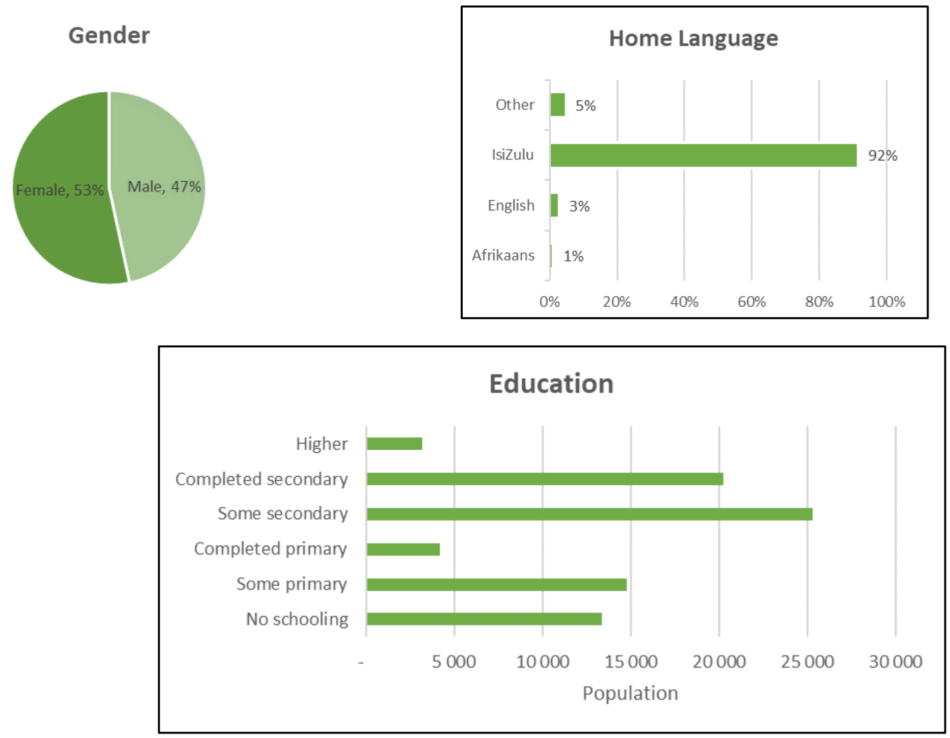


Figure 130: Demographic profile of residents in IUA 10 (StatsSA-Census 2011)

There are only 20% of economically active residents that are employed with 69% being employed in the formal sector (Figure 131). A relatively small proportion, 8%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

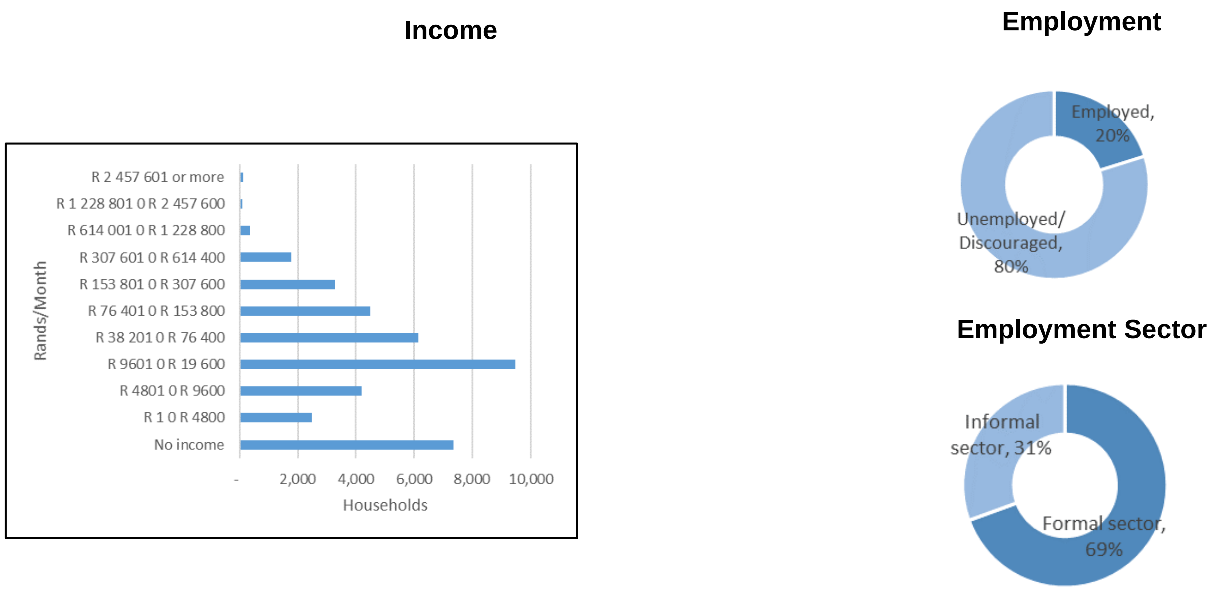


Figure 131: Economic profile of residents in IUA 10 (StatsSA-Census 2011)

Land tenure is represented predominantly by private owned land and traditional owned land with communal and state owned land to a lesser extent (Figure 132).

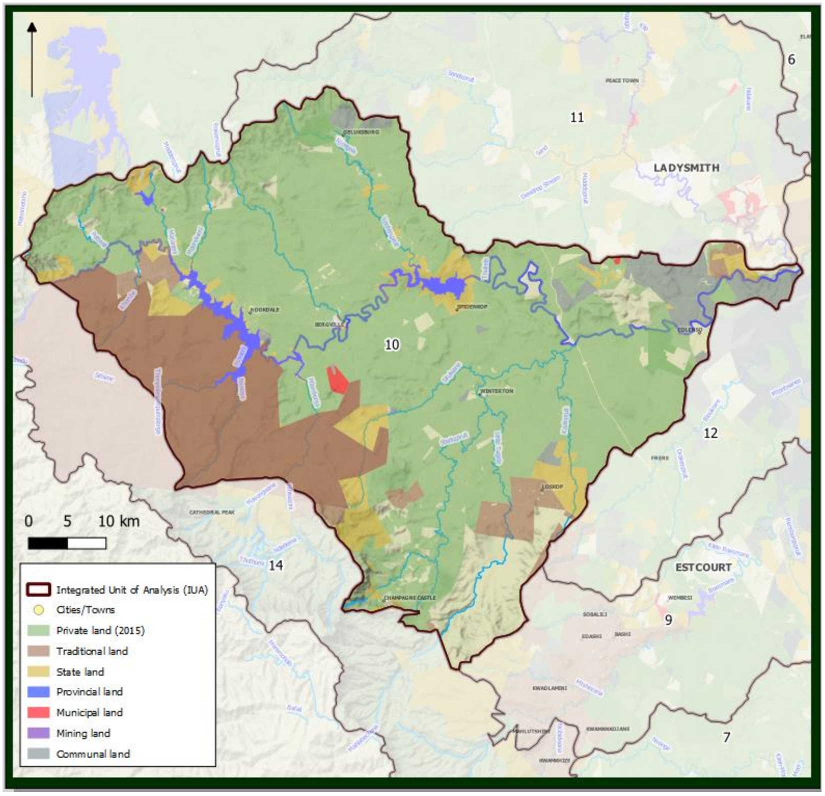


Figure 132: Land ownership within IUA 10 (DRDLR 2015)

Access to services varies greatly among residents with 67%, having limited access to piped water (>50m away from their dwelling), 83% having no access to refuse disposal services, 84% with no flush toilets and 22% having 24 hour access to the internet (Figure 133). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 25%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 47% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

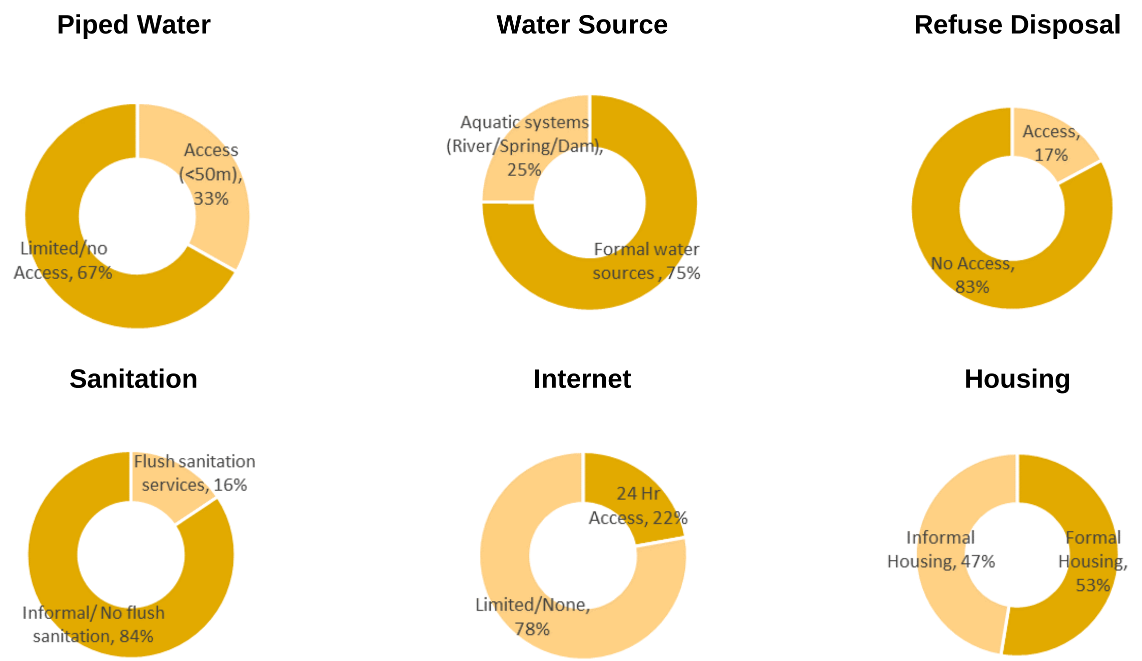


Figure 133: Access to services and indicators of wellbeing of residents in IUA 10 (StatsSA-Census 2011)

IUA 10, characterised by dense areas of irrigated agriculture (Figure 134), while being one of the largest IUAs appears to have a considerable demand of water resources. The town of Bergville also has a well-developed small-scale commercial hub, which services the surrounding farmland.

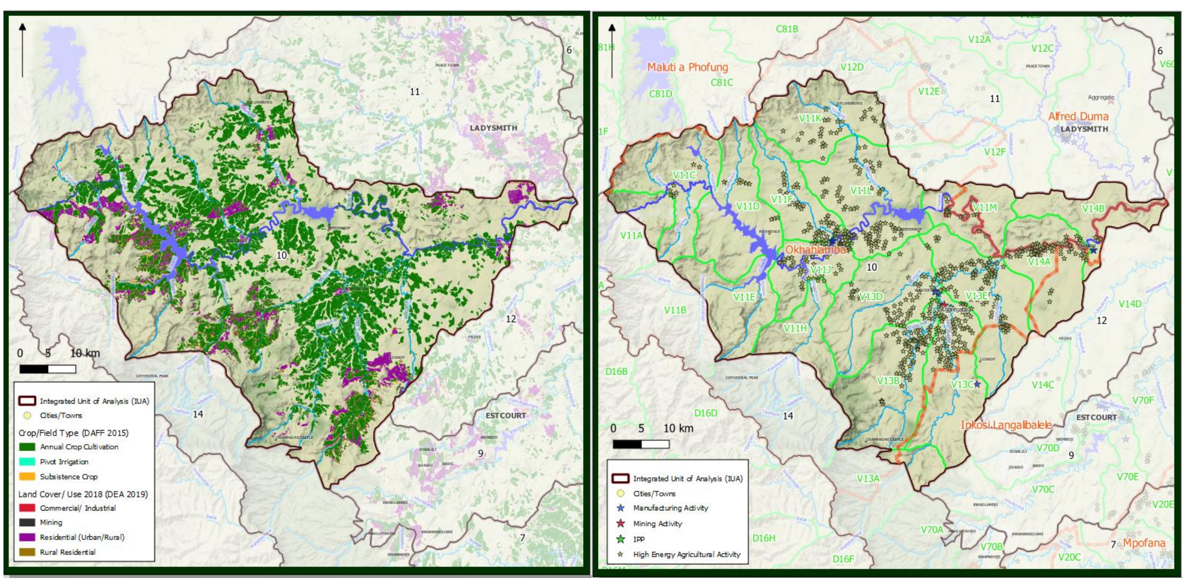


Figure 134: Land use by land cover in IUA 10 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 10

Widespread, dense areas of high intensity commercial agriculture, including a significant portion devoted to irrigated farmland (Figure 135), drives the economy of the area. Subsistence agriculture also has a significant footprint. The Tugela-Vaal Transfer Scheme is also situated in the north-east of this IUA.

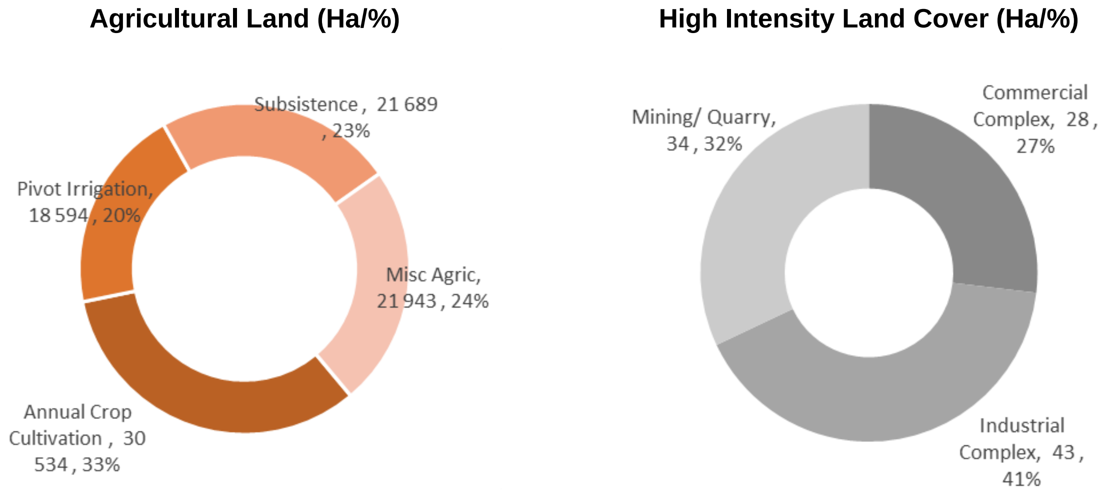


Figure 135: Classification of Agricultural Land in IUA and of High Intensity Land Cover in IUA 10

Table 74 below provides details on the municipalities which form part of IUA 10, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 74: Municipalities located within IUA 10

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 10
Okhahlamba LM	• **Agriculture** • Manufacturing • Trade • Commerce • Tourism	Wards: 1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13, 14 & 15 This municipality accounts for the bulk of IUA 10. The regional centres of Bergville and Winterton are the main towns. The economy of this area is defined by extensive high intensity agriculture, which places significant demand on the Thukela River and some of its tributaries, namely the Sterkspruit, Situlwane, Kaaispruit, and Little Thukela. The Town of Bergville also contains a small manufacturing sector, while tourism also plays a role in the economy of the area. Significant rural populations, with concomitant subsistence agriculture, can be found in the western portion of the area. The main reservoirs are the Woodstock and Spioenkop Dams.
Inkosi Langalibalele LM	• **Agriculture** • Manufacturing • Tourism • Industry • Services	Wards: 1, 2, 3, 4, 5, 18 & 19 While some commercial agriculture can be seen in wards 18 & 19, the main feature of this area is a significant rural population, practicing subsistence agriculture spanning across the other wards of this municipality within IUA 10.

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 10
Alfred Duma LM	• **Agriculture, fishing and forestry** • **Mining and quarrying** • Manufacturing • Construction • Wholesale and retail trade • Tourism	Wards: 4, 8, 11 & 25 The town of Colenso falls within this area, which has a small manufacturing hub. Some pivot irrigation contributes to the region's economy. There is also a small rural residential area which likely draws its income from the Ezakheni A manufacturing hub in the neighbouring IUA 11.

Water Resource Use

This IUA is driven by the Woodstock and Driel dams, with the associated transfer to the Vaal System. Additionally, the Spioenkop Dam while initially built as part of the transfer, is being earmarked as a greater source of water for regional water supply schemes. The proposed Jana dam, also part of the next phase of the Thukela Water Project, is positioned at the outlet of this IUA. Bulk water users include Winterton, Loskop, V13 Tertiary Rural, Colenso, Nkanyezi and V14 Tertiary Rural.

Ecosystem Services

Situated in the south-western extent of the catchment IUA 10 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by a high variety of rivers which flow into the Upper-Thukela River (Figure 136).

The landscape has a relatively low density of wetlands, predominantly seeps (80%) and unchanneled valley bottom (11%) (Figure 137).

Regionally significant aquatic resources include the Woodstock and Spioenkop Dams and various protected areas including Spioenkop Nature Reserve and portions of the Drakensberg protected areas complex. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 75).

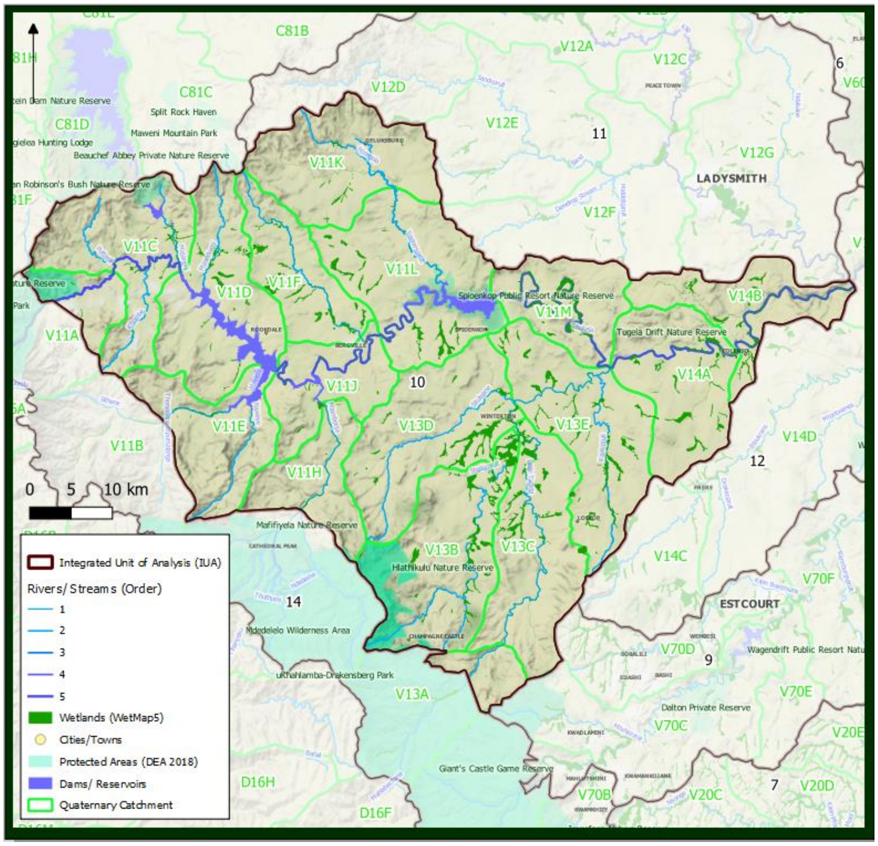


Figure 136: Locality of water resources in IUA 10

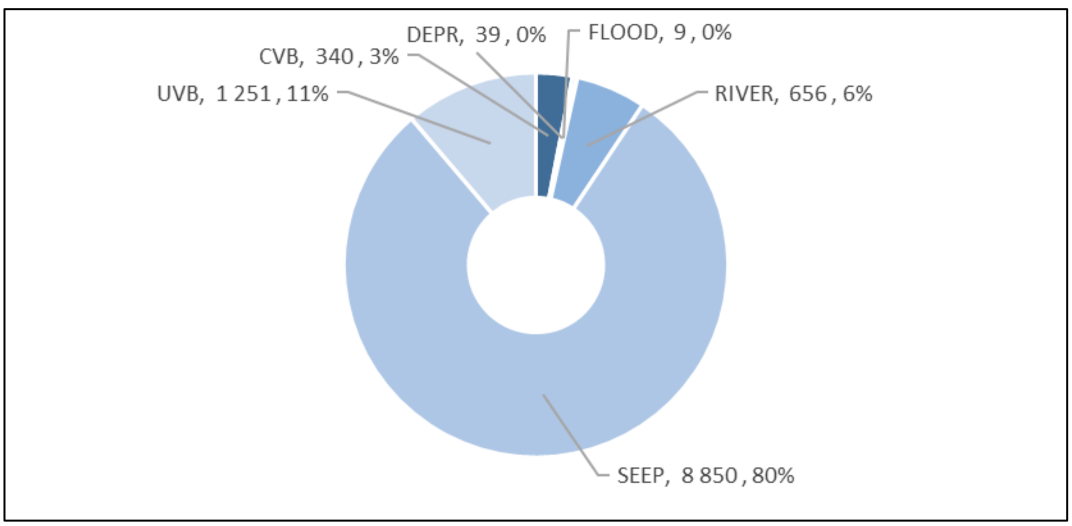


Figure 137: Wetland extent and type in IUA 10 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 75: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 10 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 10	Sector (12 Sectors)
Provisioning	**Food**	Wetland, River, Woodstock Dam	Major significance due to relatively large rural settlements associated with the escarpment and Woodstock dam	Higher	**Households**
	Fresh Water	Wetland, Upper Thukela River, Woodstock and Spioenkop Dam	Major Significance: Rural Communities associated with upstream systems and Woodstock Dam; Subsistence Agriculture (Livestock); Domestic water services at Winterton, Bergville and Colenso; Some industrial activities around key towns; Extensive commercial and irrigation activities throughout the catchment; The Vaal catchment through water transfers	Higher	**Households; Manufacturing; Agriculture**
	Raw materials	Wetland, River, Woodstock Dam	Major significance due to relatively large rural settlements associated with the escarpment and Woodstock dam	Higher	**Households**
	Medicinal resources	Wetland, River, Woodstock Dam	Major significance due to relatively large rural settlements associated with the escarpment and Woodstock dam	Higher	**Households**
Regulating	**Climate regulation**	Relatively low wetland extent	Some significance to global beneficiaries	Lower	
	Water quantity regulation	Relatively low wetland extent but SWSA in upper catchment	Major Significance: Rural Communities associated with upstream systems and Woodstock Dam; Subsistence Agriculture (Livestock); Domestic water services at Winterton, Bergville and Colenso; Some industrial activities around key towns; Extensive commercial and irrigation activities throughout the catchment;	Higher	**Households; Manufacturing; Agriculture**
	Water purification & waste management	Relatively low wetland extent	Major Significance: Rural Communities associated with upstream systems and Woodstock Dam; Subsistence Agriculture (Livestock); Domestic water services at Winterton, Bergville and Colenso; Some industrial activities around key towns; extensive commercial and irrigation activities throughout the catchment;	Higher	**Households; Manufacturing; Agriculture**
	Erosion control/ Soil stability	Wetlands, Rivers	Major Significance to high level of agricultural activities	Higher	**Agriculture; Households**
	Biological control	Wetlands, Rivers	Significance to high level of agricultural activities	Lower	
Cultural	**Landscape & amenity values**	Protected areas; Large dams and headwaters of the escarpment	Major significance to tourism industry and to rural communities through cultural value	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The water quality in the upper Thukela, upstream of Woodstock Dam, and in the headwater catchment of the Thukela River and tributaries is generally good, with minimal impact. Overall, most variables were compliant to the water criteria. High salinity is however observed within the lower reaches of quaternary catchments V11A, V11C, and within V11J, V13D, V14A and V14B, with compliance to electrical conductivity in the largely tolerable level. Non-compliance is observed in V11J in the vicinity of the Bergville WWTW discharge. Poor managed and unmaintained sewer infrastructure are a contributing factor. This could be attributed to the localised settlements in these areas, the towns of Bergville and Colenso and the agricultural activity in the lower areas below Driel Barrage and Spioenkop Dam. Intensive irrigation does occur in the lower reaches of the catchment (V11J, V13D, V14A and V14B). High ortho-phosphate levels are also observed at the same sites within these quaternary catchments, with tolerable levels and some non-compliance observed. Non-compliance to ionised ammonia is observed at some sites which is an indication of possible high organic load.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 10 - Upper Tugela River														
188282	V11A				50.7					2.93		7.9	0.29	
188283	V11A				50.9					2.14	0.10	7.9	0.24	
188292	V11A				50.9					0.82	0.10	7.9	0.05	
188293	V11A				49.7					1.16	0.10	7.9	0.16	
188294	V11A				62.8					11.02	0.10	7.6	1.38	
188295	V11A				80.3					21.88	0.10	7.6	2.36	
102722	V11C				55.9					2.97	0.10	8.4	0.10	
188305	V11C				52.3					2.13	0.44	8.3	0.10	
103323	V11C	8.1	2.8		10.7	0.3	1.1	3.3	0.1	0.05	0.02	8.0	0.01	4.1
102716	V11C	9.0	5.8	70.3	10.9	0.6	2.5	2.9	7.1	0.11	0.05	7.9	0.01	4.8
102715	V11D	7.9	4.2	76.3	11.1	0.4	2.2	2.6	5.2	0.15	0.05	8.0	0.01	6.3
102720	V11D	8.4	4.8	65.2	9.9	0.6	2.0	3.6	5.3	0.10	0.12	8.0	0.01	5.9
188306	V11D				53.0					1.68	0.45	8.1	0.20	
102732	V11E	8.3	5.0	68.4	10.9	0.6	2.6	3.3	7.4	0.12	0.11	7.9	0.01	8.4
102733	V11E	5.2	2.1		6.5	0.2	1.3	1.8	0.1	0.14	0.03	7.8	0.01	1.5
102711	V11F	27.0	32.7	328.8	45.3	0.5	7.0	15.5	34.4	0.14	0.10	8.6	0.01	19.7
102721	V11H	11.0	3.6	76.7	10.9	0.6	2.4	4.0	5.6	0.10	0.05	8.1	0.01	3.2
102708	V11J	10.6	4.8	87.1	13.0	0.5	2.6	4.1	6.8	0.12	0.14	8.1	0.01	4.6
102731	V11J	7.8	3.4	62.0	10.4	0.5	2.4	3.5	5.3	0.10	0.05	8.0	0.01	4.8
188297	V11J				101.1					31.00	0.10	7.6	2.11	
102727	V11J	7.7	3.0	63.4	9.1	0.5	2.4	3.2	4.9	0.11	0.10	8.0	0.01	5.3
188298	V11J				67.0					1.08	0.10	8.3	0.10	
188299	V11J				71.3					6.46	0.10	8.0	0.21	
102728	V11L	9.1	5.4	72.2	10.9	0.4	2.5	3.2	5.3	0.10	0.11	7.9	0.01	6.8
102730	V11L	8.1	4.2	60.5	11.1	0.5	2.3	3.4	4.9	0.11	0.17	8.0	0.01	3.1
102726	V11M	8.2	3.5	64.9	9.6	0.5	2.5	3.4	6.5	0.07	0.16	8.0	0.01	5.1
102725	V13C	14.4	8.5	134.4	17.9	0.4	2.4	6.2	8.5	0.36	0.20	8.3	0.01	4.4
102704	V13C	13.5	7.8	111.7	16.0	0.6	3.1	6.4	9.1	0.19	0.15	8.2	0.01	4.4
189136	V13D				73.8					2.59	1.00	8.1	0.25	
189140	V13D				68.5					0.77	0.94	8.2	0.11	
188847	V13D				81.7						5.10	7.6	1.80	
189139	V13D				74.7					12.95	0.10	7.8	2.12	
188302	V14A				46.9					2.40	0.91	8.9	0.10	
188301	V14B				57.5					24.77	0.10	7.6	1.800	
102695	V14B	13.7	5.7	109.8	14.8	0.6	2.7	5.8	10.0	0.08	0.14	8.2	0.010	7.4
188303	V14B				50.5					3.72	0.84	8.8	0.260	

Water Quality hotspot areas include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V11A (lower)	Thukela	Moderate	WWTW discharges, elevated nutrients/salts, rural towns and tourist resorts
V11C	Majaneni/Thukela	Moderate	Elevated nutrients, agriculture, numbered small WWTWs
V11G (lower)	Mlambonja	Moderate	WWTW discharges, elevated nutrients/salts, rural towns and tourist resorts
V11J	Sandspruit	Moderate	WWTW discharges (Bergville), elevated nutrients/salts; irrigation, erosion
V13B	Sterkspruit	Large	Elevated nutrients, irrigation, some erosion, piggeries
V13C/D	LittleThukela (lower)	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Winterton)
V14A	Thukela	Moderate	Elevated nutrients, intensive agriculture
V14B	Thukela	Moderate	Elevated nutrients, intensive agriculture; WWTW discharges (Colenso)

River Ecological information and PES

The rivers in the IUA are in a good ecological condition, falling within an A, B or C PES ecological category, with the exception of the lower reaches of the Sterkspruit and its confluence with the Little Thukela and the Majajeni tributary, which are the only D category river reaches. This is due to flow and water quality impacts related irrigation, dams, land use and erosion. The IUA includes 3 EWR sites, EWR 1 and 2 on the Thukela River and EWR 3 on Little Thukela, where Comprehensive Reserve assessments have been undertaken

Wetlands

IUA 10 is located in the upper western portion of the Thukela Catchment mostly within the Grassland Biome, and falls mostly within the Sub-Escarpment Grassland Bioregion, though a small portion of the lower reaches extend into the Sub-Escarpment Savanna Bioregion. Wetlands cover 10 534 ha of IUA 10, or 3.0% of the land surface, which is less than the average wetland coverage of 4.7% across the entire Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al.*, 2018), the most extensive wetlands within IUA 10 are Seep wetlands, which make up 84.4% of the mapped wetland area and cover 8 895 ha. Unchannelled Valley Bottom and Channelled Valley Bottom wetlands are the next most extensive wetland types at 11.9% and 3.2% respectively. The least common wetlands mapped within the IUA are Floodplain and Depression wetlands which both make up less than 1% of the wetland area within the IUA.

<u>Priority Systems in IUA 10</u>

No Priority Wetlands have been identified in IUA 10 at this stage.

<u>Baseline Ecological State</u>

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer et al., 2018) and summarised in Table 31 and Table 76, 70.4% of wetlands within IUA 10 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 6.9% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B).

Table 76: Wetland condition summary for IUA 10 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 10	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	659	1 902	6 334	8	145	187	52	308	891		9		12	19	8
%	7.4	21.4	71.2	2.3	42.6	55.1	4.2	24.6	71.2		100.0		30.6	48.8	20.6

Threats/Impacts

IUA 10 is again characterised by a broad range of land uses. In the upper reaches extensive urban villages and subsistence agriculture result in heavy utilisation and degradation of wetland habitats, while the central reaches of the IUA support commercial agriculture and cultivation, including substantial areas under irrigation. This has a significant effect on both quantity and quality of flow within wetlands. Some commercial plantations also occur within the IUA.

Groundwater

The groundwater characteristics in IUA 10 are as follows:

- Geology: Karoo Supergroup –
    - Upper Karoo Molteno-Elliot-Clarens Formations (arenite, shale, mudrock and aeolian sandstone)
    - Beaufort (arenite and mudstone)
    - Volksrust (shale)
- Dolerite intrusions: Limited.
- Borehole yield class: Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$ with Moderate (2.0 to 5.0 $\ell \cdot s^{-1}$) in parts of V11K and V11L;
- Recharge averaging from ~15 $mm \cdot a^{-1}$ to 45 $mm \cdot a^{-1}$.
- Groundwater quality (mS·m-1): <70 (western ⅔), 70-300 (eastern ⅓). Isolated hotspots present in V11H, V11D, V12A, V12B, V12G (expected groundwater deterioration related to Ladysmith developments).
- Groundwater Reserve status (allocations): High risk (SI = ~70% to 90%).
- Wetland present in V12C (to be classified as groundwater dependant system).

9.2.11 IUA 11: Klip River

The IUA is delineated as the Klip River sub-catchment, the Klip from its headwaters and its tributaries to the confluence with Thukela River.

Rationale

This IUA is based on similar ecoregion with lowlands, hills and mountains with moderate and high relief. The predominant geomorphic zone is lower foothills. The impacts on the water resources are based on irrigation, town and industrial developments. Logical to manage catchment as an entity. Although the present state of most of the rivers is moderately modified, the EIS is high.

Overview

IUA 11, the Klip River IUA, includes the local municipalities of Alfred Duma and Okhahlamba (Figure 138). The major city of Ladysmith is found in the IUA with smaller communities including Driefontein and Peace Town. The Ingula Pump Storage Scheme is found in the northern reaches of the catchment.

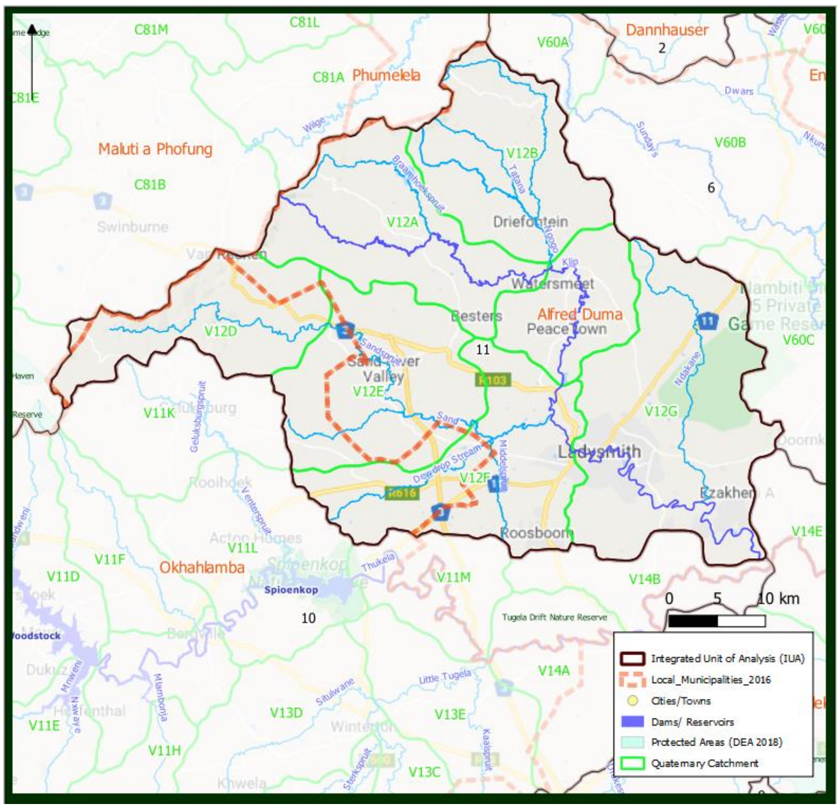


Figure 138: Overview of boundaries and features in IUA 11

Water Resources

Water resources in the IUA include the Klip River and tributaries (Table 77). The IUA includes areas defined as SWSA on the escarpment.

Table 77: Water resources and catchments of IUA 11

IUA	Main Rivers	Tributaries	Quaternaries
11	Klip River	Mhlwane River; Tatapa River; Ngoga River; Braamhoekspruit; Sandspruit; Dewdrop Stream; Middelspruit; Ndakane River	V12A; V12B; V12C; V12D; V12E; V12F; V12G;

The region falls into the Agriculture and Mixed-Use Socio-Economic Zone with land uses transforming 23% of the landscape. Agricultural land uses represent 15% and industrial and residential the remaining 8% (Figure 140).

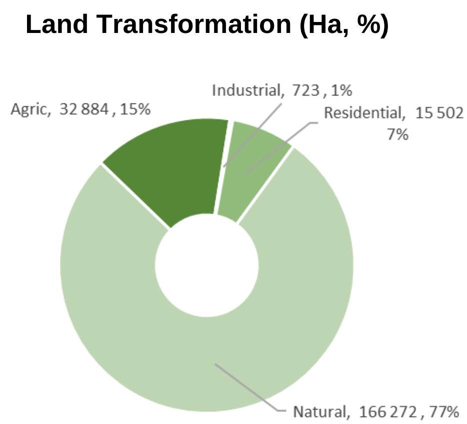


Figure 139: Land transformation per category in IUA 11 (Ha, %)

Socio-Economic Profile

The population of IUA 11 is approximately 197 366 with approximately 49 304 households. 84% of the residents of IUA 11 speak IsiZulu, 8% speak English and 2% Afrikaans (Figure 140). 41% of residents completed secondary school.

There are 34% of economically active residents that are employed with 77% being employed in the formal sector (Figure 141). A small proportion, 6%, of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

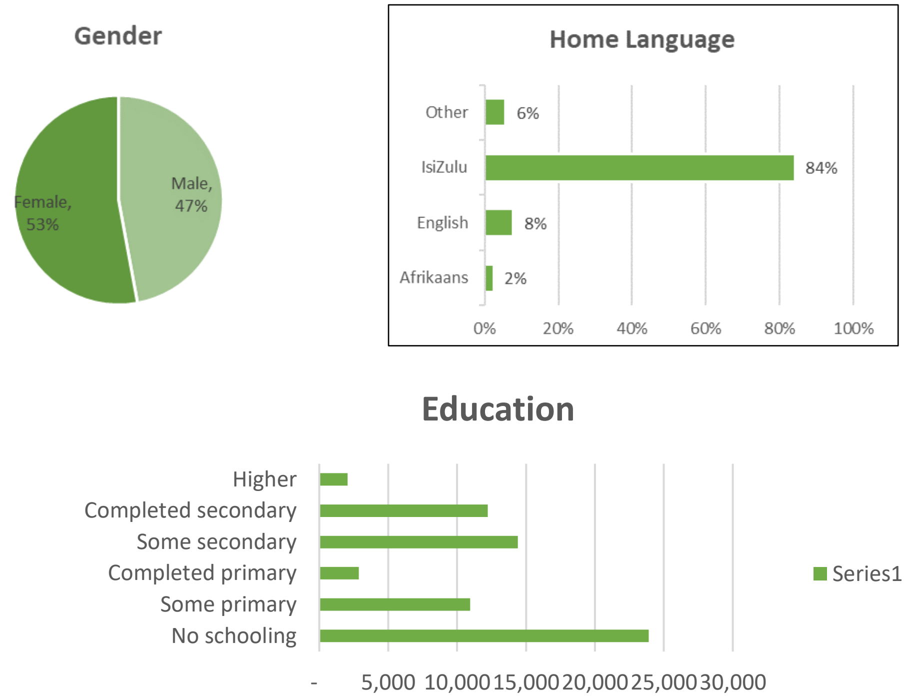


Figure 140: Demographic profile of residents in IUA 11 (StatsSA-Census 2011)

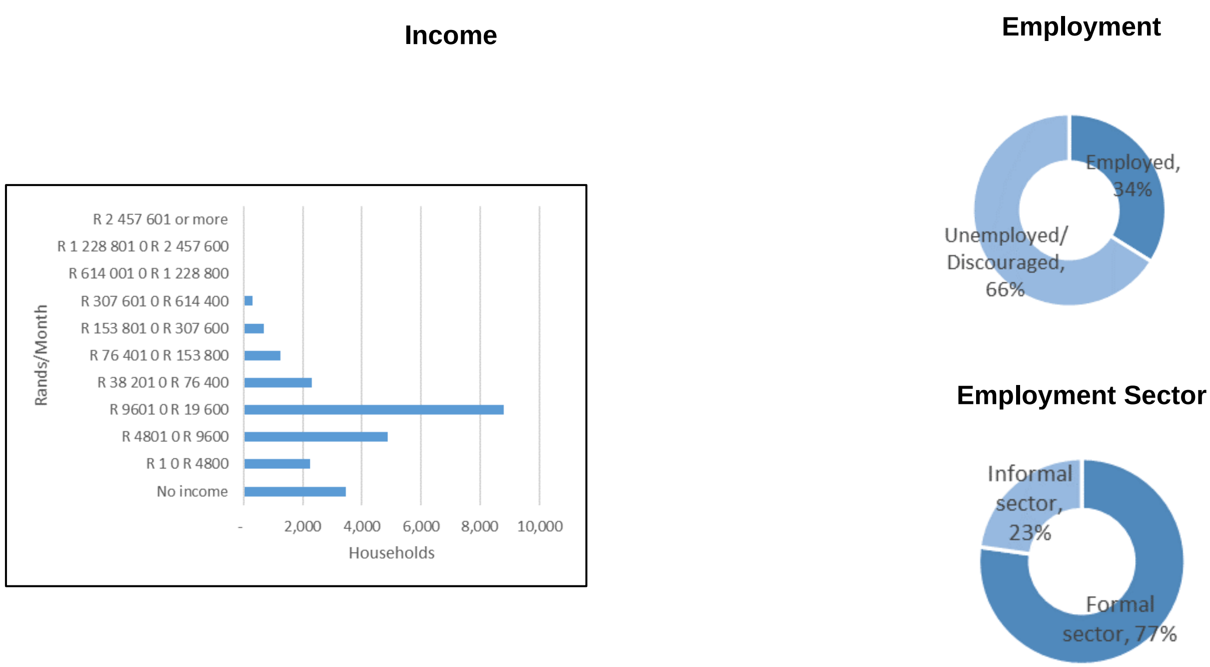


Figure 141: Economic profile of residents in IUA 11 (StatsSA-Census 2011)

Land tenure is predominantly represented by privately owned land, followed by communal owned and state owned land (Figure 142).

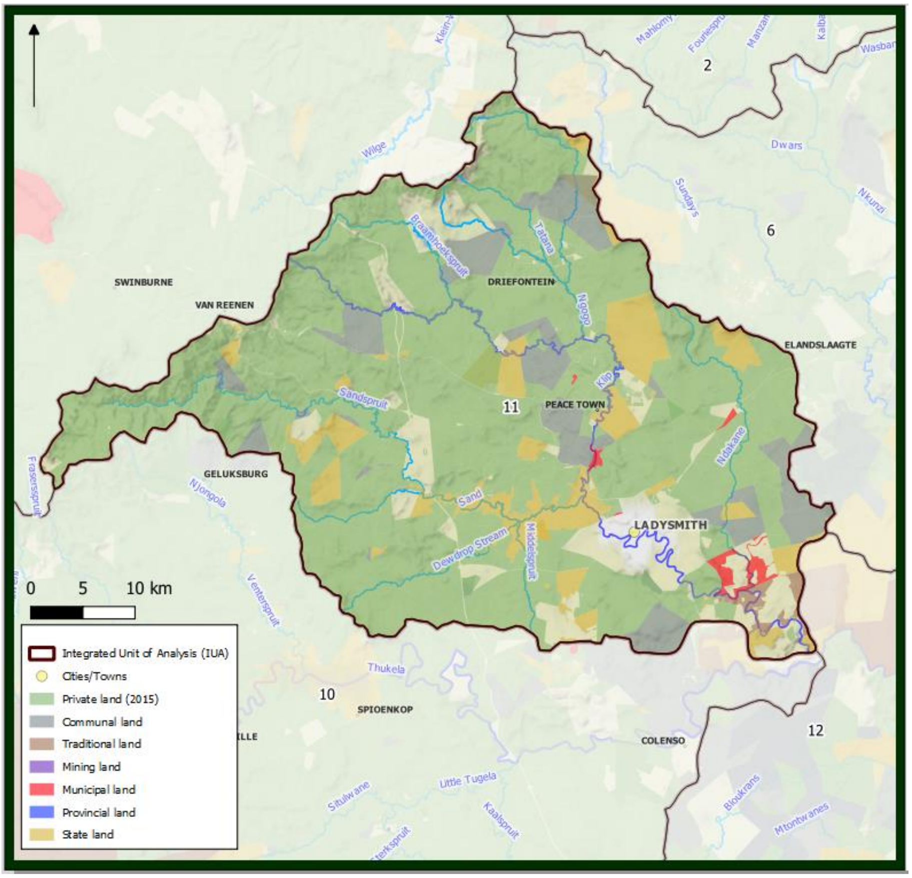


Figure 142: Land ownership within IUA 11 (DRDLR 2015)

Access to services varies greatly among residents with 28%, having limited access to piped water (>50m away from their dwelling), 36% having no access to refuse disposal services, 38% with no flush toilets and 24% having 24 hour access to the internet (Figure 143). Varied access to services indicates varied levels of wellbeing throughout the catchment. A relatively low, 6%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 17% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

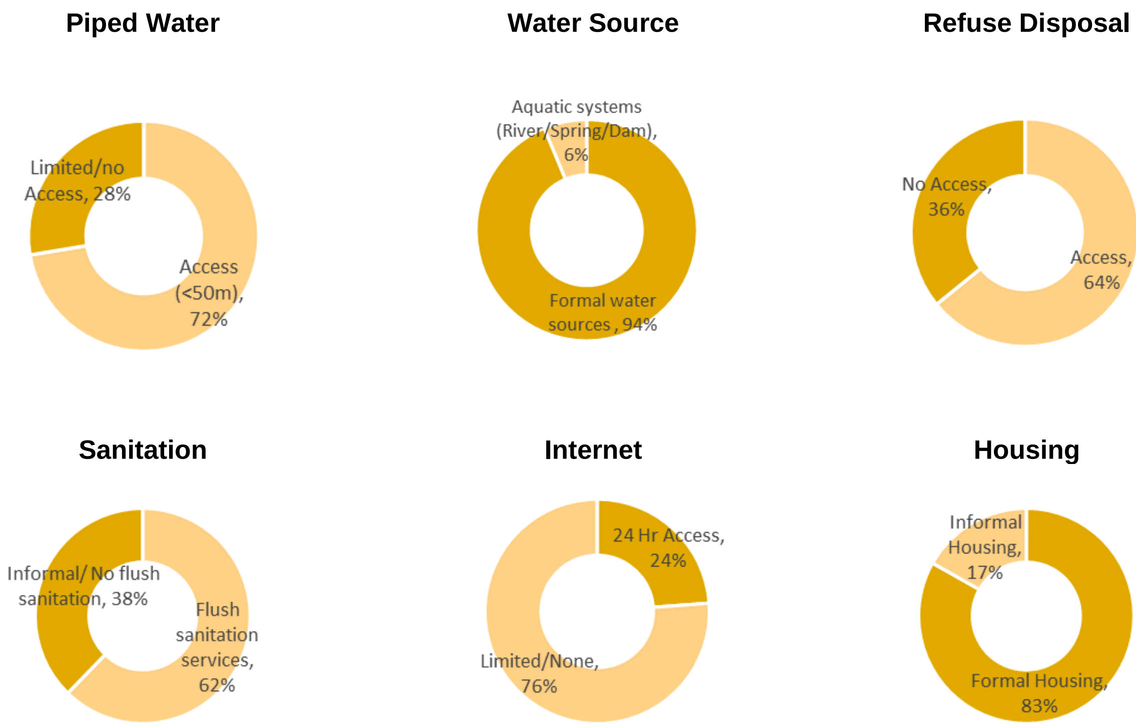


Figure 143: Access to services and indicators of wellbeing of residents (StatsSA- Census 2011)

Scattered irrigation agriculture and dryland agriculture, along with residential use represent the water demand in this IUA, which is relatively low. The central town of Ladysmith boasts a well-developed commercial sector, but no significant high water use industry (Figure 144).

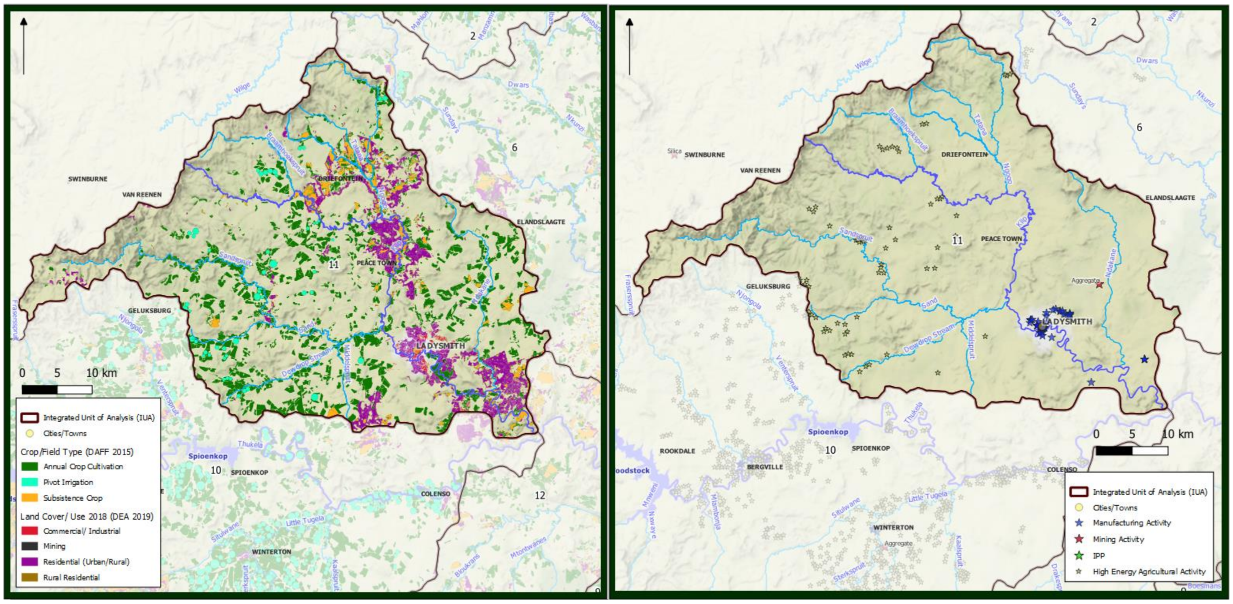


Figure 144: Land use by land (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 11

The town of Ladysmith is the economic hub of IUA 11, with higher levels of commercial and industrial activity than most of the rest of the study region. Scattered commercial agriculture, as well as grazing and subsistence farming also play a role in supporting the local population (Figure 145).

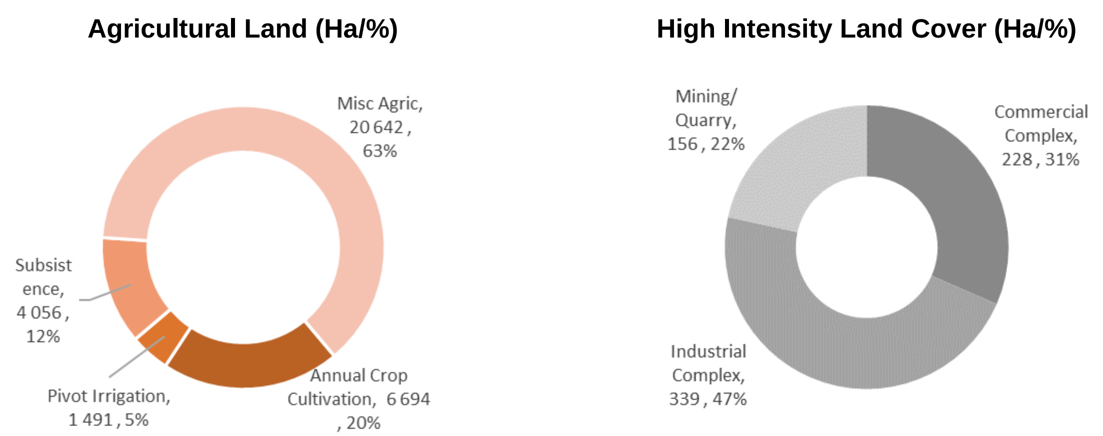


Figure 145: Classification of Agricultural Land and of High Intensity Land Cover in IUA 11

Table 78 below provides details on the municipalities which form part of IUA 11, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 78: Municipalities located within IUA 11

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 11
Alfred Duma LM	• **Agriculture, fishing and forestry** • **Mining and quarrying** • Manufacturing • Construction • Wholesale and retail trade • Tourism	Wards: 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 22, 24, 25, 26 & 27 The main economic hub of IUA 11 is Ladysmith, with the other major settlements being Peace Town and Driefontein. Ladysmith has well developed commercial and manufacturing sectors. This included the manufacturing hub of Ezakheni A, about 30 kilometres south east of the town. Two quarries in the vicinity of Ladysmith also play a role in the local economy. Scattered high intensity agriculture contributes to the region's economy, while the Peace Town and Driefontein areas area largely reliant on subsistence agriculture. The area receives most of its water from the Klip River.
Okhahlamba LM	• **Agriculture** • Manufacturing • Trade • Commerce • Tourism	Wards: 11 & 13 Some high intensity agriculture accounts for the economic activity around the headwaters of the Dewdrop Stream and Sand River.

Water Resource Use

This system is driven by the presence of Ladysmith, one of the largest centres in the Thukela. Abstractions for Ladysmith as well as flood protection drive the flows in the middle and lower reaches. Bulk water and industrial users include Ladysmith, Driefontein, Roosboom and Matiwaneskop.

Ecosystem Services

Situated in the central-western extent of the Thukela catchment IUA 11 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by the Mhlwane, Tatapa, Ngoga, Braamhoekspruit, Sandspruit, Dewdrop, Middelspruit and Ndakane River which flow into the Klip River (Figure 146). The landscape is characteristic of a variety of wetland systems, predominantly seeps (55%) and unchannelled valley bottom (28%) (Figure 147).

Regionally significant aquatic features include the upper reaches of the catchment and escarpment representing a Strategic Water Source Area (SWSA). Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 79).

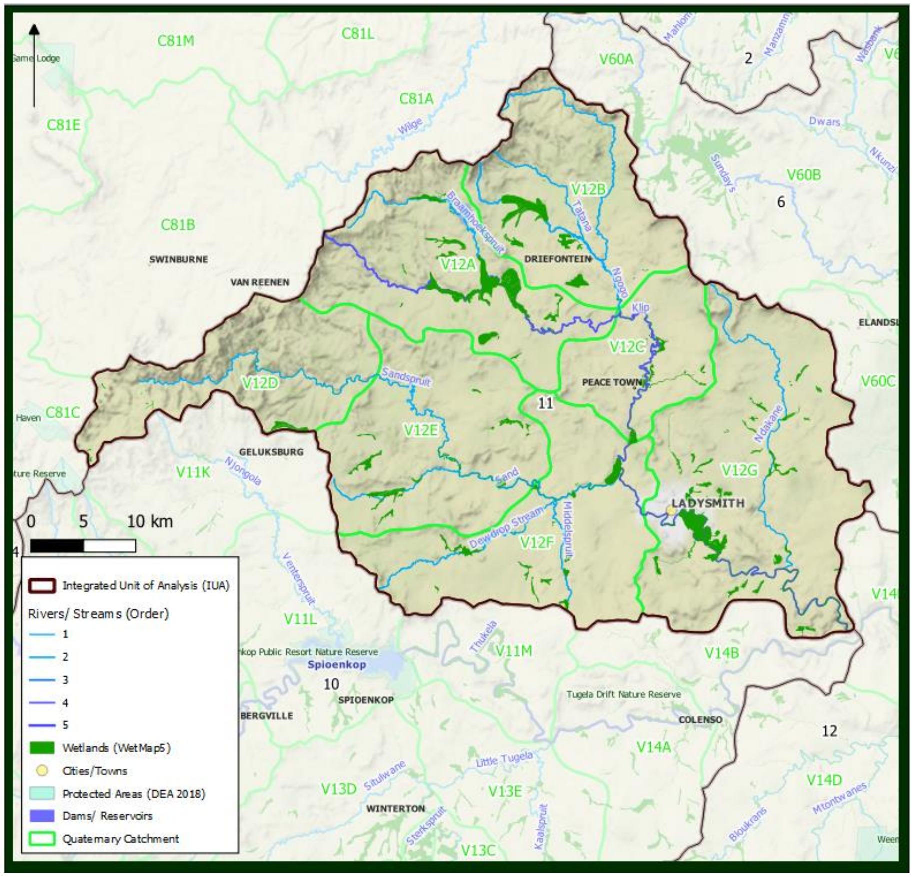


Figure 146: Locality of water resources in IUA 11

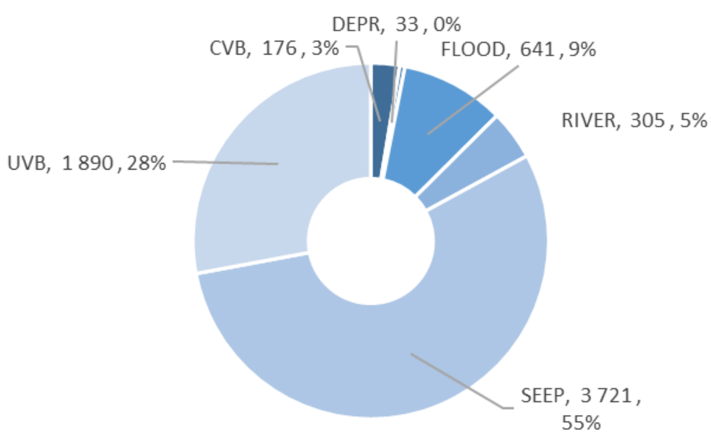


Figure 147: Wetland extent and type in IUA 11 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 79: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 11 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 11	Sector (12 Sectors)
Provisioning	Wetlands and Rivers	Major significance due to relatively large rural settlements associated with Driefontein and Peace Town	Higher	**Households**	Wetlands and Rivers
	Wetlands and Rivers	Major Significance: Rural Communities associated with Driefontein and Peace Town; Subsistence Agriculture (Livestock); Domestic water services at Ladysmith and lesser at Driefontein and Peace Town; Relatively high intensity industrial activities associated with Ladysmith; Some commercial and irrigation activities in the upper catchment;	Higher	**Households; Manufacturing; Agriculture**	Wetlands and Rivers
	Wetlands	Major significance due to relatively large rural settlements associated with Driefontein and Peace Town	Higher	**Households**	Wetlands
	Wetlands	Major significance due to relatively large rural settlements associated with Driefontein and Peace Town	Higher	**Households**	Wetlands
Regulating	Wetlands	Some significance to global beneficiaries	Lower		Wetlands
	Wetlands, Rivers and SWSA in upper catchment	Major Significance: Rural Communities associated with Driefontein and Peace Town; Subsistence Agriculture (Livestock); Domestic water services at Ladysmith and lesser at Driefontein and Peace Town; Relatively high intensity industrial activities associated with Ladysmith; Some commercial and irrigation activities in the upper catchment; SWSA in upper catchment	Higher	**Households; Manufacturing; Agriculture**	Wetlands, Rivers and SWSA in upper catchment
	Wetlands and Rivers	Major Significance: Rural Communities associated with Driefontein and Peace Town; Subsistence Agriculture (Livestock); Domestic water services at Ladysmith and lesser at Driefontein and Peace Town; Relatively high intensity industrial activities associated with Ladysmith; Some commercial and irrigation activities in the upper catchment;	Higher	**Households; Manufacturing; Agriculture**	Wetlands and Rivers
	Wetlands, Rivers	Significance to subsistence and agricultural activities	Lower		Wetlands, Rivers
	Wetlands, Rivers	Significance to subsistence and agricultural activities	Lower		Wetlands, Rivers
Cultural	Wetlands and rivers	Significance to rural communities through cultural value; Limited identified tourism or recreational services.	Lower		Wetlands and rivers
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Water quality data is limited or lacking for the upstream catchments in the IUA (V12A to V12E). Non-compliance to electrical conductivity and ortho-phosphate is found in the Klip River catchment in the vicinity of Ladysmith (V12G). The quality can be attributed to the impacts from the town and surrounding development, which includes the non-compliant discharges from the WWTWs, and poorly managed and unmaintained sewer infrastructure. Compliance to the ammonia limit is exceeded at the sites assessed in the Klip River catchment and is an indication of possible high organic load in the system. Overgrazing and soil erosion is a concern to the areas north of Ladysmith (vicinity of Driefontein Block and Matiwaneskop).

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 11 - Klip River														
102718	V12F	22.0	7.1	190.4	25.7	0.5	3.5	11.3	13.6	0.10	0.1	8.4	0.010	11.2
188288	V12G				149.5					2.15	0.9	9.0	0.100	
188289	V12G				56.9					3.89	1.5	8.9	0.406	
100001155	V12G				52.0					4.67	1.0	8.9	0.299	
100001156	V12G				122.3					3.41		8.7	0.564	
188287	V12G				71.9					16.61	0.1	7.7	2.090	
100001160	V12G	238.8	1958.6		102.3	0.1		483.8		16.15	0.2	7.7	2.100	51.9

Water Quality Hotspots in the IUA include:

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V12B	Ngogo	Moderate	Erosion and over-grazing
V12G	Klip	Large	WWTW discharges, industrial discharges (Ladysmith), elevated salts/nutrients

River Ecological information and PES

The headwaters of the Klip River are in a pristine ecological condition (V12A), (A category PES) and the Braamhoekspruit is in a largely natural condition (B ecological category) (mountainous areas). Other tributaries including the Ngogo, Sand, Ndakame and Middelspruit have a PES of a B category. The lower river reaches in the IUA are in a C category, due to flow, non-flow and water quality impacts. No EWR sites are present in the IUA, however it proposed that a Rapid 3 assessment be undertaken at a new site on Klip River, downstream of Ladysmith

Wetlands

IUA 11 is located in the upper western reaches of the Thukela Catchment mostly within the Grassland Biome, and falls mostly within the Sub-Escarpment Grassland Bioregion, though a small portion of the lower reaches extend into the Sub-Escarpment Savanna Bioregion. Wetlands cover 6 473 ha of IUA 11, or 3.0% of the land surface, which is less than the average wetland coverage of 4.7% across the entire Thukela Catchment. This IUA includes a small section of the Ingula Nature Reserve IBA (IBA #SA043)

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 11 are Seep wetlands, which make up 57.6% of the mapped wetland area and cover 3 730 ha. Unchannelled Valley Bottom and Floodplain wetlands are the next most extensive wetland types at 29.2% and 9.9% respectively. The least common wetland type mapped within the IUA is Depression wetland, which makes up less than 1% of the wetland area within the IUA. Channelled Valley Bottom wetlands make up 2.7% of the wetland area.

Priority Systems in IUA 11

No Priority Wetlands have been identified in IUA 11 at this stage.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al.,* 2018) and summarised in Table 31 and Table 80, 67% of wetlands within IUA 11 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 9.9% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B).

Table 80: Wetland condition summary for IUA 11 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 11	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	558	729	2 442	15	60	102	54	557	1 279		134	507	11	17	8
%	15.0	19.6	**65.5**	8.4	33.8	**57.8**	2.8	29.5	**67.7**		20.9	**79.1**	30.3	**47.8**	21.9

Threats/Impacts

IUA 11 includes the town of Ladysmith and associated urban areas that are known to experience flooding. Land uses within the catchment include commercial and subsistence agriculture.

Groundwater

The groundwater characteristics in IUA 11 are as follows:

- Geology: Karoo Supergroup –
  - Beaufort (arenite and mudstone)
  - Volksrust (shale)
  - Vryheid (arenite, coal and shale)
- Dolerite intrusions: Only present in the northern part (V12B) of the IUA with several large dolerite sills present.

- Borehole yield class: Minor: (0.5 to 2.0 $\ell \cdot s^{-1}$) to Moderate E (2.0 to 5.0 $\ell \cdot s^{-1}$) in the V12D and V12E;
- Recharge averaging around 45 $mm \cdot a^{-1}$;
- Groundwater quality ($mS \cdot m^{-1}$): <70 with 70-300 in the downstream areas, *i.e*. V12C, V12G and V12F (Dewdrop Stream River).
- Groundwater Reserve status (allocations): Moderate risk (SI = ~50%), but High risk (SI>70%) in V12D, V12E and V12F.
- Expansion of rural water supplies may cause over utilization of groundwater resources.

9.2.12 IUA 12: Middle Thukela River

The IUA is delineated as the Thukela River from the confluence of Klip River to the outlet of quaternary catchment V60K (to confluence of the Buffalo River) and includes the Bloukrans tributary.

Rationale

This IUA falls in the same ecoregion with diverse lowlands, hills and mountains with moderate and high relief, as well as closed hills and mountains with moderate and high relief with the geomorphic zone mainly lower foothills. This is mainly a low density, rural area with subsistence agriculture. It forms a logical management unit from the Klip River confluence (at proposed Jana Dam site and influence of the tributary catchment) to the confluence of the Buffalo River (logical break in system).

Overview

IUA 12, the Middle Thukela IUA, includes the local municipalities of Msinga, Inkosi Langalibalele and Endumeni (Figure 148). The IUA includes the towns of Tugela Ferry, Mhlangana and Pomeroy. A portion of Weenen Game Reserve falls within the IUA.

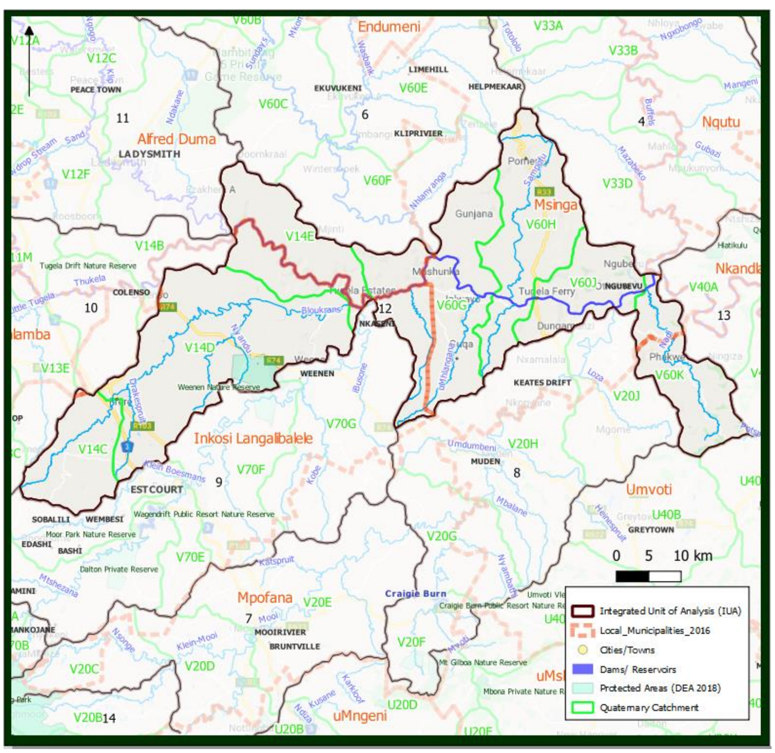


Figure 148: Overview of boundaries and features in IUA 12

Water resources

Water resources in the IUA include the Middle Thukela River and tributaries (Table 81). The region falls into the Agricultural and Rural Socio-Economic Zone with land uses transforming 28% of the landscape. Agricultural land uses represent 18% and residential the remaining 10% (Figure 149).

Table 81: Water resources and catchments of IUA 12

IUA	Main Rivers	Tributaries	Quaternaries
12	Middle Thukela River	Bloukrans River; Drakespruit; Mtontwanes River; Nyandu River; iSilwhehlenga River; uMhlangana River; Sompofu Rver; Nadi River; Mfongosi River; Manyane River; Ngcaza River; Nsuze River; Nsongeni River; Ndikwe River; Mamdleni River; Mamba River; Mambulu River; Mpisi River; Mati River; Nembe River	V14C; V14D; V14E; V60G; V60H; V60J; V60K

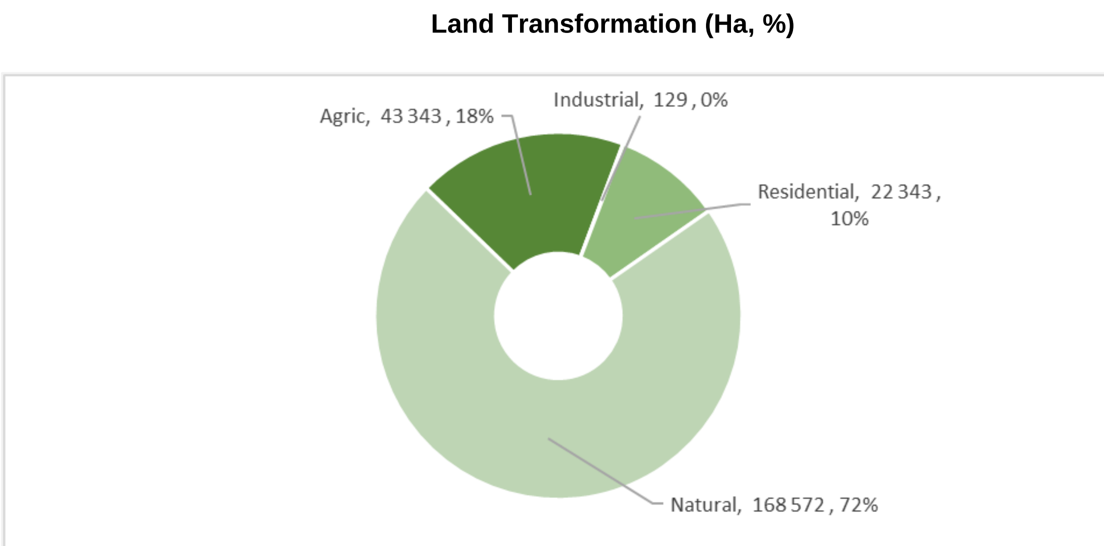


Figure 149: Land transformation per category in IUA 12 (Ha, %)

Socio Economic Profile

The population of IUA 12 is approximately 167 630 with approximately 34 418 households. The majority 95% of the residents speak IsiZulu, and 1% speak English (Figure 150). Only 23% of residents completed secondary school.

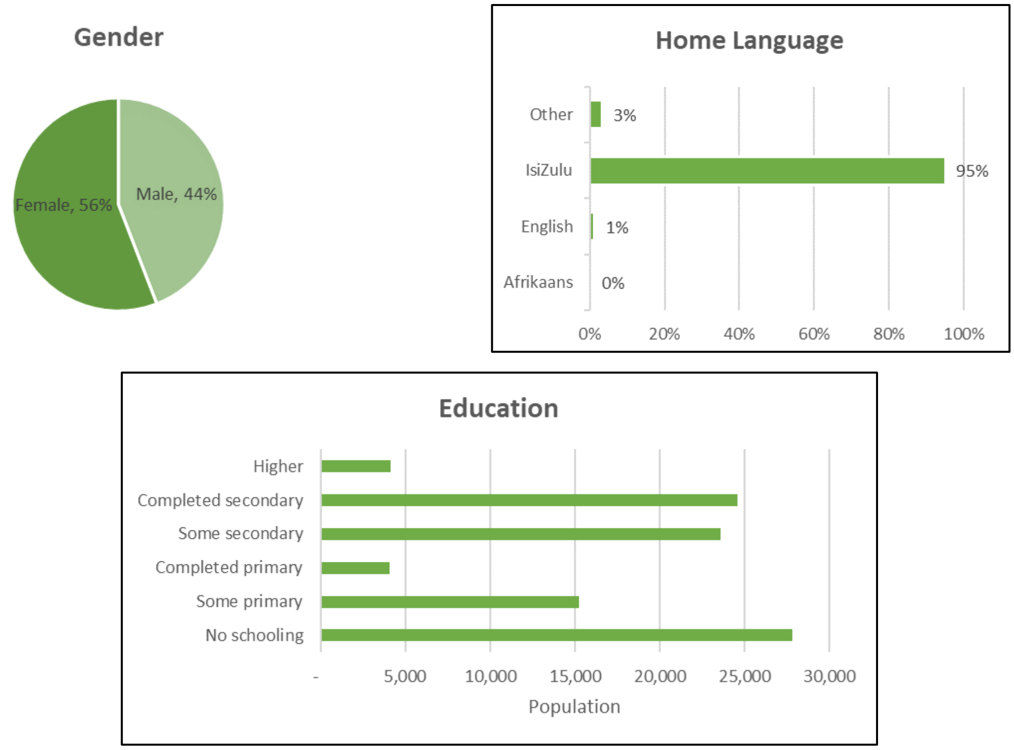


Figure 150: Demographic profile of residents in IUA 12 (StatsSA-Census 2011)

A very small proportion, 13%, of economically active residents are employed with 74% being employed in the formal sector (Figure 151). A relatively small, 8%, number of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

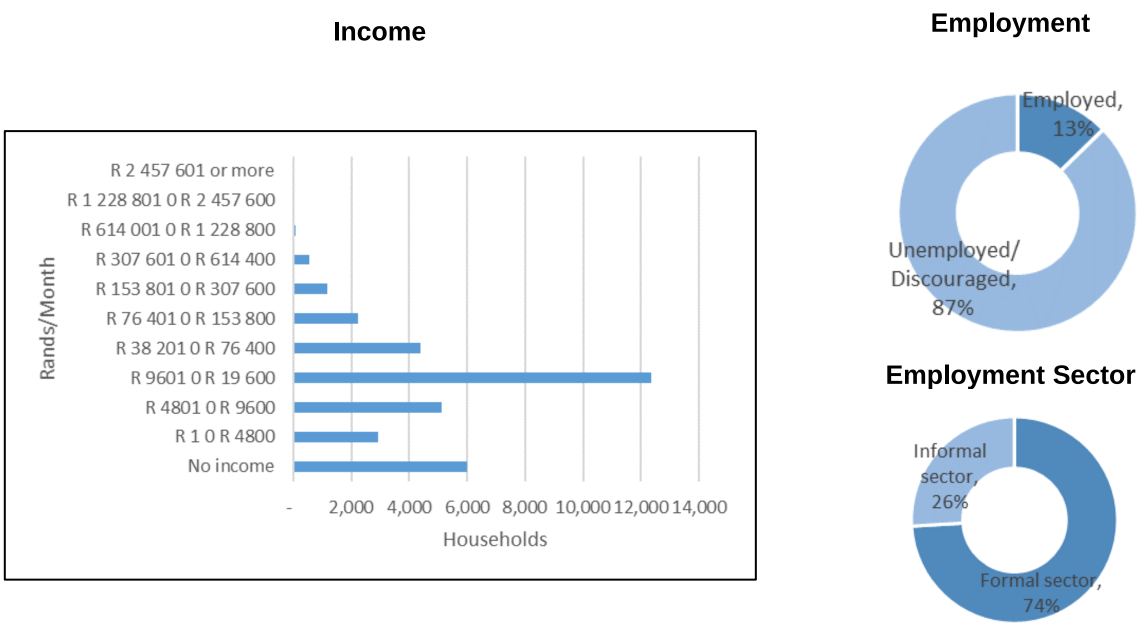


Figure 151: Economic profile of residents in IUA 12 Catchment (StatsSA-Census 2011)

Land Tenure is represented by predominantly Traditional owned land, followed by Communal owned and State owned land and to a lesser extent by privately owned land (Figure 152).

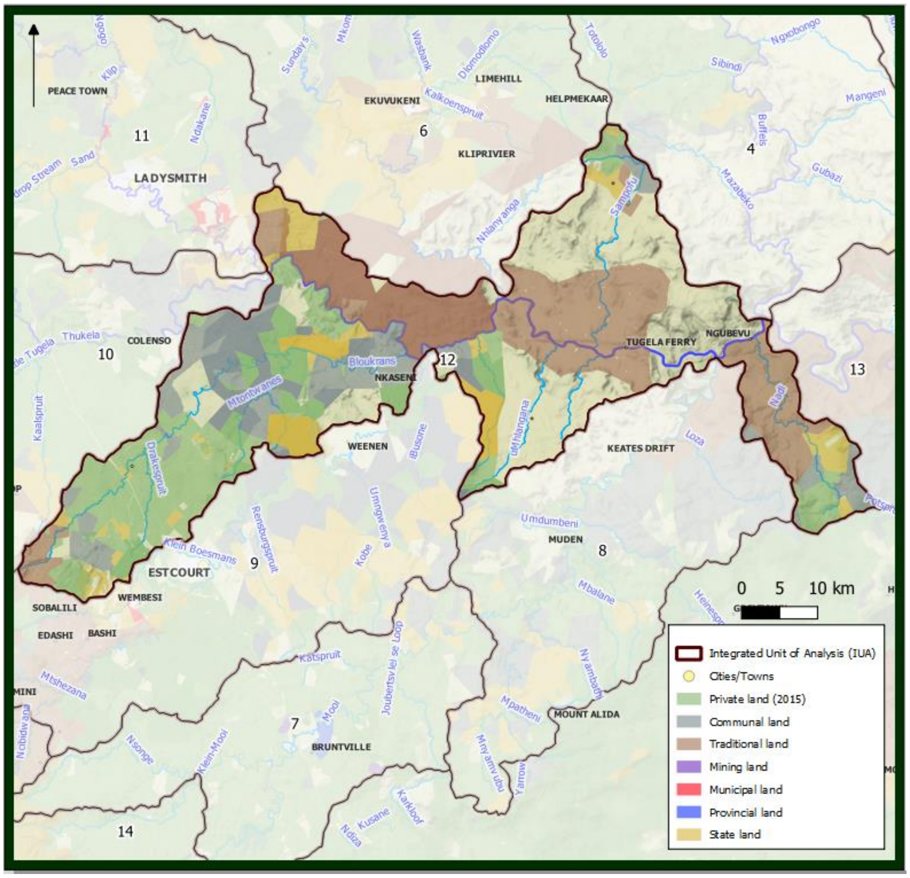


Figure 152: Land ownership within IUA 12 (DRDLR 2015)

Access to services varies greatly among residents with a large proportion, 82%, having limited access to piped water (>50m away from their dwelling), 93% having no access to refuse disposal services, most residents, 95%, with no flush toilets and only 14% having 24 hour access to the internet (Figure 153). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 40%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 64% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

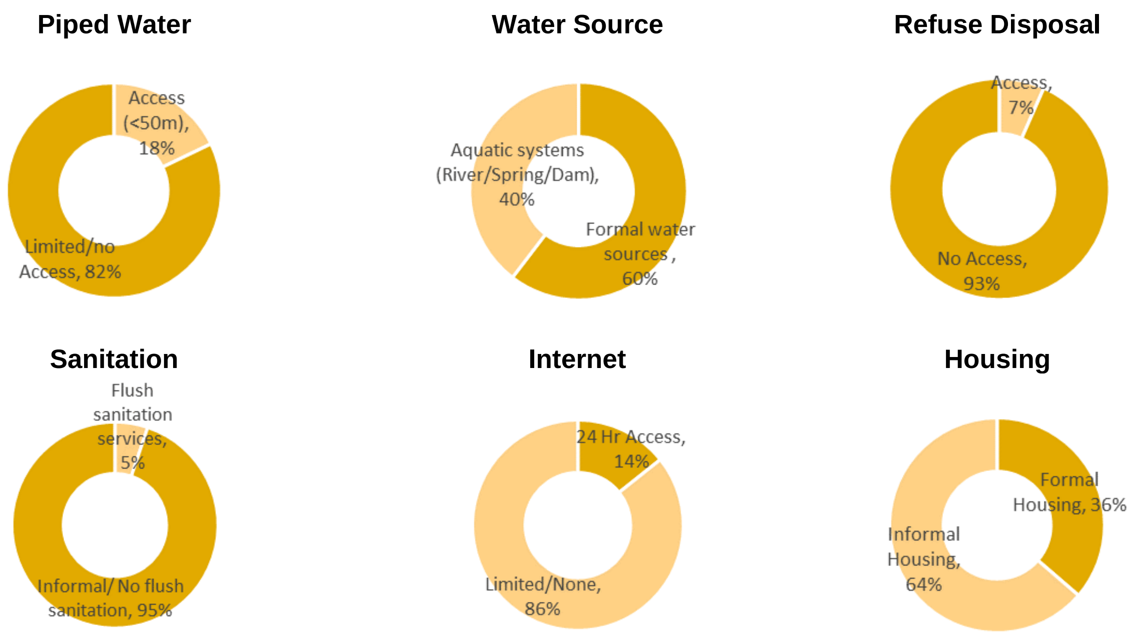


Figure 153: Access to services and indicators of wellbeing of residents in IUA 12 (StatsSA-Census 2011)

A small region of mixed dryland and irrigated agriculture can be seen in the western sector of this IUA, while subsistence agriculture is the dominant land use (Figure 154).

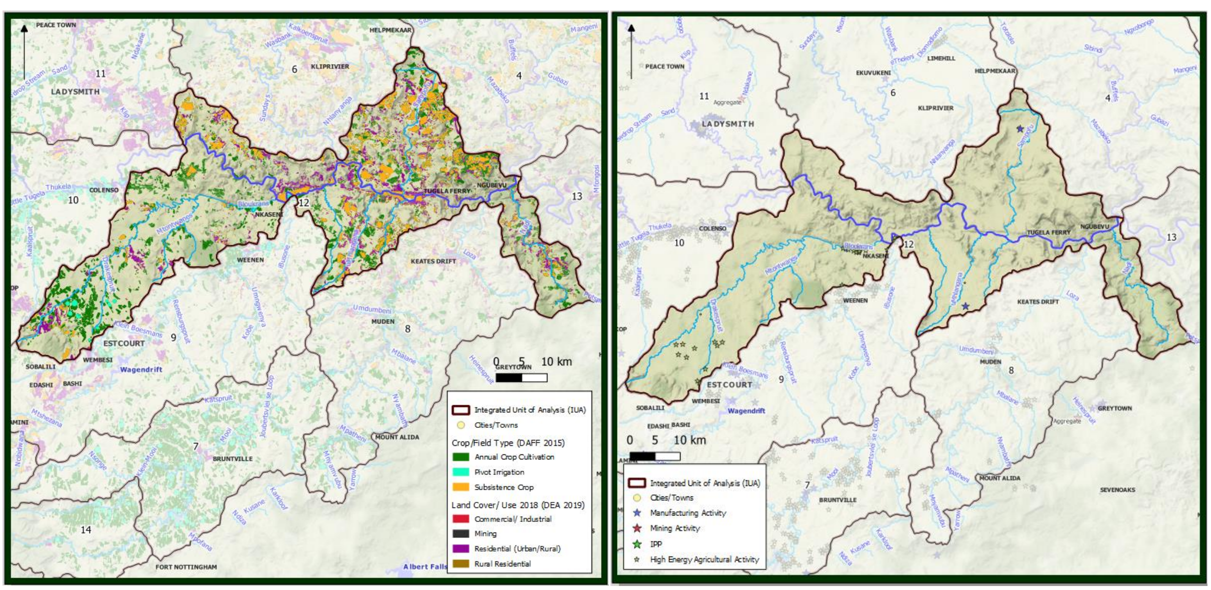


Figure 154: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 12

The largely rural population of IUA 12 is reliant on subsistence agriculture, including grazing, as well as harvesting of aquatic resources. Although small pockets of commercial agriculture are present, their contribution to the economy of the region is minimal, while quarrying accounts for the bulk of the small amount of high intensity land cover (Figure 155).

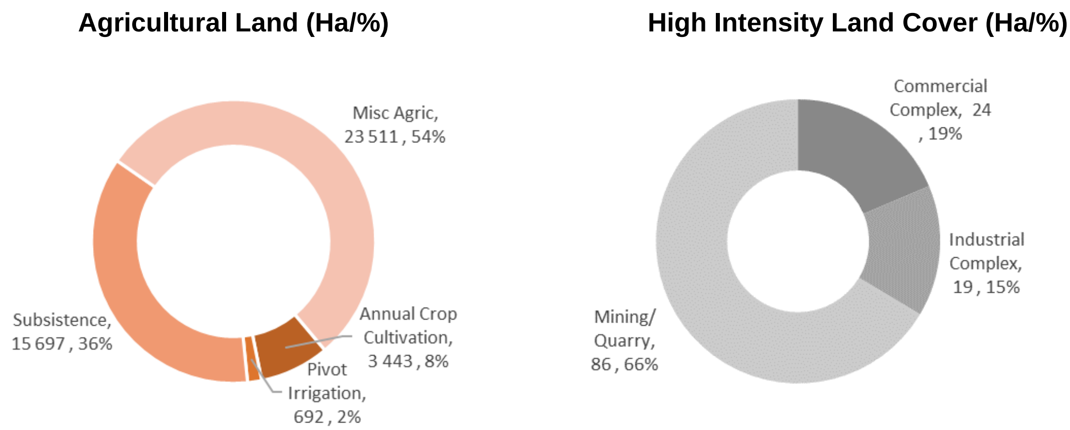


Figure 155: Classification of Agricultural Land and of High Intensity Land Cover in IUA 12

Table 82 below provides details on the municipalities which form part of IUA 12, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 82: Municipalities located within IUA 12

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 12
Msinga LM	• Community Services • Trade • Construction • Transport	Wards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16 & 17 The main economic driver of this region is tourism, with Tugela Ferry being the main town. The region is largely characterised by rural settlements and concomitant subsistence agriculture, with some scattered small scale commercial agriculture.
Alfred Duma LM	• **Agriculture, fishing and forestry** • **Mining and quarrying** • Manufacturing • Construction • Wholesale and retail trade • Tourism •	Wards: 7, 28, 29 & 30 This region is characterised by scattered rural settlements and concomitant subsistence agriculture.
Inkosi Langalibalele LM	• **Agriculture** • Manufacturing • Tourism • Industry • Services	Wards: 5, 6, 17, 18, 19, 20 & 22 Some commercial agriculture in the south western part of this IUA, contribute to the economy of the region, this includes a small area devoted to forestry. Grazing appears to make up most of the area.

Water Resource Use

This IUA is impacted on predominantly by the larger dams in the upper Thukela and upstream IUAs. It is characterised by mostly by rural water abstraction schemes and agriculture. The bulk water user in the IUA is Tugela Ferry.

Ecosystem Services

Situated along the central extent of the catchment IUA 12 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment drained by a variety of tributaries that flow into the Middle Thukela River (Figure 156).

The landscape is characteristic of a variety of wetland systems, predominantly seeps (74%) (Figure 157).

No major regionally significant aquatic features however the Middle Tugela is a key source of surface water to the communities within the IUA. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 83).

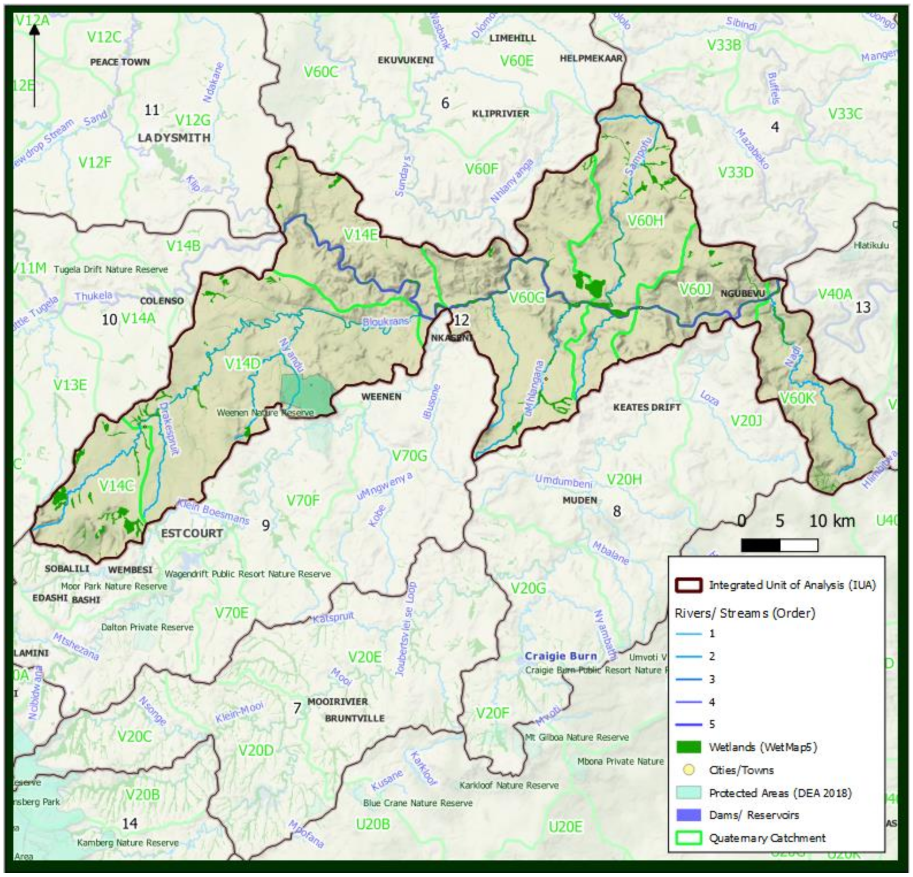


Figure 156: Locality of water resources in IUA 12

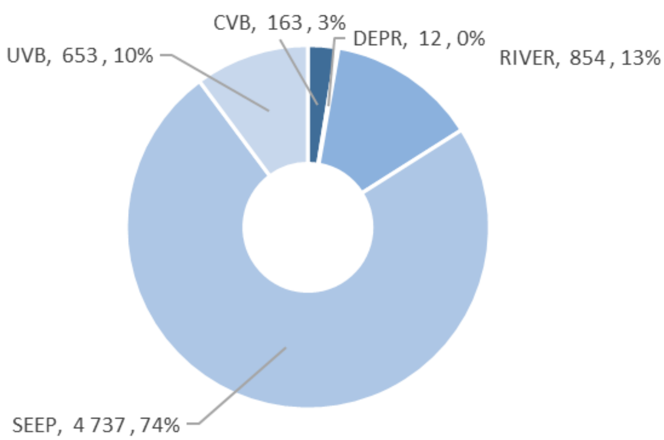


Figure 157: Wetland extent and type in IUA 12 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 83: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 12 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 12	Sector (12 Sectors)
Provisioning	**Food**	Low wetland extent	Major Significance: Highly rural undeveloped catchment; High level of subsistence agriculture.	Higher	**Households**
	Fresh Water	Middle Thukela River and tributaries	Major Significance: Middle Thukela flowing through highly rural undeveloped catchment; High level of subsistence agriculture; 40% of residents rely directly on natural sources of water; Some annual crops (potentially commercial)	Higher	**Households; Agriculture**
	Raw materials	Low wetland extent	Major Significance: Highly rural undeveloped catchment; High level of subsistence agriculture.	Higher	**Households**
	Medicinal resources	Low wetland extent	Significant: Highly rural undeveloped catchment; High level of subsistence agriculture.	Lower	
Regulating	**Climate regulation**	Low wetland extent	Minor significance to global beneficiaries; Perceived low terrestrial quality likely reduces flow	Lower	
	Water quantity regulation	Low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service	Lower	
	Water purification & waste management	Low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
	Erosion control/ Soil stability	Low wetland extent;	Extreme topography likely increases flow of services to subsistence livelihoods	Higher	**Households**
	Biological control	Low wetland extent	Minor significance to rural communities- relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
Cultural	**Landscape & amenity values**	Low wetland extent; Rivers; Landscape; Limited protected areas	Major Significance to highly rural landscape. The high reliance on natural systems likely translates into increased value and cultural connection; Limited identified tourism or recreational services.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Water quality data for this IUA is limited, with only a few monitoring points present coupled with infrequent monitoring. Water quality in the middle Thukela River is relatively good (V60G, V60J) with acceptable and ideal levels of chemical analysed variables observed. High levels on orthophosphate is found in V60G, the middle Thukela River. This is likely attributable to the upstream impacts related to agricultural run-off and the impacts from the Klip and Bushmans Rivers. The Bloukrans River (V14D) exhibits tolerable levels of electrical conductivity and elevated pH.

Monitoirng Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 12 - Middle Tugela														
102703	V14D	39.2	18.1	372.0	44.1	0.7	4.0	23.2	30.3	0.11	0.1	8.6	0.010	27.5
193392	V60G				40.4						2.2	7.7	0.200	
102781	V60J	20.2	17.3	216.7	30.0	0.5	2.9	10.8	28.8	0.12	0.3	8.4	0.010	12.7

River Ecological information and PES

The ecological condition of the Thukela and Bloukrans river reaches in the IUA range both from natural, pristine to largely natural to moderately modified (A, B and C category PES). The Bloukrans is modified in its upper and lower reaches with the middle reach in V14D in a B category, while the Nyandu tributary is in A category PES. The middle Thukela river is in a good condition in the upper reaches but has a C category PES in V60H and V60J. A small reach of the Thukela in V60H has a D ecological condition due to serious riparian-wetland zone modification due to extensive cultivation in the floodplain. The IUA includes 3 EWR sites, EWR 9; EWR 4a and 4b of the preliminary Reserve determination.

Wetlands

IUA 12 is located in the central reaches of the Thukela Catchment within the Grassland and Savanna Biomes, falling mostly within the Sub-Escarpment Savanna Bioregion but also extending into the Sub-Escarpment Grassland Bioregion. Wetlands cover only 5 719 ha of IUA 12, or 2.4% of the land surface, which is significantly less than the average wetland coverage of 4.7% across the entire Thukela Catchment.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 12 are again Seep wetlands, which make up 85.5% of the mapped wetland area and cover 4 892 ha. Unchannelled Valley Bottom and Channelled Valley Bottom wetlands are the next most extensive wetland types at 11.4% and 2.8% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 13 hectares and make up less than 1% of the wetland area within the IUA. The National Wetland Map 5 (Van Deventer *et al.,* 2018) identified no Floodplain wetland habitat within this IUA.

<u>Priority Systems in IUA 12</u>

No Priority Wetlands have been identified in IUA 12 at this stage.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al.*, 2018) and summarised in Table 31 and Table 84, 80.6% of wetlands within IUA 12 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 5.9% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B). Seep wetland systems are especially affected by degradation with over 80% of these systems considered Largely to Critically Modified. Depression wetlands were generally in the best condition with 97.3% of these wetlands falling within the C category.

Table 84: Wetland condition summary for IUA 12 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 12	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	287	544	4 061		33	129	49	184	420					12	0
%	5.9	11.1	**83.0**		20.2	**79.8**	7.5	28.2	**64.3**					**97.3**	2.7

Threats/Impacts

IUA 12 is characterised by a broad range of land uses including plantations, commercial agriculture and cultivation, urban villages and subsistence agriculture.

Groundwater

The groundwater characteristics in IUA 12 are as follows:

- Geology: Karoo Supergroup –
  - Pietermaritzburg (shale)
  - Tarkastad (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
  - Dwyka (arenite, tillite, mudstone and shale)
- Dolerite intrusions: Limited.
- Regional geological features: Tugela Fault Zone (major feature)
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~45 $mm \cdot a^{-1}$.
- Groundwater quality ($mS \cdot m^{-1}$): <70 (limited areas in the upstream (V14C & D), remaining most at 70-300. Regional groundwater quality deterioration in V60G, V60H, V60J, V20H, V20J and V60K.
- Groundwater Reserve status (allocations): Moderate risk (SI = ~45%).

9.2.13 IUA 13: Lower Thukela River

This IUA is delineated as the Lower Thukela River from confluence of the Buffalo River to the upper portion of quaternary catchment V50D.

Rationale

This IUA consist of lowlands, hills and mountains with moderate and high relief, as well as closed hills and mountains with moderate and high relief. A medium density area with mainly traditional subsistence living.

Overview

IUA 13, the Lower Thukela IUA, includes the Nkandla, uMlalazi, uMvoti and Maphumulo local municipalities (Figure 158). The relatively undeveloped IUA includes the towns of Jamesons Drift and Kranskop. Multiple protected areas including various nature reserves and forest reserves are mostly in the upstream portions of the IUA.

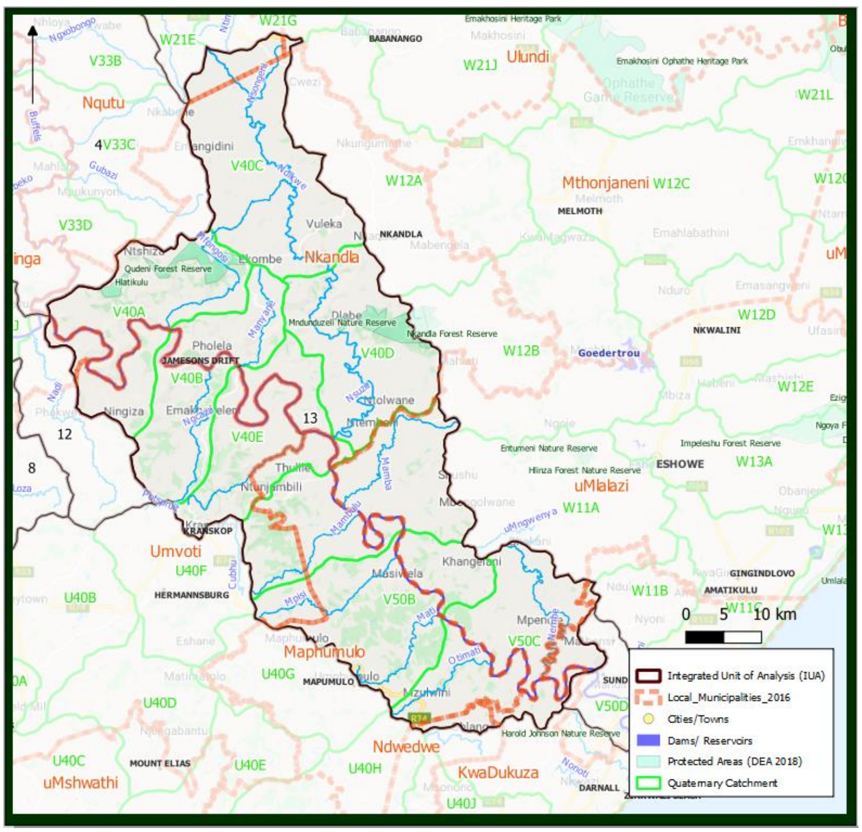


Figure 158: Overview of boundaries and features in IUA 13

Water Resources

Water resources in the IUA include the Lower Thukela River and tributaries (Table 85). Two key water transfers are from the Thukela River through the Thukela to Mhlatuze (to Goedertrouw) transfer scheme and the Lower Tugela (distributed to north and south coast) transfer schemes. The region falls into the Rural Socio-Economic Zone with land uses transforming 24% of the landscape. Agricultural land uses represent 13% and residential the remaining 11% (Figure 160).

Table 85: Water resources and catchments of IUA 13

IUA	Main Rivers	Tributaries	Quaternaries
13	Lower Thukela River	Nsuze River; Nsongeni River; Ndikwe River; Mamdleni River; Mamba River; Mambulu River; Mpisi River; Mati River; Otimati River; Nembe River	V40A; V40B; V40C; V40D; V40E; V50A; V50B; V50C

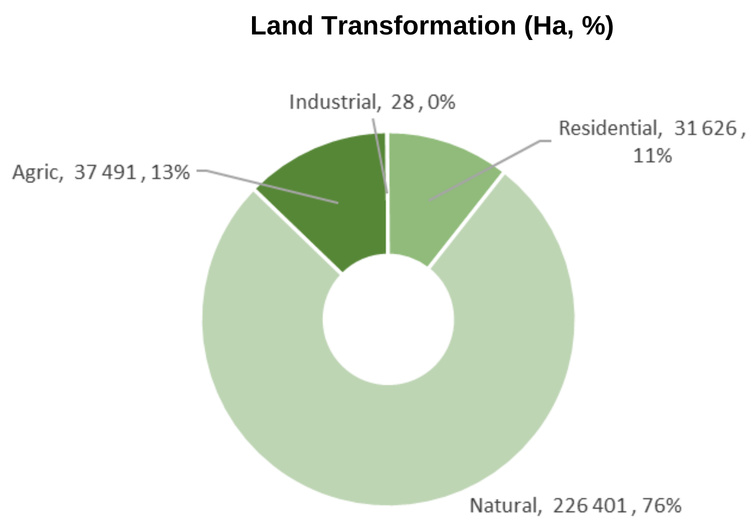


Figure 159: Land transformation per category in IUA 13 (Ha, %)

Socio Economic Profile

The population of IUA 13 is approximately 211 121 with approximately 45 923 households. The majority 94% of the residents speak IsiZulu, and 2% speak English (Figure 160). Only 29% of residents completed secondary school.

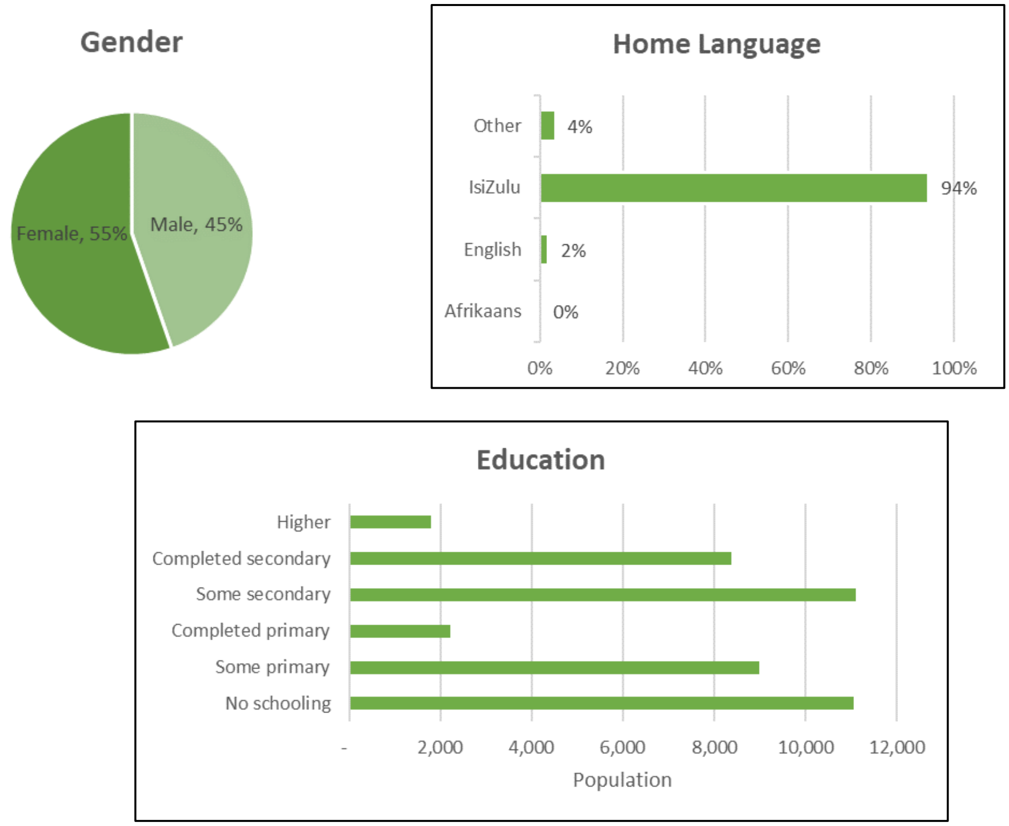


Figure 160: Demographic profile of residents in IUA 13 (StatsSA-Census 2011)

A very small proportion, 15%, of economically active residents are employed with 76% being employed in the formal sector (Figure 161). A relatively small, 7%, number of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

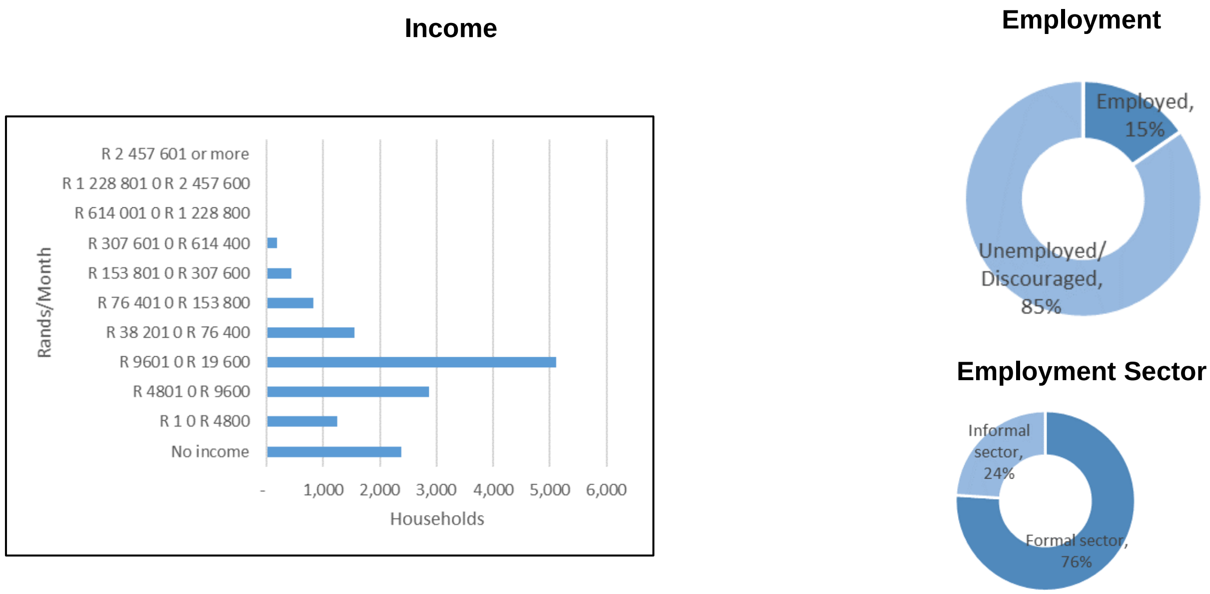


Figure 161: Economic profile of residents in IUA 13 (StatsSA-Census 2011)

Land tenure is represented predominantly by traditional owned land, followed by communal owned land. There is very little state owned and privately owned land in IUA 13 (Figure 162).

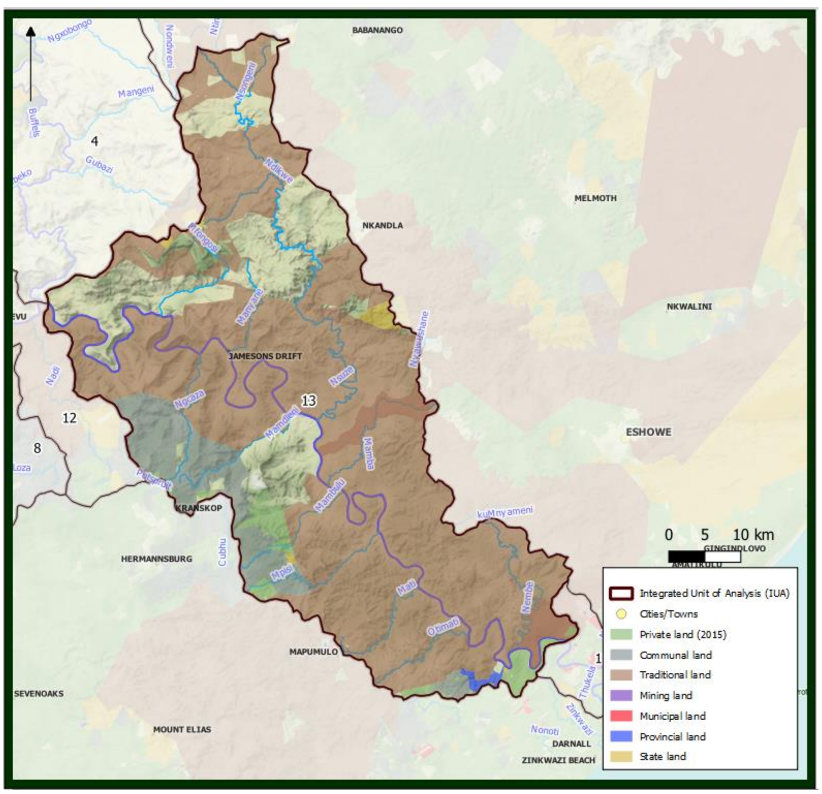


Figure 162: Land ownership within IUA 13 (DRDLR 2015)

Access to services varies greatly among residents with 64% having limited access to piped water (>50m away from their dwelling), 84% having no access to refuse disposal services, most residents, 85%, with no flush toilets and only 19% having 24 hour access to the internet (Figure 163). Varied access to services indicates varied levels of wellbeing throughout the catchment. A very high, 48%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 60% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

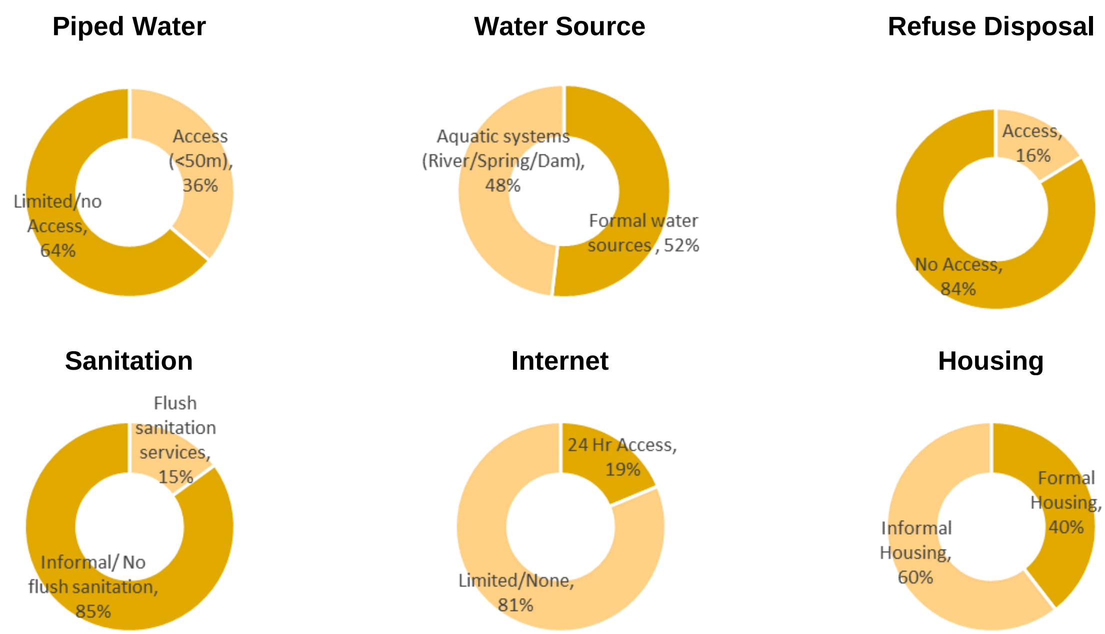


Figure 163: Access to services and indicators of wellbeing of residents in IUA 13 (StatsSA-Census 2011)

No significant local demand is placed on the water resources of this IUA, with scattered subsistence agriculture being the defining characteristic (Figure 164). The Thukela-Goedetrouw Transfer Scheme removes water from the Thukela River in this IUA to supplement the nearby economic hub of Richards Bay.

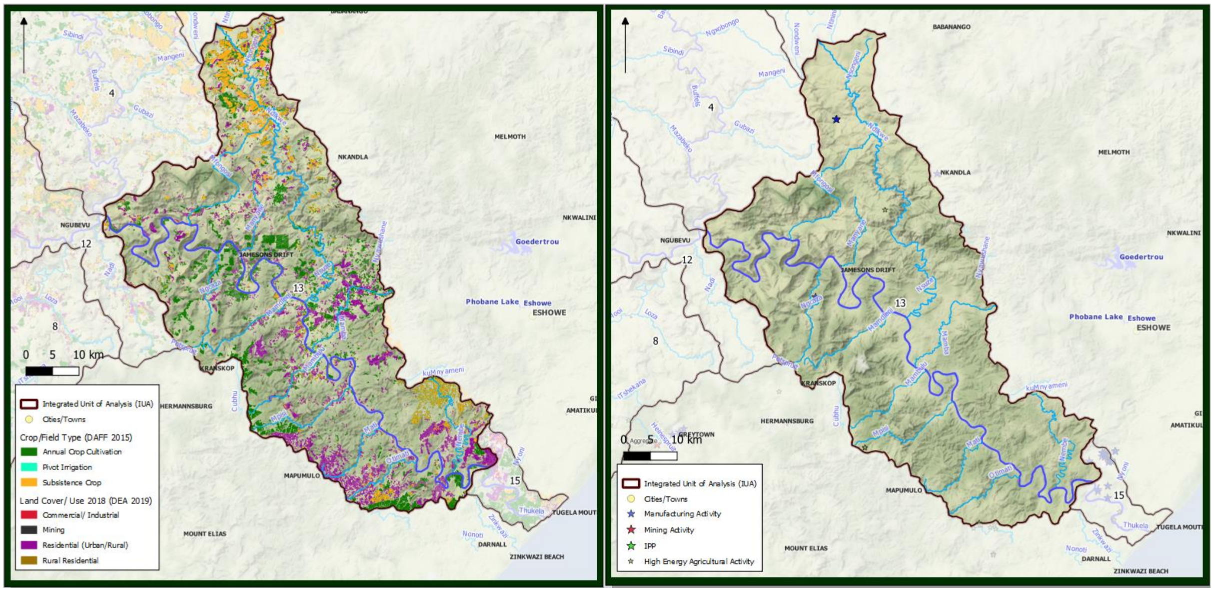


Figure 164: Land use by land cover (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 13

IUA 13, falling in the lower reaches of the Thukela River is, much like the greater study area, predominantly rural, relying almost exclusively on subsistence agriculture and grazing. While a small amount of high intensity land cover is evident (Figure 165), it is likely that many of the households in the southern part of the IUA rely on employment in the commercial zone of IUA 15.

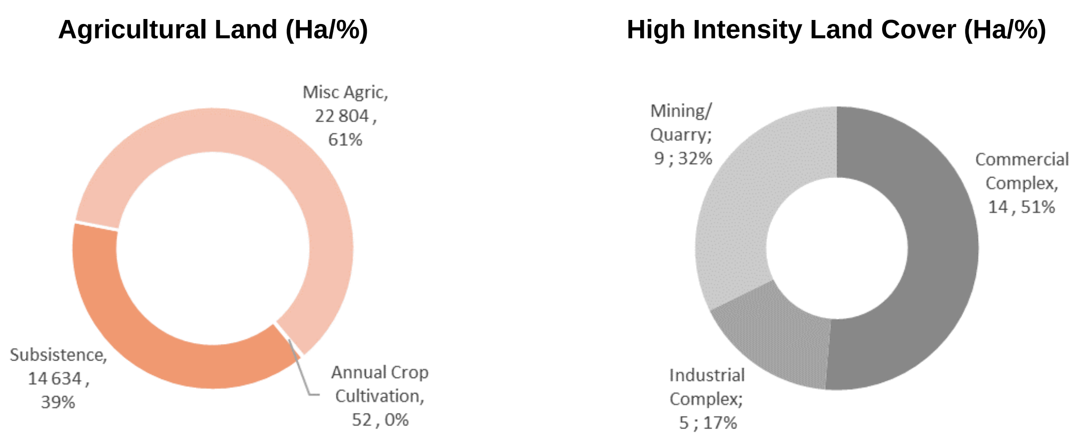


Figure 165: Classification of Agricultural Land and of High Intensity Land Cover

Table 86 below provides details on the municipalities which form part of IUA 13, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 86: Municipalities located within IUA 13

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 13
Nkandla LM	• Subsistence Agriculture Informal sector	Wards: 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13 & 14 Being the poorest municipality in the region, with mountainous terrain unsuited to agriculture, there is very little economic activity here. The Ntingwe Tea Estate is the only notable commercial operation. The Nkandla and Qudeni Forest Reserves hope to attract tourism, but the area is mainly characterised by scattered rural communities and concomitant subsistence agriculture.
Umvoti LM	• General government services • Wolesale & retail trade, catering & accommodation • Manufacturing • Finance, Insurance, Real estate & Business Services • Agriculture forestry & fishing	Wards 5, 6, 12 & 13 Kranskop is the main town in this area. The main economic driver is forestry, with some small-scale scattered commercial agriculture playing a role.
Maphumulo LM	• Manufacturing • Finance, insurance, real estate, & business services • Wholesale & retail trade, catering and accommodation • **Agriculture** • General government • Transport, storage & communication	Wards: 1, 2, 3, 4, 5, 6, 9, 10 There is little economic activity in this area, with scattered rural communities and concomitant subsistence agriculture being the dominant characteristic of this area.
Ndwedwe LM	• **Agriculture** • Tourism services	Ward: 1 This region contributes a small portion of sugar cane farming to the southern tip of the IUA.
Kwadukuza LM	• Tourism, • Forestry, • Agro-industrial manufacturing incl. sugar, • Furniture manufacturing, • Clothing, • Plastic manufacturing, • Pulp and paper	Wards: 1 & 25 Commercial sugar cane farming contributes to the economic output of this small portion of this municipality.
Mandeni LM	• Manufacturing • Finance, insurance, real estate and business services • Wholesale and retail trade, catering and accommodation	Wards: 5, 7, 10, 12, 13, 14 & 15 The town of Sundumbile is the main settlement as well as the main consumer of water in the region. This town likely draws its income from the surrounding sugar cane plantations, which fall outside of this IUA.

Water Resource Use

This IUA is impacted on predominantly by the larger dams in the upper Thukela and upstream

IUAs. It is characterised by mostly by rural water abstraction schemes and agriculture. The abstraction for the Mhlathuze transfer is also a key water use in this IUA.

Ecosystem Services

Situated in the central-eastern extent of the catchment IUA 13 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment is bordered by the quaternary catchments that are drained by a variety of tributaries that flow into the Lower Thukela River (Figure 166). The landscape is characteristic of a variety of wetland systems, predominantly riparian areas (54%), seeps (30%) and channelled valley bottom (15%) (Figure 167). No major regionally significant aquatic features however the Lower Thukela is a key source of accessible surface water to the communities within the IUA. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 87).

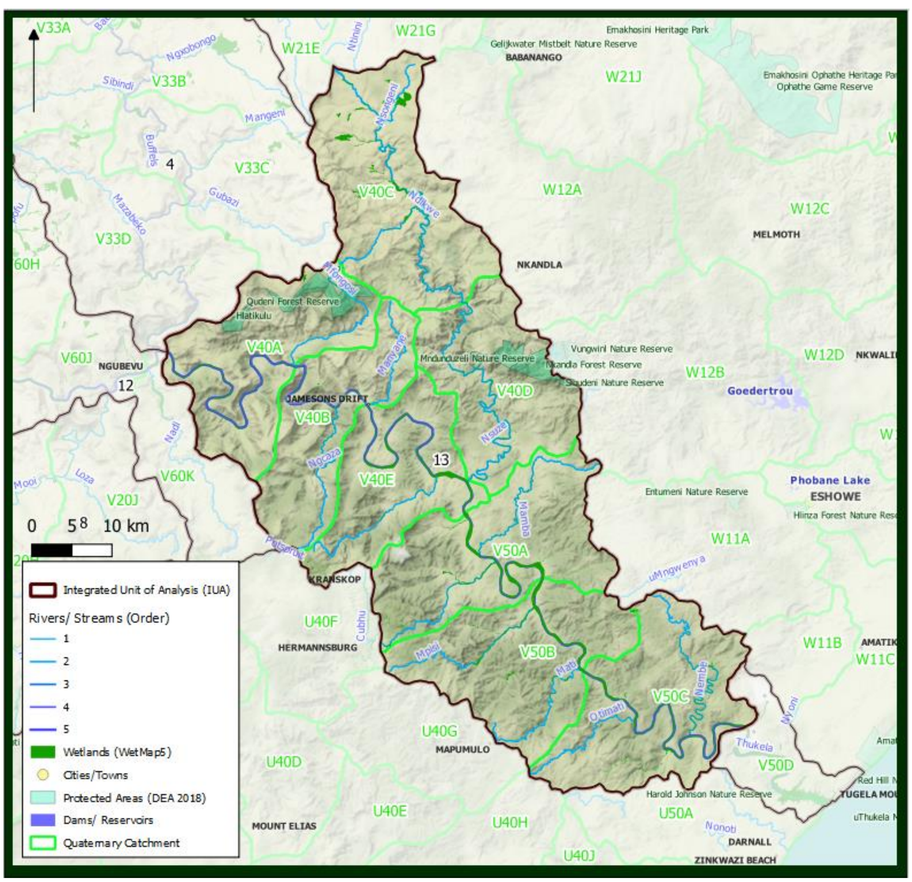


Figure 166: Locality of water resources in IUA 13

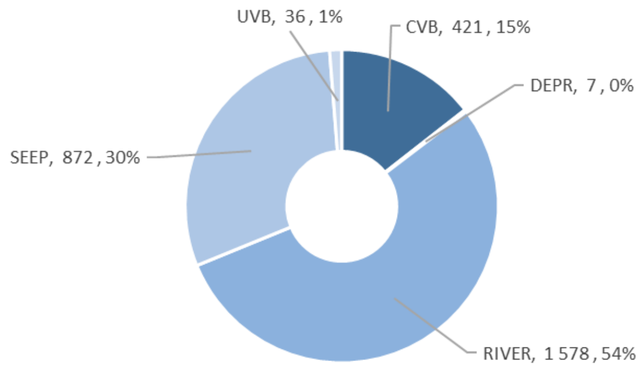


Figure 167: Wetland extent and type in IUA 13 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 87: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 13 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 13	Sector (12 Sectors)
Provisioning	**Food**	Extreme low wetland extent	Significant- Low wetland extent limits available services to highly rural undeveloped catchment; High level of subsistence agriculture in north and south of IUA	Lower	
	Fresh Water	Lower Thukela River and tributaries	Major Significance: Major transfers to Goedertrouw and WTP along the coastline; Lower Thukela flowing through highly rural undeveloped catchment; High level of subsistence agriculture in the north and south; Especially high 48% of residents rely directly on natural sources of water; Some annual crops (potentially commercial) in the upstream stretches of the IUA;	Higher	**Households; Agriculture**
	Raw materials	Extreme low wetland extent	Significant- Low wetland extent limits available services to highly rural undeveloped catchment; High level of subsistence agriculture in north and south of IUA	Lower	
	Medicinal resources	Extreme low wetland extent	Significant- Low wetland extent limits available services to highly rural undeveloped catchment; High level of subsistence agriculture in north and south of IUA	Lower	
Regulating	**Climate regulation**	Extreme low wetland extent	Minor significance to global beneficiaries;	Lower	
	Water quantity regulation	Extreme low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service	Lower	
	Water purification & waste management	Extreme low wetland extent	Significant to rural communities- however relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
	Erosion control/ Soil stability	Extreme low wetland extent	Extreme topography likely increases flow of services to subsistence livelihoods however lack of wetland systems limits flow.	Lower	
	Biological control	Extreme low wetland extent	Minor significance to rural communities- relatively low extent of wetlands likely reduces flow of this ecosystem service;	Lower	
Cultural	**Landscape & amenity values**	Extreme low wetland extent	Potentially major significance to highly rural landscape. The high reliance on natural systems likely translates into increased value and cultural connection; Limited identified tourism or recreational services.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

The IUA has limited water quality data available (sites, frequency and analysis) in catchments V40A to V50C. Compliance assessment has been based on limited samples up to 2016 for this area. Tolerable levels of electrical conductivity and non-compliant levels of orthophosphate are observed. High orthophosphate levels are a risk to potential eutrophication of the river system.

Monitoring Point ID	Drainage Region	EC	NO3-N	pH	PO4-P
		(mS/m)	(mg/l)	(pH units)	(mg/l)
		95	50	95	50
IUA 13 - Lower Tugela					
188875	V40E	67.8	1.3	7.8	4.60
188878	V50A	78.8	14.0	8.0	3.95

Water Quality hotspot areas include

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V40E	Thukela	Moderate	elevated nutrients,/salts, rural communities, subsistence agriculture, over-grazing
V50A	Thukela	Small	elevated nutrients/salts, rural communities, subsistence agriculture, dryland sugarcane, over-grazing, erosion (sediments); small scale sand mining on Mamba

River Ecological information and PES

The major portion of the IUA is in a very good ecological condition, with Thukela River and tributaries in a largely natural to natural state (A and B PES ecological categories). The moderately modified section of the Thukela River in V40A and the tributaries Mandleni, Mpisi and Mati (C category PES) are driven predominantly by habitat modifications and flow modifications. The part of the IUA is sparsely populated, with limited development. The IUA includes 2 EWR sites, EWR 15 and 16 as part of the Comprehensive Reserve determination undertaken.

Wetlands

IUA 13 is located in the lower reaches of the Thukela Catchment within mostly the Savanna Biome, but also including areas of the Grassland and Indian Ocean Coastal Belt Biomes. Most of the IUA falls within Sub-Escarpment Savanna Bioregion, but also extends into the Sub-Escarpment Grassland, Lowveld and Indian Ocean Coastal Belt Bioregions. Wetlands cover only 1 014 ha of IUA 13, or 0.3% of the land surface, which is significantly less than the average wetland coverage of 4.7% across the entire Thukela Catchment and the lowest amongst all the IUAs.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 13 are again Seep wetlands, which make up 85.6% of the mapped wetland area and cover 868 ha. Channelled Valley Bottom and Unchannelled Valley Bottom wetlands are the next most extensive wetland types at 10.2% and 3.6% respectively. The least common wetlands mapped within the IUA are Depression wetlands which cover only 6 hectares and make up less than 1% of the wetland area within the IUA. The National Wetland Map 5 (Van Deventer *et al.,* 2018) identified no Floodplain wetland habitat within this IUA.

Priority Systems in IUA 13

No Priority Wetlands have been identified in IUA 13 at this stage.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 88, 77.4% of wetlands within IUA 13 are considered to be Largely to Critically Modified (wetland condition D/E/F), with only 7.0% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B).

Table 88: Wetland condition summary for IUA 13 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al.*, 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 13	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	66	55	748		103	1			36				5	0	0
%	7.6	6.3	**86.1**		**99.3**	0.7			**100.0**				**94.4**	2.0	3.7

Threats/Impacts

IUA 13 is a largely rural area characterised by a broad range of land uses including plantations, commercial agriculture and cultivation, and extensive urban villages and subsistence agriculture.

Groundwater

The groundwater characteristics in IUA 13 are as follows:

- Geology: Karoo Supergroup formations with Karoo + Namaqua-Natal (Metamorphic) Province Group + Barberton Sequence:
  - Pietermaritzburg (shale)
  - Tarkastad (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
  - Dwyka (arenite, tillite, mudstone and shale)
  - Natal (arenite and shale)

  - Tugela (Gneiss and schist)
  - Mambulu (Gabbro and norite)
  - Mapumulo (Gneiss)
- Dolerite intrusions: None.
- Regional geological features: Large fault/shear zones present in the lower section (i.e. V50B).
- Borehole yield class (Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$);
- Recharge averaging from ~15 $mm \cdot a^{-1}$ (upstream Thukela section) to 45 $mm \cdot a^{-1}$ (downstream section).
- Groundwater quality ($mS \cdot m^{-1}$): <70 (northern ½), 70-300 (southern ½: V50A and V50B). Hot spot conditions present in V40E (needs further investigation of land use practices).
- Groundwater Reserve status (allocations): No risk (SI = ~30%).

9.2.14 IUA 14: Escarpment Rivers

This IUA is delineated as the source of the upper Thukela River and its tributaries within the uKhahlamba Drakensberg National Park (park boundary as IUA boundary).

Rationale

This IUA is characterised by closed hills, mountains with moderate and high relief with prominent escarpments towards the east. The area is protected, is a UNESCO World Heritage site and is delineated as a SWSA. Tourism is the main activity in this IUA. Most of the rivers are in near natural present state with high to very high EIS. This unit would require more stringent protection measures.

Overview

IUA 14, the Escarpment IUA, straddles the local municipalities of Okhahlamba, Inkosi Langalibalele and Mpofana (Figure 168). The IUA is highly undeveloped and includes no major towns. Communities are largely present in the northern reaches. Much of the IUA is protected through the Drakensberg complex of national parks, wilderness areas and nature reserves.

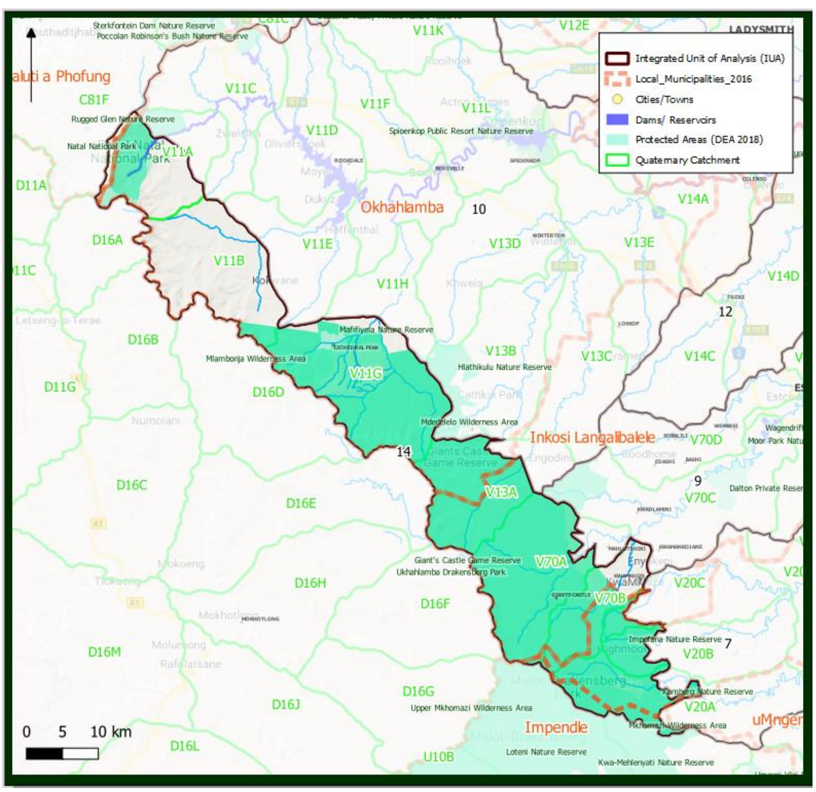


Figure 168: Overview of boundaries and features in IUA 14

Water Resources

Key water resources in the IUA include the headwaters for many tributaries to the Thukela River (Table 89). The IUA represents protected areas, SWSAs and the UNESCO World Heritage site along the entire IUA.

Table 89: Water resources and catchments of IUA 14

IUA	Main Rivers	Tributaries	Quaternaries
14	Escarpment Rivers	Thukela headwaters; Upper Little Thukela; Upper Boesmans River; Upper Mooi River; Upper Little Mooi River; Mtshezana River; Nsibidwana River; Sithene River; Thonyelana-mpumalanga River; Mnweni River (upper); Ndumeni River; Thuthumi River; Ndedema River; Mhlwazini River; Mlambonja River (upper)	V20A (upper reaches); V20B (upper reaches); V70A (upper reaches); V70B; V13A (upper reaches); V11G; V11B; V11A (upper reaches)

The region falls into the Agricultural Socio-Economic Zone with land uses transforming only 2% of the landscape. Agricultural land uses represent 1% and residential the remaining 1% (Figure 169).

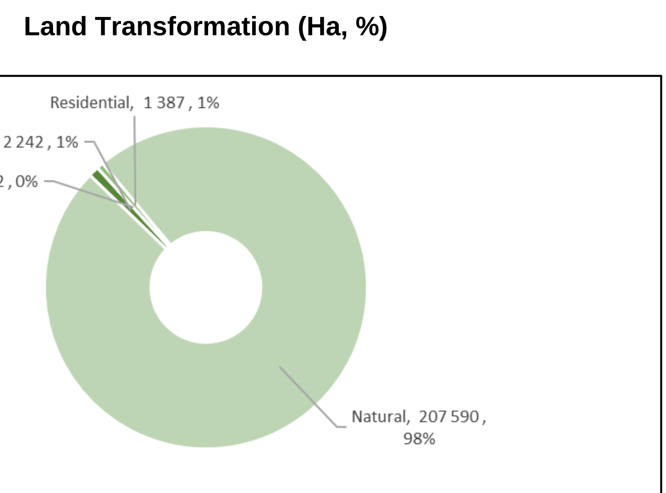
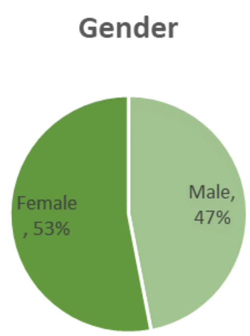
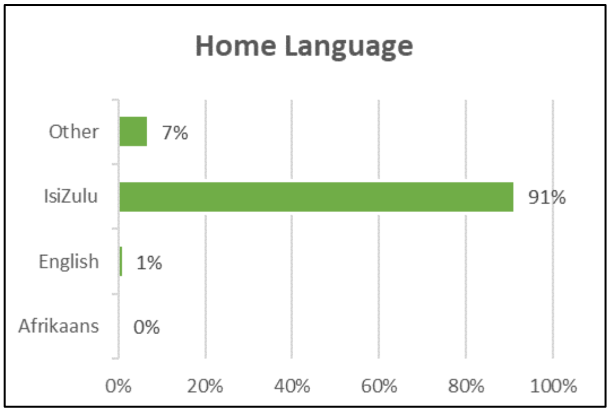


Figure 169: Land transformation per category in IUA 14 (Ha, %)

Socio Economic Profile

The population of IUA 14 is approximately 29 297. The majority, 91%, of the residents speak IsiZulu, and 1% speak English (Figure 170). Only 23% of residents completed secondary school.





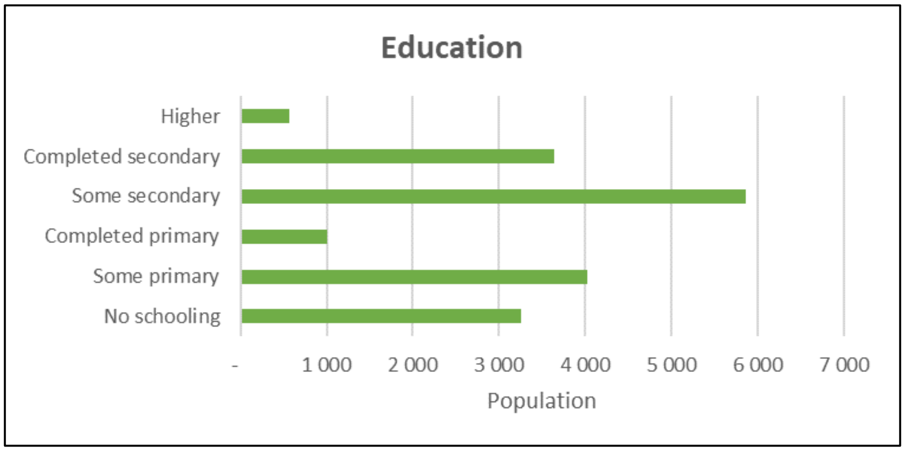


Figure 170: Demographic profile of residents in IUA 14 (StatsSA-Census 2011)

A very small proportion, 13%, of economically active residents are employed with 65% being employed in the formal sector (Figure 171). A relatively small, 9%, number of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

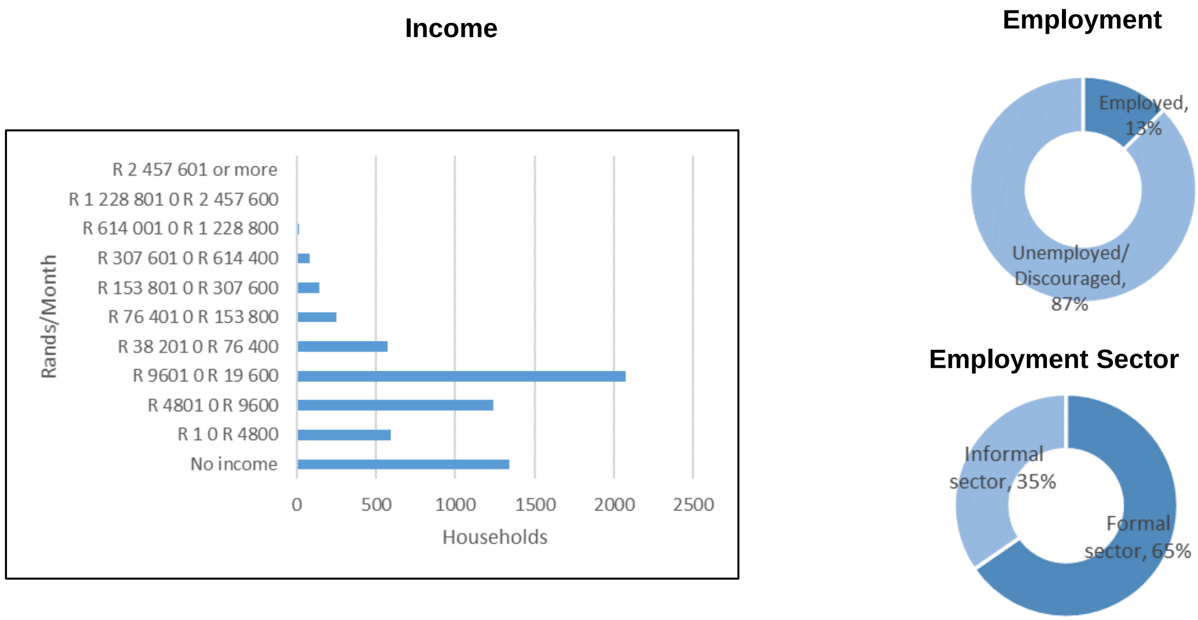


Figure 171: Economic profile of residents in IUA 14 (StatsSA-Census 2011)

Land tenure is represented by a large portion of traditional owned land followed by state owned land (Figure 172).

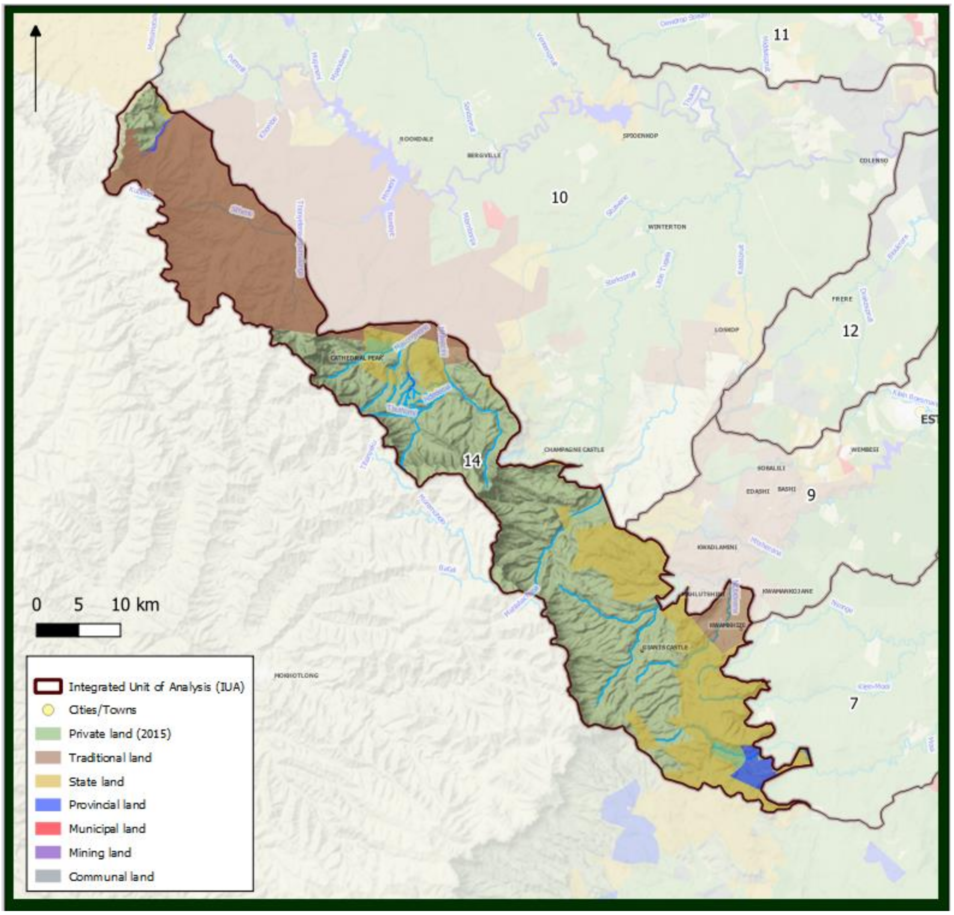


Figure 172: Land ownership within IUA 14 (DRDLR 2015)

Access to services varies greatly among residents with 86% having limited access to piped water (>50m away from their dwelling), 95% having no access to refuse disposal services, most residents, 95%, with no flush toilets and only 24% having 24 hour access to the internet (Figure 173). Varied access to services indicates varied levels of wellbeing throughout the catchment. A high, 54%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 56% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

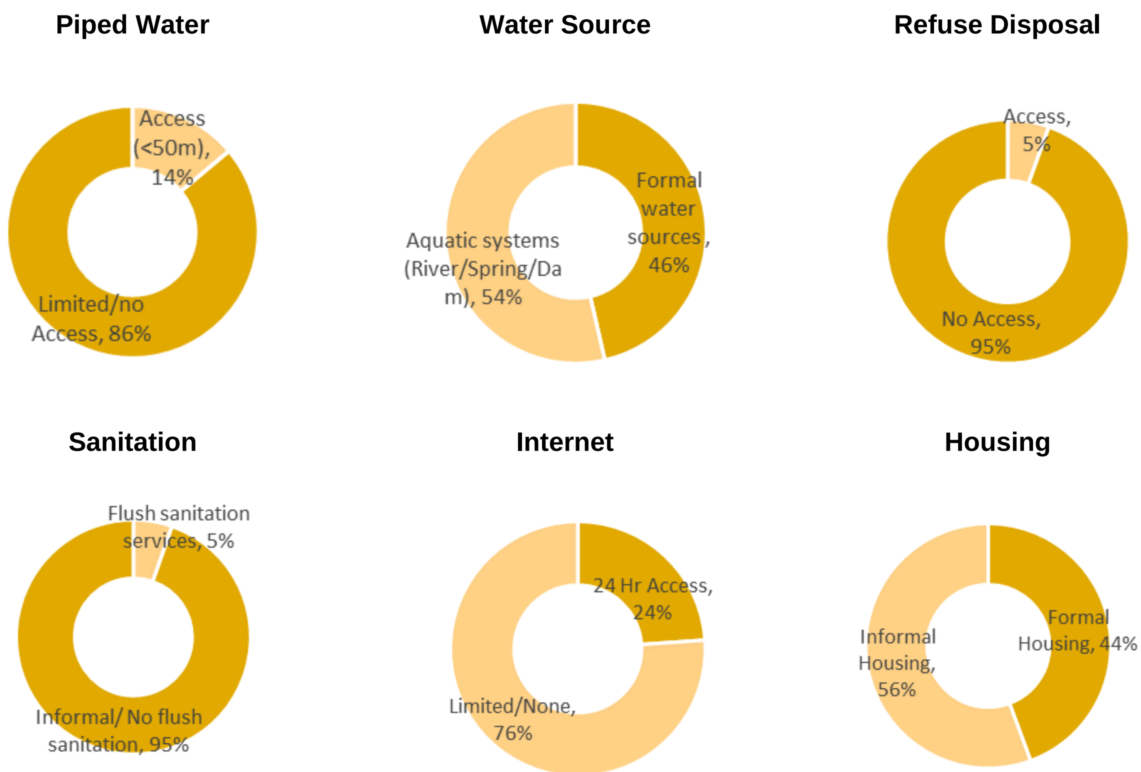


Figure 173: Access to services and indicators of wellbeing of residents in IUA 14 (StatsSA-Census 2011)

This IUA is the least developed IUA in the larger catchment and consists of mostly protected land, which serves as a strategic source of water for the entire basin (Figure 174).

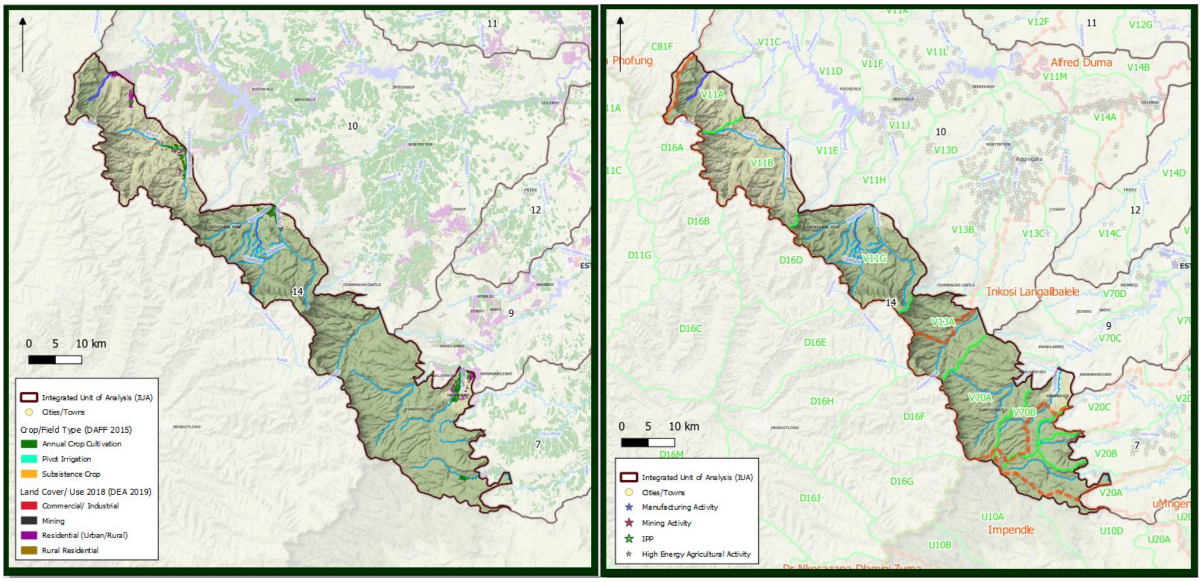


Figure 174: Land use by land cover in IUA 14 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 14

IUA 14 is comprised mainly of undeveloped escarpment which is protected. There is are scattered regions of rural communities who practise subsistence agriculture (the predominant land use in the catchment) (Figure 175).

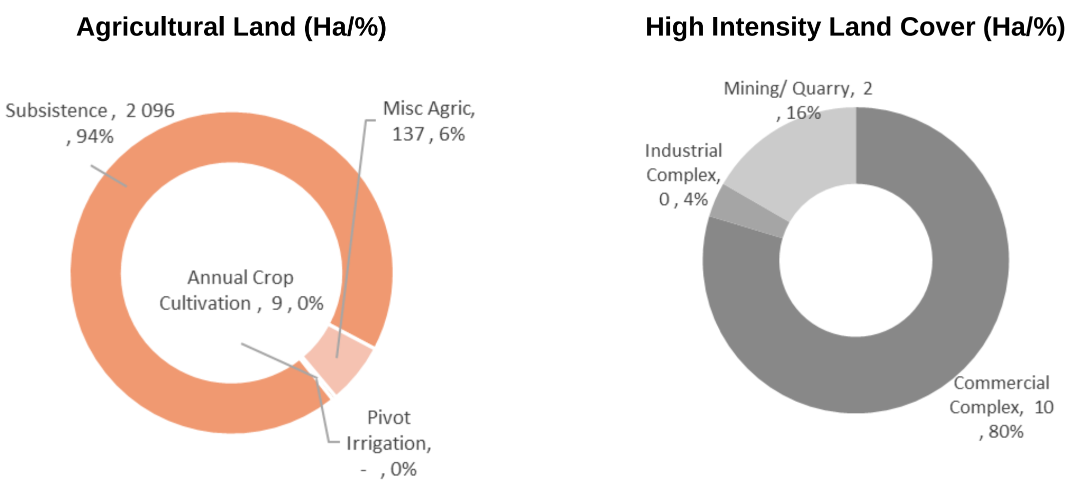


Figure 175: Classification of Agricultural Land and of High Intensity Land Cover in IUA 14

Table 90 below provides details on the municipalities which form part of IUA 14, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 90: Municipalities located within IUA 14

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 14
Okhahlamba LM	• **Agriculture** • Manufacturing • Trade • Commerce • Tourism • **(Water transfer)**	Wards: 3, 5, 6, 7, 9, 10 & 14 This region's main economic driver is tourism, with a number of nature reserves falling within the area.
Inkosi Langalibalele LM	• **Agriculture** • Manufacturing • Tourism • Industry • Services	Wards: 1 & 12 Falling almost entirely into the uKhahlamba-Drakensburg National Park, this region is mainly reliant on tourism. Some rural settlements also exist, which rely mainly on subsistence agriculture.
Impendle LM	• **Agriculture** • Tourism • Social services	Ward: 1 The tiny sliver of ward one that falls within IUA 14 falls completely within the Mkhomazi Wilderness Area, making tourism the only economic sector.
Mpofana LM	• **Agriculture** • Tourism • SMMEs • Co-ops	Ward: 2 Large portions of ward two that falls within IUA 14 falls completely within protected areas, making tourism the key economic sector
uMngeni LM	• **Agriculture** • Wholesale/retail • Business / real estate • Manufacturing	Ward: 3 Again, focus is on protected areas within this ward.

Water Resource Use

This IUA has limited water resources development and has been identified due to its environmental importance, and importance in generating runoff from the highest rainfall parts of the Thukela catchment.

Ecosystem Services

Situated in the extreme western extent of the uThukela tertiary catchment IUA 14 consists of a variety of aquatic and terrestrial ecological infrastructure which likely provide a range of ecosystem services to associated communities. The catchment represents the undeveloped escarpment and is bordered by the quaternary catchments that are drained by a variety of tributaries which form headwaters for numerous escarpment rivers (Figure 176).

The landscape is characteristic of a variety of wetland systems, predominantly seeps (40%), riparian habitats (33%) and channelled valley bottom (16%) (Figure 177).

The region is classified as a Strategic Water Source Area (SWSA) and is largely undeveloped and protected within the Drakensberg complex of protected areas. Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 91).

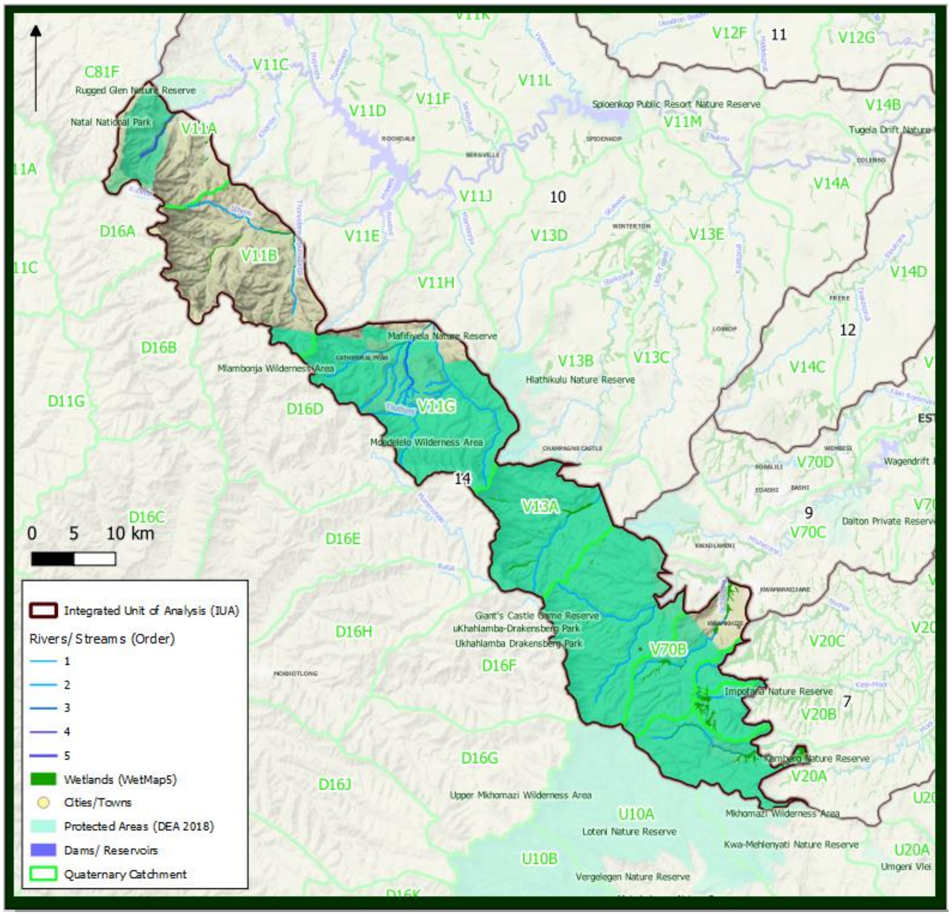


Figure 176: Locality of water resources in IUA 14

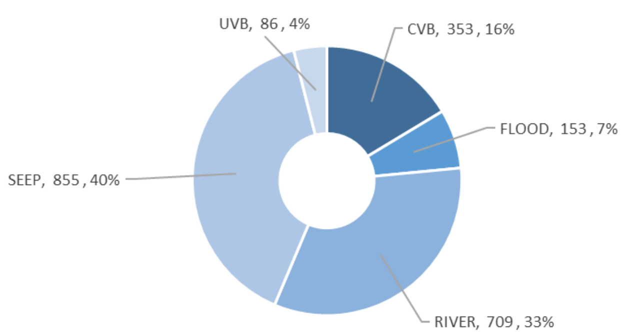


Figure 177: Wetland extent and type in IUA 14 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 91: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 14 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 14	Sector (12 Sectors)
Provisioning	**Food**	Escarpment, Limited wetlands; Streams and headwaters	Significance: Rural relatively undeveloped catchment with some subsistence agriculture.	Lower	
	Fresh Water	Escarpment, Limited wetlands; Streams and headwaters	Major Significance to the greater uThukela catchment; Subsistence agriculture in various region	Higher	**Agriculture; Households**
	Raw materials	Escarpment, Limited wetlands; Streams and headwaters	Significance: Rural relatively undeveloped catchment with some subsistence agriculture	Lower	
	Medicinal resources	Escarpment, Limited wetlands; Streams and headwaters	Significance: Rural relatively undeveloped catchment with some subsistence agriculture	Lower	
Regulating	**Climate regulation**	Limited wetlands; Drakensberg complex of protected areas	Major significance to global beneficiaries;	Higher	
	Water quantity regulation	Highly significant SWSA in upper catchment	Major Significance to limited activities within catchment however highly significant to the greater uThukela catchment	Higher	**Multiple sectors**
	Water purification & waste management	Limited wetlands	Relatively low significance to beneficiaries	Lower	
	Erosion control/ Soil stability	Good condition terrestrial systems and escarpment	Major significance: Subsistence agriculture in north and commercial and irrigation agricultural activities in the south	Higher	**Agriculture; Households**
	Biological control	Good condition terrestrial systems and escarpment	Major significance: Subsistence agriculture in north and commercial and irrigation agricultural activities in the south	Higher	**Agriculture; Households**
Cultural	**Landscape & amenity values**	Escarpment and extensive protected areas; uKhahlamba Drakensberg Park (RAMSAR Site)	Major significance: RAMSAR site services global beneficiaries; Potentially major significance to rural communities. The high reliance on natural systems likely translates into increased value and cultural connection.	Higher	**Tourism; Households; Society**
	Ecotourism & recreation				
	Educational values and inspirational services				

Water Quality

Water quality of the source of the rivers is not monitored as they are situated in protected areas and nature reserves within the Park, in mountainous wilderness areas. The rivers are largely pristine, in good ecological condition, and it is assumed that they would be of good water quality.

There are a few sites just outside the Ukhahlamba Drakensberg Park boundary in some catchments that were assessed for water quality compliance. The water quality on the Mlambonja tributary (V11G) was found to have high salinity and nutrients. These sites are located in the vicinity of the Cathedral Peak Resort sewage effluent discharge. It is evident that the water quality is being impacted by the effluent discharge. At the sites on the Bushmans River (V70G) where trout farming occurs and the Mooi River (V20B) water quality is good.

Monitoring Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA 14 - Escarpment														
188844	V11G				126.5					0.61	0.29	8.4	0.10	
188861	V11G				87.2					2.01	0.33	8.1	0.34	
188853	V11G				87.8					12.01	2.80	7.9	2.01	
102798	V70B	9.4	5.1	86.6	11.2	0.6	2.4	4.0	5.4	0.15	0.05	8.1	0.010	4.1
188045	V20A	7.0	3.9	55.8	9.4	0.4	2.8	2.9	4.6	0.24	0.05	8.0	0.010	3.0

River Ecological information and PES

The headwater streams of this escarpment IUA are in a largely natural to natural state (A and B PES ecological categories). The tributaries which are in a pristine, close to natural state, are located within the uKhahlamba Drakensberg National Park. The protected status of the area and location within the mountainous terrain limits the impacts on these headwater systems.

Wetlands

IUA 14, which includes the only Ramsar Site within the Thukela Catchment, is located along the high-lying western watershed of the catchment within the Grassland Biome, falling mostly within the Drakensberg Grassland Bioregion but also extending into the Sub-Escarpment Grassland Bioregion. Wetlands cover only 1 469 ha of IUA 14, or 1.0% of the land surface, which is significantly less than the average wetland coverage of 4.7% across the entire Thukela Catchment. The bulk of this IUA is located within the Maloti Drakensberg Park IBA (IBA #SA064), but also includes a section of the Sterkfontein Dam Nature Reserve IBA (IBA #SA046).

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 14 are Seep wetlands, which make up 55.9% of the mapped wetland area and cover 822 ha. Channelled Valley Bottom and Floodplain wetlands are the next most extensive wetland types at 24.3% and 15.3% respectively. No Depression wetlands were identified within the IUA. Unchannelled Valley Bottom wetlands make up 4.5% of the wetland area within this IUA.

<u>Priority Systems in IUA 14</u>

Included in the Priority Wetland list but not visible in the Priority Wetland layer in Figure 32 are the wetlands associated with the Natal Drakensberg Park Ramsar Site (see www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa). There are different names for this park which could be confusing. Natal Drakensberg Park is the name used to refer to the Ramsar Site but geographically, this is the same area as the uKhahlamba Drakensberg National Park (www.environment.gov.za/ sites/default/files/docs/ publications/ worldwetlandsdayphamplet). This area includes extensive but often relatively small wetlands that are not captured in the National Wetland Map 5 or the NFEPA wetland layer (as a result of a mapping scale constraint) but which are important components of the mountain catchment areas which comprise the Natal Drakensberg Park Ramsar Site. Parts of this area included wilderness areas, nature reserves, and state forests. This area forms the border and mountain catchment area between South Africa and the Kingdom of Lesotho. It is critically important due to its high runoff yield and good water quality, supplying rural, agricultural, urban and industrial users downstream (www.Ramsar.org). The rivers that originate here support extensive wetlands of various types within the Afro-alpine and Afromontane belts of the region (www.Ramsar.org). A number of systems, including valley bottom and floodplain systems, also occur along the headwaters and main stems of some of the river systems draining the broader Thukela catchment.

Stillerust is one of the larger wetlands in this IUA and is located in the Kamberg Nature Reserve within the Natal Drakensberg Park Ramsar Site. The wetland is approximately 22 ha in extent and comprises a backswamp area on the floodplain of the Mooi River including cut-off meanders or ox-bows (Begg, 1989). The wetland is dominated by a mixed hygrophilous grassland-sedge community.

<u>Baseline Ecological State</u>

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 92, 63.8% of wetlands within IUA 14 are considered to be Largely to Critically Modified (wetland condition D/E/F), with 31.2% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B). These findings are surprising given that large portions of this IUA fall within the Ukhahlamba Drakensberg Park and are under statutory protection.

Stillerust is indicated as having a wetland condition of mostly D/E/F (Van Deventer *et al.* 2018), though the NFEPA wetland attribute data (Nel *et al*., 2011) indicates the main body of the wetland to be in a wetland condition of A/B.

Table 92: Wetland condition summary for IUA 14 showing wetland condition for Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer *et al*., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 14	Seep			Channelled VB			Unchannelled VB			Floodplain		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	344	67	411	88		268	25	6	35			225
%	41.9	8.2	49.9	24.8		75.2	38.1	9.4	52.5			100.0

Threats/Impacts

Most of IUA 14 falls within the Ukhahlamba Drakensberg Park and is protected. Some agricultural activities occur within the lower-lying portions of this IUA. The Stillerust wetland was historically impacted by agricultural activities but as it is now protected, probably the largest threat to the system comes from alien invasive plants and runaway or un-manged fires or too frequent burning. Evidence of a threat of possible alien vegetation encroachment into the system can be seen when examining recent imagery of the system (using either Google Earth or ESRI Basemap).

Groundwater

The groundwater characteristics in IUA 14 are as follows:

- Geology: Karoo Supergroup :
  - Drakensberg (basalt)
  - Upper Karoo Molteno-Elliot-Clarens Formations (arenite, shale, mudrock and aeolian sandstone)
  - Beaufort (arenite and mudstone)
  - Vryheid (arenite, coal and shale)
  - Volksrust (shale)
- Dolerite intrusions: Limited.
- Borehole yield class (Insignificant: 0.1 to 0.5 $\ell \cdot s^{-1}$ in north to Minor: 0.5 to 2.0 $\ell \cdot s^{-1}$ central and south);
- Recharge averaging from 40 to 50 $mm \cdot a^{-1}$.
- Groundwater quality ($mS \cdot m^{-1}$): <70, however, "hot spot" groundwater quality deterioration noted in V70B.
- Groundwater Reserve status (allocations): Moderate risk (SI = ~60%), but High (SI>70%) in Mooi River headwaters area (GRU O: V20A, V20B, V20C and V20D).

9.2.15 IUA 15: Thukela Estuary and upstream Thukela Reach

The lowest reach of the Thukela River in V50D and Thukela Estuary is delineated as the IUA.

Rationale

This reach is impacted with land use and development. Hardworking catchment area, and with the commercial development zone SEZ delineated. Transfer of water to north and south coast from this reach of the Thukela River.

The Estuary is a management unit with requirements and ecological specifications that are different to river systems.

Overview

IUA 15, the Thukela Mouth Estuary IUA, is found within Mandeni local municipality (Figure 178). It includes the town of Mandini (portion thereof) and communities of Thukela Mouth and Sundumbili. The IUA includes various protected areas including Nature reserves and the Thukela Mouth Marine Protected Area. The key water resources in the IUA include the Thukela Mouth Estuary (Table 93).

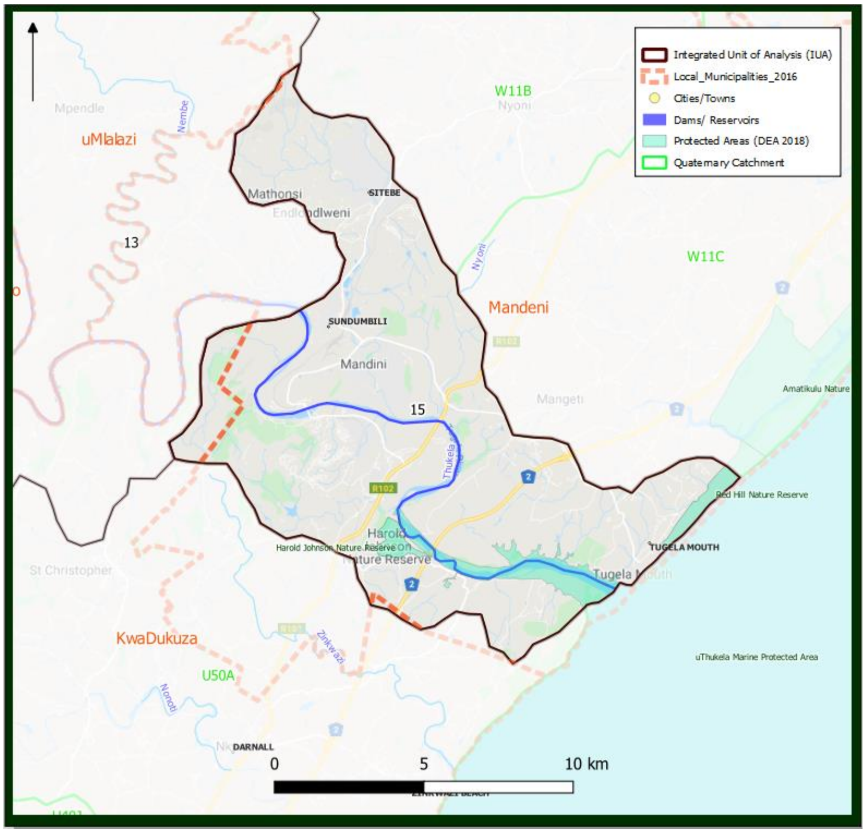


Figure 178: Overview of boundaries and features in IUA 15

Table 93: Water resources and catchments of IUA 15

IUA	Water Resource	Quaternaries
15	Thukela River, Thukela Estuary	V50D

The region falls into the Commercial Development Socio-Economic Zone with land uses transforming 50% of the landscape. Agricultural land uses represent 36%, industrial 2% and residential the remaining 8% (Figure 179).

Land Transformation (Ha, %)

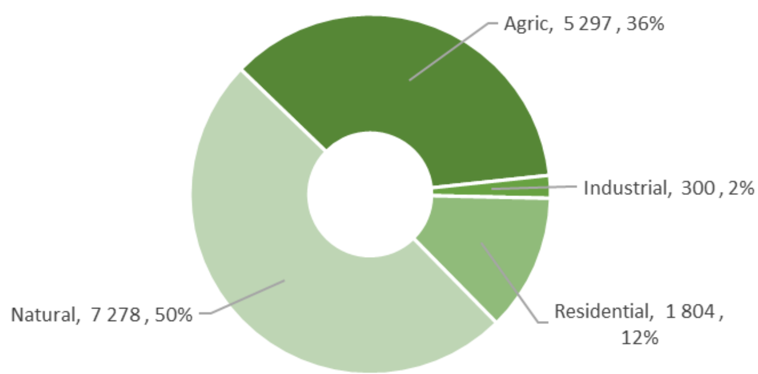


Figure 179: Land transformation per category in IUA 15 (Ha, %)

Socio Economic Profile

The population of IUA 15 is approximately 39 161 with approximately 12 818 households. 85% of the residents in IUA 15 speak IsiZulu, 2% speak English and 1% Afrikaans (Figure 180). 37% of residents completed secondary school.

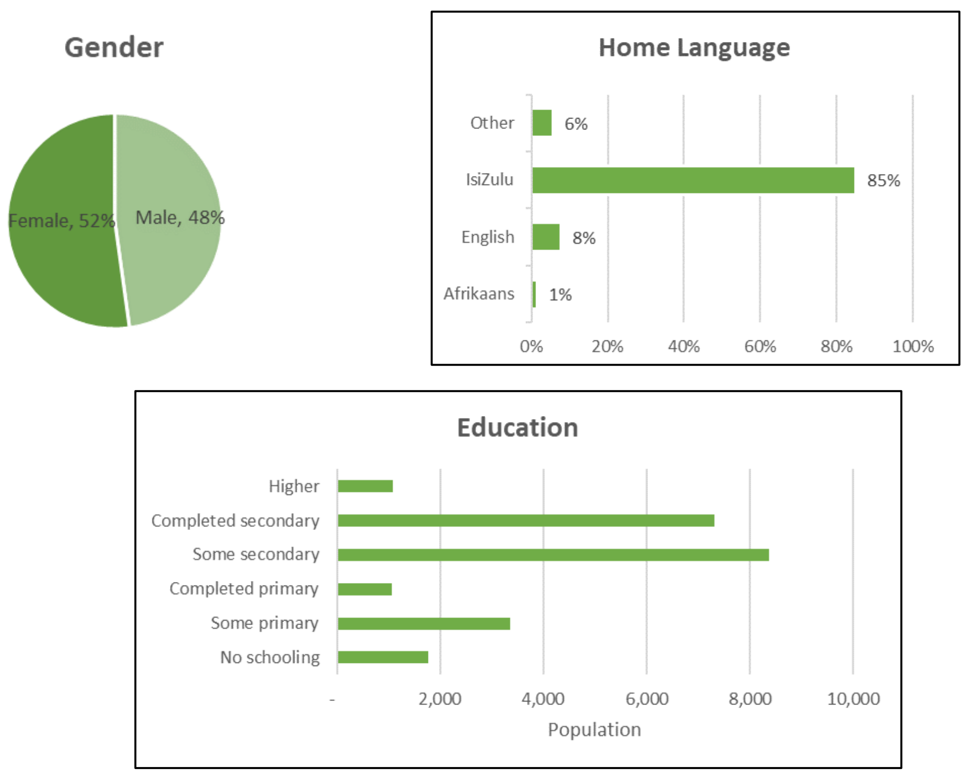


Figure 180: Demographic profile of residents in IUA 15 (StatsSA-Census 2011)

In IUA 15, 41% of economically active residents are employed with a large proportion, 80%, being employed in the formal sector (Figure 181). A relatively small, 6%, number of residents earn below minimum wage (<R4800) (Stats SA-Census 2011).

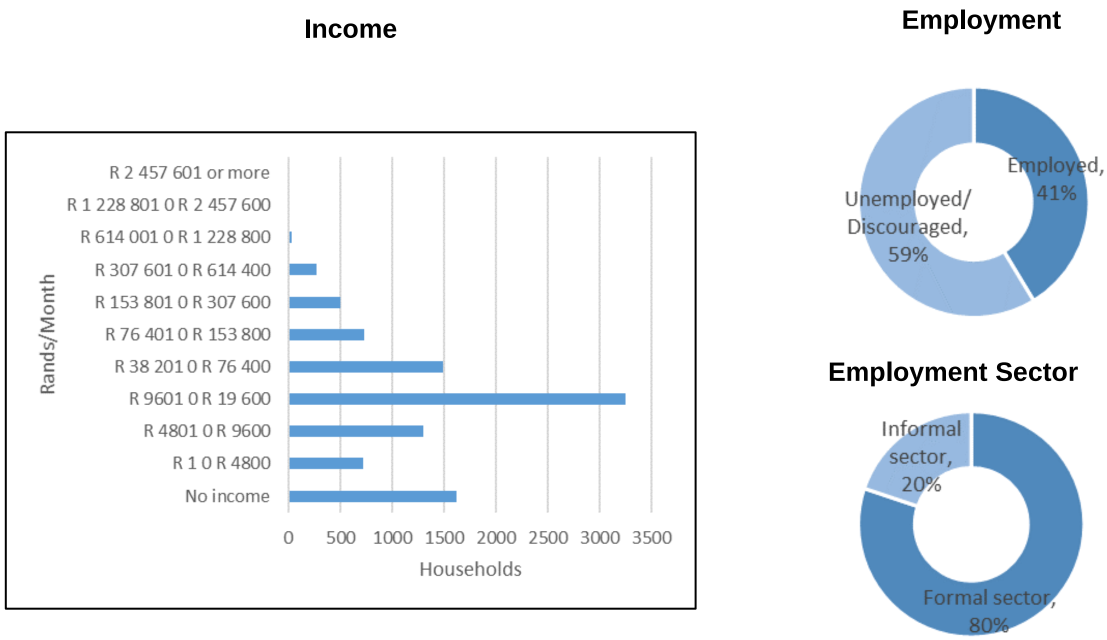


Figure 181: Economic profile of residents in IUA 15 (StatsSA-Census 2011)

Land tenure is predominantly represented by privately owned land, followed by traditional owned land and state owned land, communal land and municipal land to a lesser extent (Figure 182).

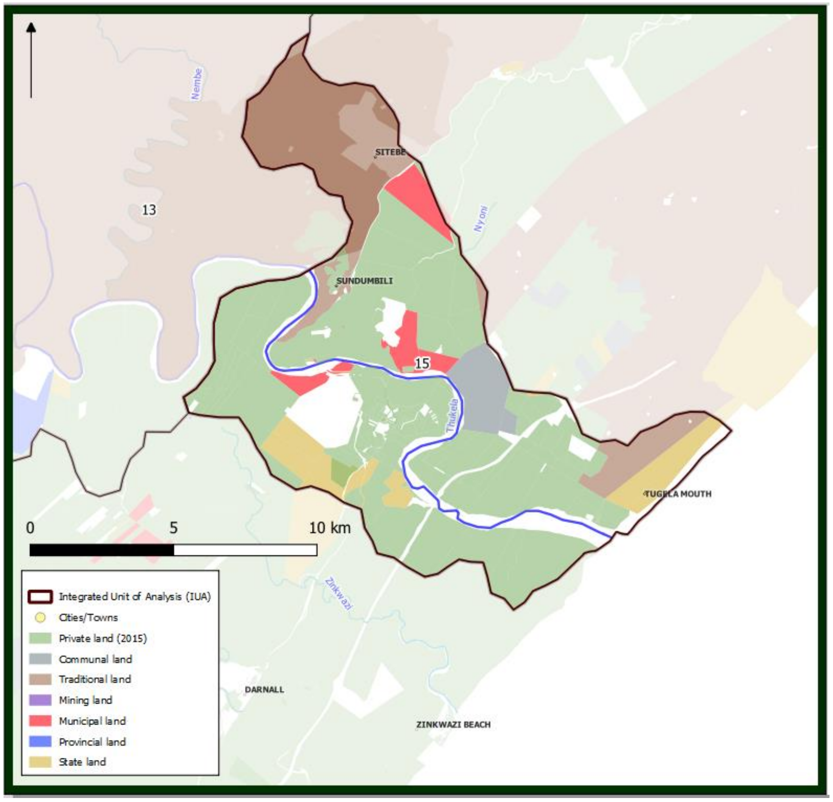


Figure 182: Land ownership within IUA 15 (DRDLR 2015)

Access to services varies greatly among residents with 33% having limited access to piped water (>50m away from their dwelling), 62% having no access to refuse disposal services, 67% with no flush toilets and only 21% having 24 hour access to the internet (Figure 183). Varied access to services indicates varied levels of wellbeing throughout the catchment. A relatively high, 12%, number of residents rely on rivers, streams and dams (impoundments) as their primary source of water and 39% dwelling in informal housing (traditional dwelling/hut/shack/squatter settlement/tent).

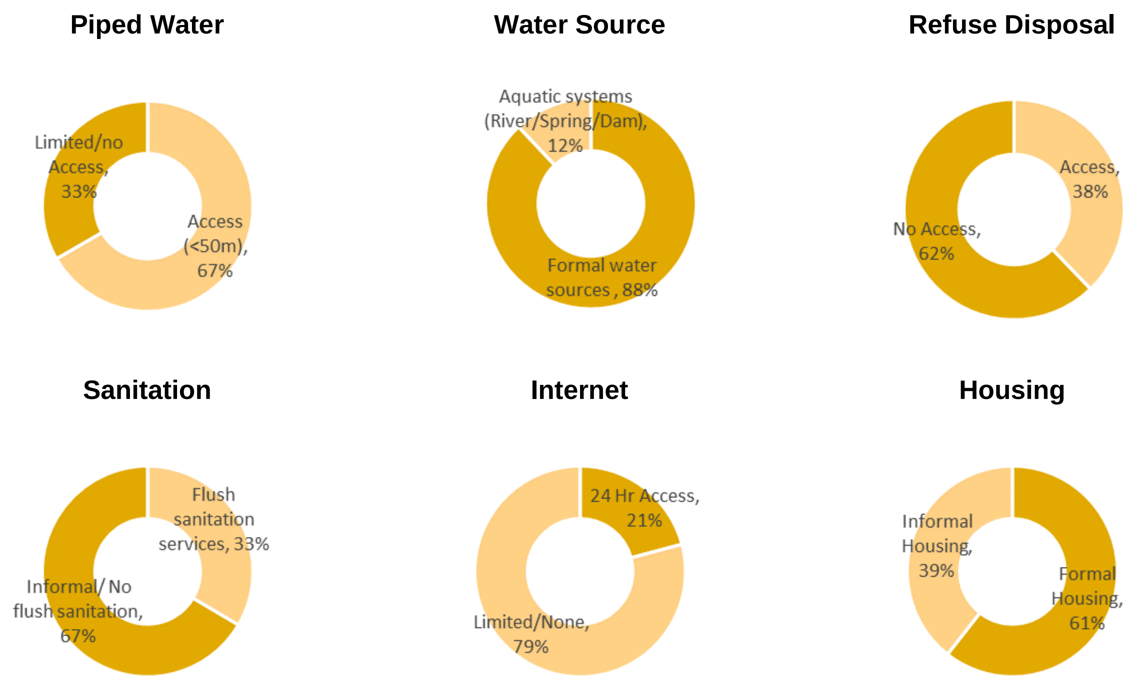


Figure 183: Access to services and indicators of wellbeing of residents in IUA 15 (StatsSA-Census 2011)

High levels of industrial manufacturing and sugarcane cultivation characterise this IUA, with residential and industrial water use being a major user of water resources (Figure 184).

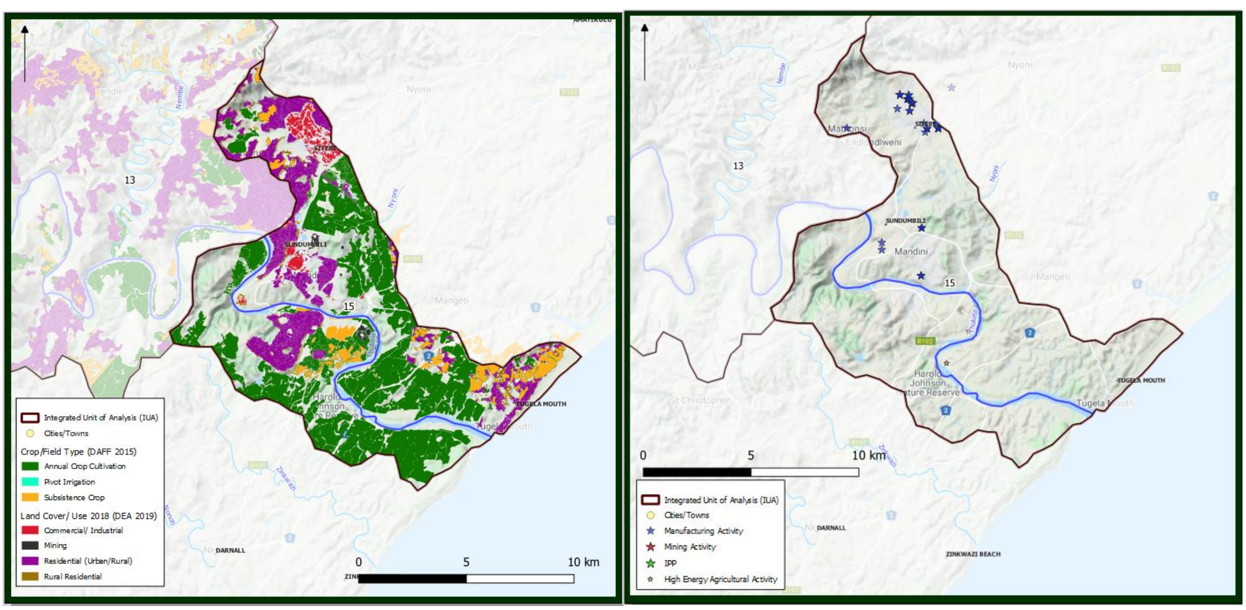
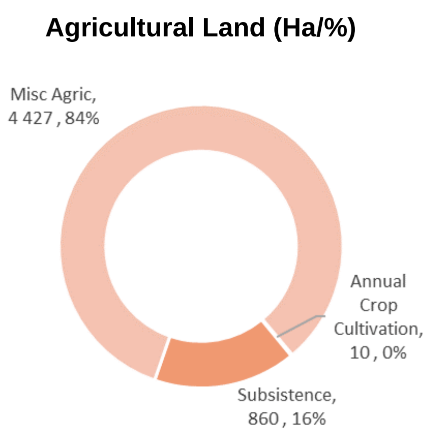


Figure 184: Land use by land cover in IUA 15 (DEA 2019/DAFF 2015) and locality of high energy industries in IUA 15

The economy of IUA 15 is driven by the industrial complex of Isithebe in the northern region. Sugarcane cultivation also plays a role in the local economy. Although accounting for a relatively small area of the total land cover (Figure 185), the industrial complex represents high value production. The industrial and household sectors are likely the highest consumers of water resources in this area.



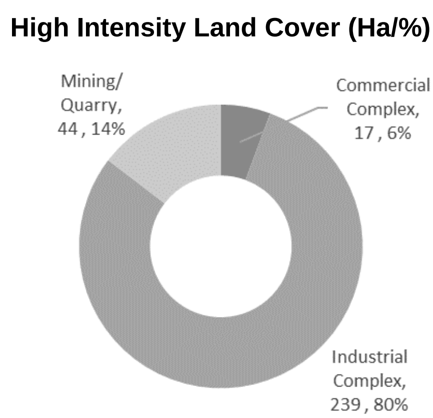


Figure 185: Classification of Agricultural Land in IUA and of High Intensity Land Cover in IUA 15.

Table 94 below provides details on the municipalities which form part of IUA 15, notes which wards fall within the IUA, and identifies the main economic drivers relevant to the IUA.

Table 94: Municipalities located within IUA 15

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)-(IUA relevant sector in bold)	Relevance to IUA 15
Mandeni LM	• Manufacturing; • Finance, insurance, real estate and business services; • Wholesale and retail trade, catering and accommodation; • **(Water Transfer)**	Wards: 2, 3, 4, 5, 7, 9, 10, 11, 12, 13, 15, 16 & 17. Mandeni claims the largest industrial estate in KZN. Manufacturing based in Isithebe: textiles, plastics, chemicals & furniture. This site has been identified as likely base for an IDZ. The large Sappi Tugela Mill is one of the prominent features. Agriculture is mostly sugarcane. Two hydroponic agri-hub projects (2500m^2 each). The Lower Thukela Bulk Water Supply Scheme (LTBWSS) transfers water from the Thukela River to the coastal pipeline supplying water to the KwaDukuza area. IDP indicates planned development of agricultural value chains, organic horticulture products, hydroponics and aquaculture as well as a focus on niche high-value agricultural products. Proposed Ndulinde Sub-Regional Water Supply Scheme (wards 5, 6, 11, 12, 16 & 7), source is Sundumbili WW; Proposed Macambini S-R WSS (wards 1, 2, 3, 8 & 9),

Local Municipality (LM)	Economic breakdown for LM (Municipal IDP's)- (IUA relevant sector in bold)	Relevance to IUA 15
		source is Sundumbili WW; Inyoni Housing Bulk Water & Sanitation Project (Ward 10)
KwaDukuza LM **Wards: 2 & 25**	• Tourism, • Sugar, • Forestry, • Agro-industrial manufacturing, • Furniture manufacturing, • Clothing, • Plastic manufacturing, and • Pulp and paper	Ward: 3 Agricultural production in the small part of this ward falling into IUA 15 is the main economic activity.

Water Resource Use

This IUA has a number of larger abstractions just upstream of the estuary, due to the development along the coast. This includes the existing Sappi and Mandeni abstractions, as well as the recently completed Lower Thukela BWSS. Releases from the upstream Spioenkop and Spring Grove Dams are envisaged in the long term to support this Lower Thukela BWSS during low flow periods.

Ecosystem Services

Situated at the outflow of the Thukela IUA 15 consists of a variety of aquatic and terrestrial ecological infrastructure which provide a range of ecosystem services to beneficiaries. The catchment is bordered by the quaternary catchment that drains the Thukela River of which forms the Thukela mouth estuary (Figure 186).

Although a variety of wetland systems are present the estuary is the predominant aquatic wetland system in the catchment (Figure 187). Utilising the presence of ecological infrastructure and ecosystem services mapping exercise was conducted utilising the presence of ecological infrastructure together with socio-economic status quo to identify likely flows of ecosystem services (Table 95).

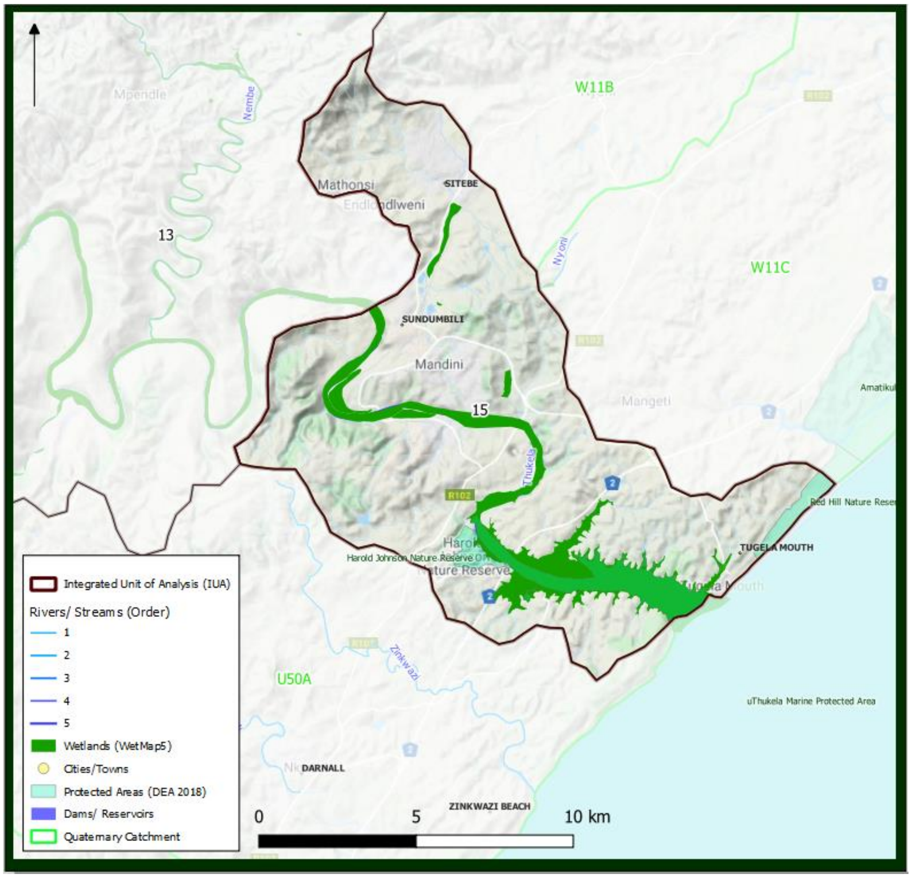


Figure 186: Locality of water resources in IUA 15

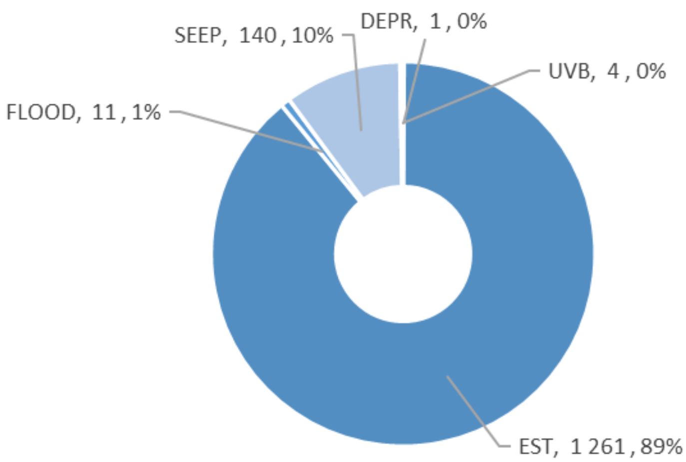


Figure 187: Wetland extent and type in IUA 15 (UVB: Unchanneled Valley Bottom; CVB: Channelled Valley Bottom; FLOOD: Floodplain; RIVER: Riparian zone; DEPR: Depression; SEEP: Seepage)

Table 95: Key ecosystem services with corresponding ecological infrastructure, beneficiaries and sector in IUA 15 (includes services with relatively high benefits for the catchment)

Key Ecosystem Service		Key Ecological Infrastructure	General Beneficiaries	Benefit to IUA 15	Sector (12 Sectors)
Provisioning	**Food**	Estuary; Wetlands, Rivers	Significant to rural communities present within catchment	Lower	
	Fresh Water	Rivers	Major significance to activities within the Industrial Development Zone situated at Mandini; Scattered subsistence communities and commercial agriculture (sugar cane);	Higher	**Manufacturing; Agriculture; Tourism Households**
	Raw materials	Estuary; Wetlands, Rivers	Significant to rural communities present within catchment	Lower	
	Medicinal resources	Estuary; Wetlands, Rivers	Significant to rural communities present within catchment	Lower	
Regulating	**Climate regulation**	Limited carbon sequestering wetlands;	Minor significance to global beneficiaries;	Lower	
	Water quantity regulation	Low wetland extent; Thukela Mouth estuary	Significant to rural communities	Lower	
	Water purification & waste management	Low wetland extent; Thukela Mouth estuary	Significant to rural communities	Lower	
	Erosion control/ Soil stability	Low wetland extent; Thukela Mouth estuary	Significant to commercial and subsistence agricultural activities	Lower	
	Biological control	Thukela Mouth Estuary	Major significance to all beneficiaries of provisioning services from the Thukela Mouth Estuary. Estuaries play a vital role in regulation and support of biological systems and therefore represent highly productive systems. Support of biological diversity to greater systems.	Higher	**Households; Society**
Cultural	**Landscape & amenity values**	Thukela Mouth Estuary; Ocean and coastline; Marine protected areas	Major significance: Tourism and real estate industry and urban and rural communities through cultural values	Higher	**Tourism; Households; Society; Finance, Real Estate and Business Services**
	Ecotourism & recreation				
	Educational values and inspirational services				

River

Water Quality

Water quality in the lowest reach of the Thukela River upstream of the estuary in V50D is impacted, and compliance indicates unacceptable levels of electrical conductivity and orthophosphate. This is attributable to the impacts from the town of Mandini, Isithebe Industrial complex, the discharges from the paper mill and changes in river flow due to bulk water abstraction. The river reach is identified as a water quality hotspot area due to the WWTW discharges from Sundumbili and Mandini and industrial and urban impacts.

Monitoring Point ID	Drainage Region	Ca	Cl	DMS (TDS)	EC	F	K	Mg	Na	NH4-N	NO3-N	pH	PO4-P	SO4
		(mg/l)	(mg/l)	(mg/l)	(mS/m)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(pH units)	(mg/l)	(mg/l)
		95	95	95	95	95	95	95	95	95	50	95	50	95
IUA15 Thukela Estuary and upstream Tugela reach														
102779	V50D	34.6	23.1	279.7	35.4	0.6	3.0	12.6	27.4	0.20	0.17	8.4	0.01	28.9
188472	V50D				204.4						1.14	7.9	1.20	
188473	V50D				28.6						0.34	8.4	0.20	
188475	V50D				221.6						1.20	8.3	1.50	
194574	V50D				1087.0					0.13	0.37	8.0	0.10	
194575	V50D				531.8					0.43	0.10	7.8	0.10	
194576	V50D				714.3					0.05	0.78	8.5	0.10	
188474	V50D				111.9					10.86	2.80	8.0	2.95	
1000003827	V50D	75.2			140.8			12.4	283.5	0.79	0.10	8.5	0.20	
188471	V50D				263.0					1.21	1.45	8.8	4.20	

Ecological information and PES

The lowest reach of the Thukela River in upper portion of quaternary V50D is in a moderately modified condition. The lower Thukela River upstream of the Thukela Estuary (V50D), includes the town of Mandini, the Sappi Paper Mill as well as the Umgeni Water Bulk Water Transfer, all of which drive the C PES category in this reach. The IUA includes 2 EWR sites, EWR17 and 18 as part of the intermediate Reserve determination undertaken.

Wetlands

IUA 15 is located along the Indian Ocean Coast in the lower reaches of the Thukela Catchment within the Indian Ocean Coastal Belt Biome and Bioregion. Wetlands cover only 152 ha of IUA 15, or 1.0% of the land surface, which is significantly less than the average wetland coverage of 4.7% across the entire Thukela Catchment. However, the Thukela Estuary also occurs within this IUA.

Based on the National Wetland Map 5 (Van Deventer *et al*., 2018), the most extensive wetlands within IUA 15 are again Seep wetlands, which make up 92% of the mapped wetland area and cover 140 ha. Floodplain wetlands are the next most extensive wetland type at 7.3%. The least common wetlands mapped within the IUA are Depression wetlands which cover only 1 hectare and make up less than 1% of the wetland area within the IUA. The National Wetland Map 5 (Van Deventer et al., 2018) identified no Channelled or Unchannelled Valley Bottom wetland habitat within this IUA.

Priority Systems in IUA 15

No Priority Wetlands have been identified in IUA 15 at this stage.

Baseline Ecological State

Based on the wetland condition data taken from the National Wetland Map 5 (Van Deventer *et al*., 2018) and summarised in Table 31 and Table 96, 63.7% of wetlands within IUA 15 are considered to be Largely to Critically Modified (wetland condition D/E/F), with more than 36% of wetlands considered to be in a Natural to Largely Natural condition (wetland condition A/B).

Table 96: Wetland condition summary for IUA 15 showing wetland condition for Depressions, Floodplains, Seeps, Channelled and Unchannelled Valley Bottom systems (source: GIS coverage of Van Deventer et al., 2018). Highlights show in which condition category the bulk of wetland habitat was recorded (Green for A/B, yellow for C, and orange for D/E/F). Empty cells denote 0 values.

IUA 15	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
Wetland Extent (ha)	53		87							1		10	1		
%	38.0		**62.0**							8.8		**91.2**	**100.0**		

Threats/Impacts

IUA 15 includes the commercial centres of Sundumbili and Mandini. Water quality is a known concern from these urban areas and associated industrial centres. Commercial sugar cane production has resulted in extensive transformation and draining of wetland habitat.

Groundwater

The groundwater characteristics in IUA 15 are as follows:

- Geology: Karoo Supergroup:
  - Coastal Cenozoic Deposits: (Berea red sands and arenite)
  - Pietermaritzburg (shale)
  - Vryheid (arenite, coal and shale)
  - Dwyka (arenite, tillite, mudstone and shale)
  - Natal (arenite and shale)
- Dolerite intrusions: Limited.
- Regional features present related to pre-Karoo tectonic events.
- Borehole yield class: Insignificant (0.1 to 0.5 $\ell \cdot s^{-1}$);
- Recharge averaging: ~15 $mm \cdot a^{-1}$.
- Groundwater quality ($mS \cdot m^{-1}$): 70-300.
- Groundwater Reserve status (allocations): Critical risk (SI = ~100%). Groundwater allocation is <0.3 $Mm^3 \cdot a^{-1}$. Reserve as % of recharge = 64%.

Estuary

Boundary of Estuary

The boundaries of the Thukela Estuary used during the Estuarine Flow Requirements study (DWAF, 2004) were defined as follows (Gauss Projection, Clarke 1880 Spheroid) (Figure 188):

- Downstream boundary: Estuary mouth (31°29'56"E, 29°13'24"S)
- Lateral boundaries: Five metre contour from MSL along banks
- Upstream boundary: Approximately 6 km from the mouth

However, the Estuarine Functional Zone (EFZ) of the estuary as described in the National Biodiversity Assessment 2018 (van Niekerk *et al.* 2019) now recognises the upper boundary as being 8.7 km from the estuary mouth. This is the same boundary used in the uThukela MPA in terms of Section 22A of the National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003) at GPS point 29°11'59.1"S, 31°25'27.1"E (which corresponds with -29.199736, 31.424198 as defined in the Government Gazette No. 42478, 2019).

Functional Zone

The Estuary Functional Zone boundaries are described above (Boundary of estuary) and are illustrated in Figure 188 as described in the National Biodiversity Assessment 2018 (van Niekerk et al. 2019).

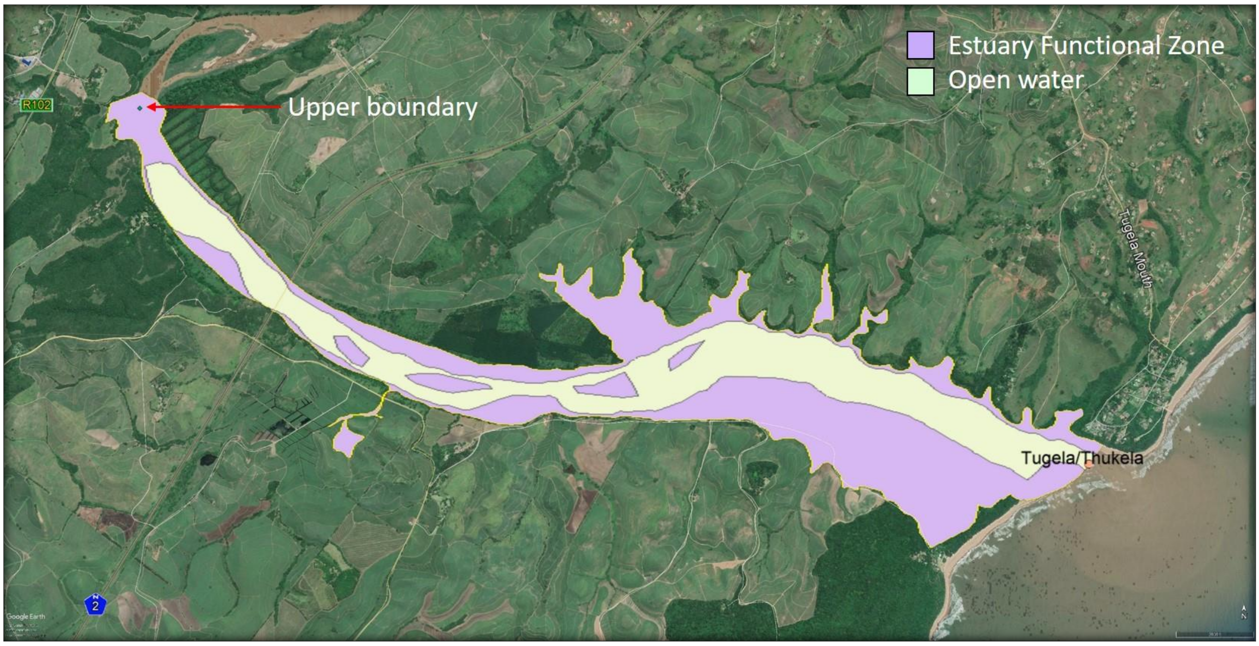


Figure 188: Google Earth image of the Thukela Estuary Functional Zone (EFZ) based on the National Biodiversity Assessment 2018 (van Niekerk et al. 2019)

Estuary Node

There has been long-term monitoring at the old N2 Bridge (John Ross Bridge; 29°10’15.12”S, 31°23’40.27”E) and the Mandini monitoring station (V5H002); however, this is slightly upstream of the confluence with the polluted eMandeni stream. Measurements within the EFZ at Havelock Farm (at new N2 bridge; 29°12’46.52”S, 31°26’08.35”E) would be most suitable.

Estuary Present Ecological State

An intermediate level EWR study was conducted during the period 2001-2004 and Thukela Estuarine Flow Requirements Report (Volume 1) published in 2004 (DWAF, 2004). Based on available information and a once off study during a low flow period in August 2001, the preliminary Reserve assessment indicated that the overall estuarine health score was 70 (Table 83), which translates into a PES of C (moderately modified) (Table 84). The estuarine health score was determined using the Estuarine Health Index that takes into consideration the abiotic drivers (hydrology, hydrodynamics and mouth condition, water quality, and physical habitat alteration) and biotic responses (microalgae, macrophytes, invertebrates, fish, and birds).

Table 97: Estuary Health Index scores allocated to the Thukela Estuary (present state) based on the 2001-2004 Estuarine Flow Requirements study (DWAF, 2004)

Variable	Weight	Score	Weighted score
Hydrology	25	87	22
Hydrodynamics and mouth condition	25	80	20
Water quality	25	54	14
Physical habitat alteration	25	80	20
Habitat health score			**75**
Microalgae	20	65	13
Macrophytes	20	60	12
Invertebrates	20	60	12
Fish	20	70	14
Birds	20	70	14
Biotic health score			**65**
ESTUARINE HEALTH SCORE			**70**

Table 98: Associated Present Ecological State and general descriptions with Estuarine Health Index (EHI) scores

EHI score	Present Ecological State	General description
91 – 100	A	Unmodified, natural
76 – 90	B	Largely natural with few modifications
61 – 75	C	Moderately modified
41 – 60	D	Largely modified
21 – 40	E	Highly degraded
0 – 20	F	Extremely degraded

The Thukela Estuary was allocated an Estuary Importance score of 76, which falls within the 60 – 80 range, indicating that the estuary is important. Of the five criteria contributing to the importance rating, functional importance was allocated a score of 100 because of the movement corridor provided by the estuary for river invertebrates that breed in the marine environment and the roosting area provided for marine or coastal birds. At the time of the Estuarine Freshwater Requirements study, the Ecological Reserve Category, based on the estuary's PES, was determined to be a PES + 1; i.e. a Category B. If it was not possible to achieve this state then a best attainable state of a Category C would be the minimum requirement.

10 HOTSPOT IDENTIFICATION

A hotspot represents a river reach with a high ecological importance and/ or sensitivity which 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 hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered or to protect ecosystems. They usually represent areas that are already stressed or will be stressed in future (Louw and Huggins, 2007; Louw *et al*., 2010).

The hotspot identification therefore provides an indication of where new EWR sites should be selected, the level of EWR assessment required at each biophysical node, where flow requirements would be necessary and where river nodes would be required for scenario development and evaluation. The outcome is then to ensure that these identified hotspot areas/ reaches are addressed by information from existing EWRs, rapid Reserves or biological surveys in terms of flow, quality, biota and habitat requirements and to identify the no-flow impacts.

The process of hotspot identification in the Thukela comprised the evaluation of resource stress and ecological condition, and water use stress, which included an assessment of:

- Integrated Ecological Importance (IEI) – considering PES, Ecological Importance (EI), Ecological Sensitivity (ES), and Ecological Importance and Sensitivity (EIS).
- Integrated Water Use Index (IWUI) – Water use (quantity and quality) was assessed by assigning a score to a river reach dependent on its impact scoring relative to the PES, to determine resource stress.

The IEI and IWUI were determined using the 2013 PES/EI/ES data as the basis for the assessment of the 285 sub-quaternary reaches in the Thukela Catchment.

EI and ES of sub-quaternary reaches were assessed to obtain an indication of its sensitivity to environmental modification within the context of PES. The EIS was scored by selecting the highest of EI or ES per sub-quaternary catchment. Ecological scoring was rated on a scale of 0 to 4 using the matrix in Figure 190 and Table 99. This matrix was used when undertaking the Vaal Comprehensive Reserve determination. Based on the matrix an integrated ecological importance score was determined per sub-quaternary reach.

Table 99: Scoring applied to rate ecological importance

Ecological Score	EI/ES	PES
0	Very low	A
1	Low	B
2	Moderate	C
3	High	D
4	Very high	E/F

The IWUI was derived by assigning a qualitative score to a reach relative to quantity and quality use. Quantity and quality water use was individually scored, rated as 0 to 5 based on the modification to the river reach in respect of the impact to its PES (Table 100) and considering the status quo undertaken as part of this assessment. The IWUI (resource stress) score was then determined selecting the highest of the two scores.

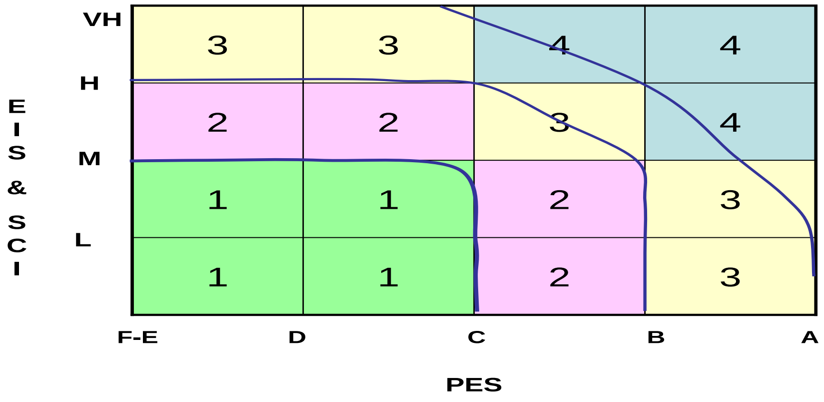


Figure 189: Matrix to applied to derive ecological score

Table 100: Scoring applied to rate water use

Impact Score	Impact	PES rating/Status
0	None	None
1	Low	Small
2	Moderate	Moderate
3	High	Large
4/5	Very high	Serious/Critical

The IEI and IWUI scores for the sub-quaternary reaches were then evaluated to identify the hotspots in the Thukela catchment and the level of EWR assessment required by applying the matrix indicated in Figure 191. Table 101 presents the identified hotspots with only the hotspots with an evaluation IWUI and IEI scoring of 3 or 4 indicated.

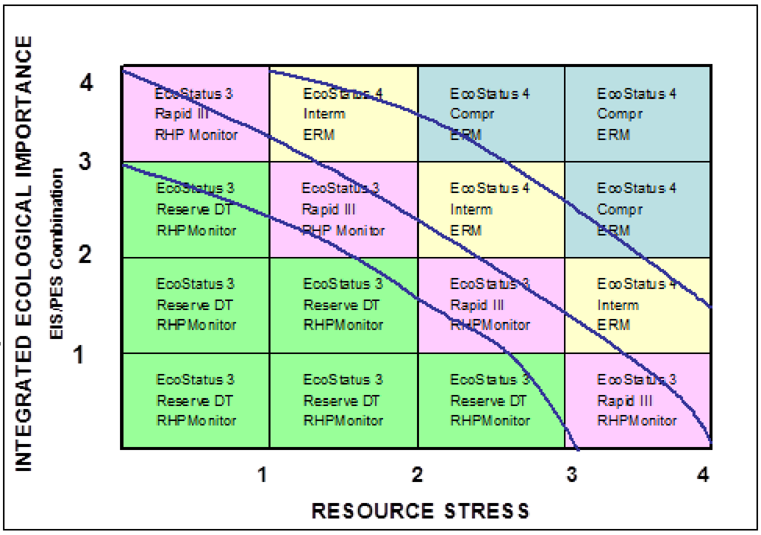


Figure 190: Matrix applied to determine level of EWR assessment required

Table 101: Hotspots

Thukela, Little Thukela, Klip					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI (0-5)	IEI (0-4)	Level
V11A-03277	V11A	Thukela	3	4	Intermediate
V11B-03410	V11B	Sithene	1	3	Biological
V11B-03470	V11B	Thonyelana-mpumalanga	1	3	Biological
V11C-03181	V11C	Majaneni	4	3	Comprehensive
V11C-03196	V11C	Thukela	1	3	Biological
V11C-03203	V11C	Putterill	1	4	Rapid 3
V11C-03261	V11C	Thukela	1	3	Biological
V11C-03285	V11C	Khombe	2	4	Intermediate
V11D-03170	V11D	Mpandweni	1	4	Rapid 3
V11E-03400	V11E	Mnweni	4	3	Comprehensive
V11E-03446	V11E	Nxwaye	4	4	Comprehensive
V11F-03182	V11F	Sandspruit	3	3	Intermediate
V11G-03572	V11G	Mlambonja	2	3	Biological
V11G-03576	V11G	Mlambonja	1	4	Rapid 3
V11G-03579	V11G	Mlambonja	1	4	Rapid 3
V11G-03582	V11G	Mhlwazini	1	3	Biological
V11G-03635	V11G	Un-named tributary	1	4	Rapid 3
V11H-03422	V11H	Mlambonja	2	3	Rapid 3
V11J-03381	V11J	Thukela	3	3	Intermediate
V11K-03106	V11K	Geluksburgspruit	1	4	Rapid 3
V11K-03119	V11K	Njongola	1	3	Biological
V11L-03141	V11L	Venterspruit	3	2	Rapid 3
V11L-03301	V11L	Thukela	3	3	Intermediate
V12A-02922	V12A	Braamhoekspruit	2	4	Intermediate
V12A-02962	V12A	Klip	0	4	Biological
V12A-03003	V12A	Klip	1	4	Rapid 3
V12B-02860	V12B	Mhlwane	2	3	Rapid 3
V12B-02895	V12B	Tatana	2	3	Rapid 3
V12B-02932	V12B	Ngogo	2	4	Intermediate
V12B-02972	V12B	Ngogo	2	3	Rapid 3
V12B-02990	V12B	Ngogo	3	3	Rapid 3
V12E-03122	V12E	Sand	1	3	Biological
V12E-03171	V12E	Un-named tributary	2	3	Rapid 3
V12F-03115	V12F	Sand	1	3	Biological
V12F-03209	V12F	Dewdrop Stream	3	2	Rapid 3
V12F-03212	V12F	Un-named tributary	1	4	Rapid 3
V12F-03215	V12F	Middelspruit	1	3	Biological
V12G-03029	V12G	Ndakane	1	3	Biological
V12G-03125	V12G	Klip	3	2	Rapid 3
V12G-03256	V12G	Klip	3	2	Rapid 3
V13B-03497	V13B	Sterkspruit	3	2	Rapid 3
V13B-03689	V13B	Sterkspruit	1	3	Biological
V13C-03495	V13C	Little Thukela	3	3	Rapid 3
V13D-03379	V13D	Situlwane	2	3	Rapid 3
V13D-03464	V13D	Little Thukela	3	3	Intermediate
V13E-03362	V13E	Little Thukela	3	2	Rapid 3
V14B-03296	V14B	Thukela	2	3	Rapid 3
V14D-03374	V14D	Bloukrans	1	3	Biological
V14D-03439	V14D	Nyandu	1	4	Rapid 3
V14D-03481	V14D	Mtontwanes	1	3	Biological
V14D-03488	V14D	Nyandu	1	4	Rapid 3
V14E-03233	V14E	Thukela	2	4	Intermediate
V14E-03352	V14E	Thukela	2	3	Rapid 3

Mooi					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI (0-5)	IEI (0-4)	Level
V20A-04023	V20A	Mooi	4	2	Intermediate
V20B-04034	V20B	Klein-Mooi	3	2	Rapid 3
V20C-03919	V20C	Nsonge	4	2	Intermediate

Mooi					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI (0-5)	IEI (0-4)	Level
V20E-03742	V20E	Mooi	3	3	Intermediate
V20E-03833	V20E	Katspruit	3	2	Rapid 3
V20E-03849	V20E	Mooi	3	2	Rapid 3
V20E-03881	V20E	Joubertsvlei se Loop	4	3	Comprehensive
V20E-03884	V20E	Mooi	3	3	Intermediate
V20F-03931	V20F	Mnyamvubu	3	3	Intermediate
V20F-03945	V20F	Mnyamvubu	1	4	Rapid 3
V20F-03952	V20F	Mpatheni	4	3	Comprehensive
V20F-03955	V20F	Rietvleispruit	2	3	Rapid 3
V20G-03780	V20G	Mooi	2	3	Rapid 3
V20G-03830	V20G	Mnyamvubu	2	3	Rapid 3
V20G-03850	V20G	Nyambathi	2	3	Rapid 3
V20G-03853	V20G	Mnyamvubu	3	2	Biological
V20H-03500	V20H	Mooi	3	2	Rapid 3
V20H-03584	V20H	Umdumbeni	1	3	Biological
V20H-03696	V20H	Mooi	2	3	Rapid 3
V20H-03716	V20H	Mooi	3	3	Intermediate
V20H-03750	V20H	Mhlopheni	3	2	Rapid 3
V20H-03785	V20H	Mbalane	1	3	Biological

Buffalo, Bloed, Ngagane					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI	IEI	Level
V31A-02254	V31A	Thaka	2	4	Intermediate
V31A-02319	V31A	Slang	1	4	Rapid 3
V31B-02277	V31B	Buffels	2	3	Rapid 3
V31B-02290	V31B	Slang	3	3	Intermediate
V31B-02341	V31B	Buffels	2	3	Rapid 3
V31C-02354	V31C	Harte	1	4	Rapid 3
V31C-02417	V31C	Ngogo	3	3	Intermediate
V31C-02448	V31C	Ngogo	2	3	Rapid 3
V31D-02370	V31D	Buffels	3	2	Rapid 3
V31D-02387	V31D	Doringspruit	4	2	Intermediate
V31D-02492	V31D	Buffels	3	3	Intermediate
V31E-02647	V31E	Klipspruit	3	3	Intermediate
V31E-02653	V31E	Un-named tributary	1	4	Rapid 3
V31E-02663	V31E	Ngagane	2	3	Rapid 3
V31E-02703	V31E	Ngagane	1	4	Rapid 3
V31E-02708	V31E	Ngagane	2	4	Intermediate
V31E-02730	V31E	Mahlomyane	1	4	Rapid 3
V31E-02731	V31E	Kalbas	3	3	Intermediate
V31E-02732	V31E	Fouriespruit	2	3	Rapid 3
V31E-02733	V31E	Manzamnyama	2	3	Rapid 3
V31E-02747	V31E	Un-named tributary	1	4	Rapid 3
V31F-02600	V31F	Horn	4	3	Intermediate
V31G-02618	V31G	Ngagane	4	2	Intermediate
V31J-02487	V31J	Ncandu	3	3	Intermediate
V31K-02516	V31K	iNgagane	3	2	Rapid 3
V31K-02541	V31K	iNgagane	4	2	Intermediate
V32A-02398	V32A	Dorpspruit	3	3	Intermediate
V32B-02414	V32B	Kweekspruit	1	3	Biological
V32B-02457	V32B	Buffels	2	3	Rapid 3
V32B-02499	V32B	Dorpspruit	2	3	Rapid 3
V32B-02515	V32B	Buffels	2	3	Rapid 3
V32C-02533	V32C	Buffels	2	3	Rapid 3
V32D-02575	V32D	Buffels	2	3	Rapid 3
V32D-02592	V32D	Eerstelingspruit	1	3	Biological
V32E-02660	V32E	Mzinyashana	3	2	Rapid 3
V32E-02750	V32E	Ngobiya	3	2	Rapid 3
V32E-02785	V32E	Sandspruit	1	3	Biological
V32E-02810	V32E	Sterkstroom	3	2	Rapid 3

Buffalo, Bloed, Ngagane					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI	IEI	Level
V32E-02831	V32E	Sandspruit	2	3	Rapid 3
V32E-02877	V32E	Sandspruit	3	2	Rapid 3
V32F-02707	V32F	Buffels	2	3	Rapid 3
V32G-02465	V32G	Bloed	3	3	Intermediate
V32H-02834	V32H	Bloed	3	2	Rapid 3
V33A-02899	V33A	Buffels	3	2	Rapid 3
V33B-03024	V33B	Buffels	3	3	Intermediate
V33B-03062	V33B	Sibindi	1	3	Biological
V33B-03090	V33B	Buffels	3	3	Intermediate
V33C-03114	V33C	Buffels	3	3	Intermediate
V33C-03137	V33C	Mangeni	1	3	Biological
V33C-03211	V33C	Buffels	2	3	Rapid 3
V33C-03213	V33C	Gubazi	1	3	Biological
V33D-03147	V33D	Mazabeko	1	3	Biological
V33D-03206	V33D	Buffels	2	3	Rapid 3
V33D-03260	V33D	Buffels	2	3	Rapid 3

Lower Thukela					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI	IEI	Level
V40A-03318	V40A	Mfongosi	1	4	Rapid 3
V40B-03370	V40B	Manyane	1	4	Rapid 3
V40B-03429	V40B	Thukela	2	3	Rapid 3
V40B-03438	V40B	Thukela	2	3	Rapid 3
V40B-03505	V40B	Ngcaza	1	3	Biological
V40C-03099	V40C	Nsuze	1	3	Biological
V40C-03159	V40C	Nsuze	1	4	Rapid 3
V40C-03253	V40C	Ndikwe	1	3	Biological
V40D-03249	V40D	Nsuze	1	4	Rapid 3
V40E-03457	V40E	Thukela	3	3	Intermediate
V40E-03556	V40E	Thukela	3	3	Intermediate

Lower Thukela					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI	IEI	Level
V50A-03552	V50A	Mamba	1	3	Biological
V50A-03602	V50A	Thukela	3	3	Intermediate
V50A-03616	V50A	Thukela	3	3	Intermediate
V50A-03680	V50A	Mambulu	1	3	Biological
V50A-03707	V50A	Thukela	3	3	Intermediate
V50B-03786	V50B	Thukela	3	3	Intermediate
V50C-03788	V50C	Nembe	1	4	Rapid 3
V50C-03860	V50C	Thukela	3	3	Intermediate
V50C-03882	V50C	Thukela	3	3	Intermediate
V50C-03920	V50C	Otimati	0	4	Biological
V50D-03903	V50D	Thukela	4	2	Intermediate

Sundays					
Sub-quat	Quat	River	Resource stress	Ecological	IWUI+IEI
			IWUI (0-5)	IEI (0-4)	Level
V60B-02826	V60B	Sundays	3	2	Rapid 3
V60B-02883	V60B	Nkunzi	4	2	Intermediate
V60D-02827	V60D	Manzimnyama	3	2	Rapid 3
V60D-02868	V60D	Wasbank	3	2	Rapid 3
V60D-02898	V60D	Wasbank	2	3	Rapid 3

Sundays					
Sub-quat	**Quat**	**River**	**Resource stress**	**Ecological**	**IWUI+IEI**
			IWUI (0-5)	**IEI (0-4)**	**Level**
V60D-02920	V60D	Biggersgatspruit	3	2	Rapid 3
V60E-02955	V60E	Wasbank	3	3	Rapid 3
V60E-03013	V60E	eTholeni	3	1	Biological
V60E-03016	V60E	Wasbank	1	3	Biological
V60E-03025	V60E	Wasbank	3	2	Rapid 3
V60E-03077	V60E	eTholeni	3	2	Rapid 3
V60E-03134	V60E	Wasbank	3	2	Rapid 3
V60E-03139	V60E	Kalkoenspruit	3	2	Rapid 3
V60F-03177	V60F	Nhlanyanga	1	3	Biological
V60G-03247	V60G	Thukela	1	3	Biological
V60G-03348	V60G	Thukela	1	3	Biological
V60G-03372	V60G	Thukela	1	3	Biological
V60G-03425	V60G	iSikhehlenga	1	3	Biological
V60H-03431	V60H	Thukela	3	2	Rapid 3

Bushmans					
Sub-quat	**Quat**	**River**	**Resource stress**	**Ecological**	**IWUI+IEI**
			IWUI	**IEI**	**Level**
V70A-03876	V70A	Bushmans	1	3	Biological
V70A-03925	V70A	Mtshezana	0	4	Biological
V70A-03966	V70A	Bushmans	0	4	Biological
V70B-03927	V70B	Ncibidwana	1	3	Biological
V70C-03745	V70C	Bushmans	3	2	Rapid 3
V70C-03822	V70C	Mtshezana	1	4	Biological
V70C-03900	V70C	Bushmans	1	3	Biological
V70D-03699	V70D	Klein Bushmans	4	2	Intermediate
V70F-03548	V70F	Bushmans	3	2	Rapid 3
V70G-03440	V70G	Bushmans	3	3	Rapid 3
V70G-03543	V70G	iBusone	1	3	Biological
V70G-03565	V70G	Umngwenya	1	3	Biological
V70G-03679	V70G	uMngwenya	1	3	Biological
V70G-03688	V70G	Kobe	1	3	Biological

11 BIOPHYSICAL NODES

The IUAs are broad scale units defined by socio-economic zones and catchment boundaries within which ecological information is provided at a finer scale of resolution (DWAF, 2007b). IUAs are further delineated into resource units to account for the finer scale resolution of ecological information and localised catchment resource quality aspects. Each resource unit within an IUA is represented by a biophysical node. Biophysical nodes are therefore nested within the IUAs (DWAF, 2007b).

Biophysical nodes represent flow requirements and ecological state relevant for the resource unit 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. The nodes are used to assess the response of upstream water resources to changes in water quality, quantity and timing (DWA, 2007). Biophysical nodes should be located at interactions between ecosystems and at the end points of eco-system reaches to account for interactions. Allocation nodes should be located at the downstream edge of a reach of interest, as required for modelling and to allow for meaningful trade-offs.

The establishment of biophysical nodes is guided by a number of considerations and characteristics. The key characteristics/criteria for the significant water resources are:

- Biophysical and eco-regional characteristics;
- Broad-scale hydrological and geomorphological characters;
- Tributaries;
- Ecological Importance and Sensitivity categories of water resources;
- Present ecological state;
- Water infrastructure;
- Location of Ecological Water Requirement (EWR) sites and ecological information; and
- Water management, planning and allocation information.

11.1 Identification of nodes

Based on the IUAs delineated for the Thukela catchment and preliminary resource units identified, biophysical nodes are based on the criteria and considerations above to account for ecological status and protection, flow requirements, water quality hotspots and ecosystem interactions.

For the Thukela catchment 62 resource units have been delineated and thus include 62 biophysical nodes (Table 102):

- 59 river nodes,
- 2 wetland nodes (V31A and V32G), and
- a node to cater for the requirements of the Thukela Estuary.

Based on the hotspot evaluation undertaken, the level of EWR assessment required for each of the identified 59 river biophysical nodes have been determined as shown in Table 102. It can be seen from the table that for some of these resource units, no EWR assessment level is required. This is due to either no water resource stress and/ or low EI or ES. Thus, these resource units will be included as part of the system configuration without any specification of flow requirements.

For all major dams (water infrastructure), no biophysical nodes have been included in these reaches. Those areas where water quality impacts exist and where management and planning information indicated an area of interest, nodes have been identified. Typically, areas or water resources with a high EIS or high conservation value has required the inclusion of a biophysical node on the downstream reach (e.g. those in IUA14). The nodes proposed will be confirmed and finalised during the 'quantification of the EWRs' as the next task in the process.

Table 102: Numbers of biophysical nodes identified per IUA indicating level of EWR Assessment

IUA	No. of Biophysical Nodes	Proposed Level of EWR Assessment				Other
		No assessment	Desktop biological	Rapid	Inter-mediate	Wetland, Estuary#
1 – Upper Buffalo	5	1	2	1		1
2 – Ngagane River	4			2	2	
3 – Middle Buffalo	3	1			2	1
4 – Lower Buffalo	2	1			1	1
5 – Blood River	2		1			
6 - Sundays	4			1	3	
7 – Upper Mooi	4	1		1	2	1
8 - Mooi	4	1		1	2	1
9 – Middle/Lower Bushmans	3	1			2	1
10 - Upper Thukela	10	6		2	2	6
11 - Klip	3	2		1		2
12 – Middle Thukela	4	2			2	2
13 – Lower Thukela	5	2		1	2	2
14 - Escarpment	8		8			
15 – Thukela Estuary	1					

11.2 Proposed Biophysical Nodes

The proposed biophysical nodes are tabled below in Table 103:. The biophysical node prefixed by a "R" refers to a node on a river reach; "W" indicates a wetland node and "E" indicates an estuary node. The level of EWR assessment required associated with the node is also provided.

Table 103: Proposed biophysical nodes

IUA	Quaternary catchment	Tributaries	Proposed Resource Unit	Biophysical node	Node at IUA outlet	Proposed EWR Assessment Level	Existing EWR
1	V31A	Thaka & Slang	Wetland RU (Wakkerstroom)	W1	R4	Wetland	
	V31B	Slang	Slang to confluence with Buffalo	R1		Biological	
	V31C	Harte & Ngogo	Ngogo to confluence with Buffalo	R2		Biological	
	V31D	Doringspruit	Tributary catchment	R3		No assessment	
	V31B, C, D	Buffalo	Buffalo to confluence to Ngagane	R4		Rapid 3	
2	V31E	Kalbas, Fourie, Klip, Mahlomyane & upper Ngagane	Upper Ngagane to Chelmsford Dam	R5	R8	Rapid	May13_EWR1 on Ngagane
	V31F	Horn	Horn to confluence with Ngagane	R6		Intermediate	May13_EWR2 on Horn
	V31H, J	Ncandu	Ncandu to confluence with Ngagane	R7		Rapid	
	V31G, K	Ngagane	Ngagane from Chelmsford Dam to confluence with Buffalo	R8		Intermediate	May13_EWR3 on Ngagane
3	V32A, B	Dorp, Kweek, Wasbank	Dorps to confluence with Buffalo	R9	R11	Intermediate	
	V32C, D, E, F	Tiyna, Mbabane, Eesteling, Sand		R10		No assessment	
	V32B, C, D, E, F	Buffalo	Buffalo from Ngagane to Blood River confluence	R11		Intermediate	Thukela_EWR13 on Buffalo
4	V33A, B, C, D	Totololo, Batse, Sibindi, Ngxobongo, Mangeni, Gubazi, Mazabeko	Tributary catchments	R12	R13	No assessment	
	V33A, B, C, D	Buffalo	Buffalo from Blood to Thukela confluence	R13		Intermediate	Thukela_EWR14 on Buffalo

IUA	Quaternary catchment	Tributaries	Proposed Resource Unit	Biophysical node	Node at IUA outlet	Proposed EWR Assessment Level	Existing EWR
5	V32G	Blood River	Wetland RU (Blood River)	W2	R14	Wetland	
	V32H	Hoqo	Blood \River from outlet of V32H to confluence with the Buffalo River	R14		Desktop	
6	V60B, C	Dwars, Nkunzi	Nkunzi to confluence with Sundays	R15	R18	Intermediate	
	V60D, E	Wasbank & tributaries	Wasbank to confluence with Sundays	R16		Rapid	
	V60A, B, C	Sundays	From source to confluence with Wasbank	R17		Intermediate	Thukela_EWR7 on Sundays
	V60F	Sundays	From Wasbank to Thukela confluence	R18		Intermediate	Thukela_EWR8 on Sundays
7	V20B (lower portion), D	Little-Mooi	From source to Mooi confluence	R19	R22	Rapid	
	V20C	Nsonge	Tributary catchment	R20		No assessment	
	V20E	Katspruit, Joubertsvlei	Joubertsvlei to confluence with Mooi	R21		Intermediate	
	V20A (lower portion), D, E	Mooi	Downstream Spring Grove Dam to outlet of V20E	R22		Intermediate	EWR_Mooi_N3 (V20D)
8	V20F, G	Mnyamvubu, Mpatheni, Rietvlei, Nyambathi	Mnyamvubu downstream of Craigie Burn Dam to confluence with Mooi	R23	R26	Rapid	
	V20H, J	Tshekana, Umdumbeni, Loza	Tributary catchments	R24		No assessment	
	V20G	Mooi	Mooi to Mnyamvubu confluence	R25		Intermediate	Thukela_EWR11 on Mooi
	V20H, J	Mooi	Mooi from Mnyamvubu to Thukela confluence	R26		Intermediate	Thukela_EWR12 on Mooi

IUA	Quaternary catchment	Tributaries	Proposed Resource Unit	Biophysical node	Node at IUA outlet	Proposed EWR Assessment Level	Existing EWR
9	V70A (lower portion), C	Mtshezana, Boesmans, Ncibidwana	Tributary catchments up to Wagendrift Dam	R27	R29	No assessment	
	V70D	Little Bushmans	Little Bushmans to confluence with Bushmans	R28		Intermediate	
	V70E, F, G	Bushmans, Rensburgspruit, uMngwenya, Busone	Bushmans from Wagendrift Dam to confluence with Thukela	R29		Intermediate	Thukela_EWR5 and Thukela_EWR6 on Bushmans
10	V11A (lower portion), C, D	Thukela, Putterill, Majaneni, Khombe	Tributary catchments	R30	R39	No assessment	
	V11E	Mnweni	Tributary catchment	R31		No assessment	
	V11F	Sandspruit	Tributary catchment	R32		No assessment	
	V11H	Mlambonja and tributaries	Tributary catchment	R33		No assessment	
	V11J	Thukela	Reach between Driel and Spioenkop Dam	R34		Intermediate	Thukela_EWR1 on Thukela
	V11K, L	Njongola, Venterspruit, Spioenkop Dam	Tributary catchment	R35		No assessment	
	V11M	Thukela	Spioenkop Dam to Little Thukela confluence	R36		Rapid	Thukela_EWR2 on Thukela
	V13B, D	Sterkspruit, Situlwane	Tributary catchment	R37		No assessment	
	V13A (lower portion), C, E	Little Thukela River	From IUA14 outlet to confluence with Thukela River	R38		Intermediate	Thukela_EWR3 on Little Thukela
	V14A, B	Thukela	From Little Thukela confluence to proposed Jana Dam/ Klip confluence	R39		Rapid	
11	V12A, B, C, E, F	Klip, Braamhoek, Tatana, Ngoga, Mhlwane, Sand, Dewdrop	Tributary catchments	R40	R42	No assessment	

IUA	Quaternary catchment	Tributaries	Proposed Resource Unit	Biophysical node	Node at IUA outlet	Proposed EWR Assessment Level	Existing EWR
	V12D	Sandspruit	Upper reaches of Sandspruit	R41		No assessment	
	V12G	Klip, Ndadkane	Klip from Ladysmith to confluence with Thukela	R42		Rapid	
12	V14C, D	Bloukrans, Drake, Mtontwanes, Nyandu	Tributary catchments	R43	R46	No assessment	
	V14E	Thukela	From Klip confluence to Bushmans confluence	R44		Intermediate	Thukela_EWR4A or 4B on Thukela d/s of proposed dam
	V60G, H, K	Sikhehlenga, Sampofu, Nadi	Tributary catchments	R45		No assessment	
	V60G, H, J, K	Thukela	Thukela from Bushmans confluence to d/s Mooi confluence	R46		Intermediate	Thukela_EWR9 on Thukela
13	V40A, B	Mfongosi, Ngcaza, Manyane	Tributary catchments	R47	R51	No assessment	
	V40A, B	Thukela	Thukela from d/s Mooi confluence to Middeldrift transfer	R48		Intermediate	Thukela_EWR15 on Thukela
	V40C, D	Nsuze and tributaries	Nsuze from source to confluence with Thukela	R49		Rapid	
	V50A, B, C	Mamba, Mambulu, Mpisi, Mati, Nembe, Mandeni	Tributary catchments	R50		No assessment	
	V40E, V50A, B, C	Thukela	Thukela from Middeldrift to reach in V50D	R51		Intermediate	Thukela_EWR16 on Thukela
14	V11A	Thukela headwaters	Upper reaches of Thukela River	R52	R59	Desktop, biological	
	V11B	Sithene River; Thonyelana-mpumalanga River	Source to confluence of Sithene and Thonyelana Rivers	R53		Desktop, biological	

IUA	Quaternary catchment	Tributaries	Proposed Resource Unit	Biophysical node	Node at IUA outlet	Proposed EWR Assessment Level	Existing EWR
	V11G	Mlambonja River (upper); Mhlwazini River; Ndedema River; Ndumeni River; Thuthumi River	Source to confluence of Mlambonja and Mhlwazini Rivers	R54		Desktop, biological	
	V13A	Upper Little Thukela River (headwaters)	Upper reaches of Little Thukela River	R55		Desktop, biological	
	V70A	Upper Boesmans River; Mtshezana River	Upper reaches of Boesmans River	R56		Desktop, biological	
	V70B	Nsibidwana River	Source to outlet of V70B	R57		Desktop, biological	
	V20A	Upper Mooi River	Upper reaches of Mooi River	R58		Desktop, biological	
	V20B	Upper Little Mooi River	Upper reaches of Little Mooi River	R59		Desktop, biological	
15	V50D (upper portion)	Mandeni Stream	Thukela reach upstream Estuary to Mngeni transfer	-		No assessment	
	V50D	None	Estuary	E1		Other	

12 DECISION ANALYSIS FRAMEWORK

The Classification process requires the use of a decision analysis framework that allows for the assessment of the implications of different catchment configuration scenarios at an IUA level on economic prosperity, social wellbeing and ecological condition. In addition to this, these assessments may need to be considered at various scales.

This Decision Analysis Framework is based on the interaction of four components (Figure 191):

1) Ecological infrastructure (EI);
2) Ecosystem services;
3) Human wellbeing; and
4) Economic production.

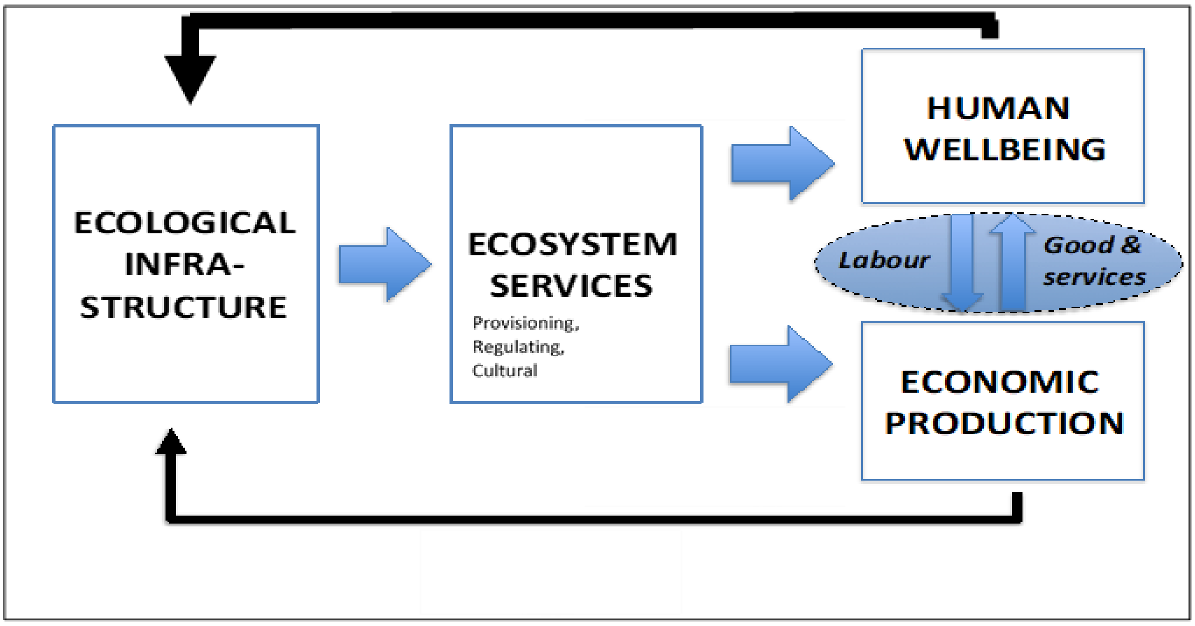


Figure 191: Schematic representation of the Decision Analysis Framework used to inform the assessment of the implications of different catchment configuration scenarios

Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable ecosystem services to people, such as fresh water, climate regulation, soil formation and disaster risk reduction. In the case of catchment management, ecological infrastructure could include aquifers, wetlands and sub-catchments. The supply of ecosystem services is dependent on the type, condition and extent of the ecological infrastructure. Ecological infrastructure in a good ecological condition would theoretically provide a robust flow of ecosystem services while ecological infrastructure in an impacted condition would deliver a less robust set of ecosystem services. The supply of ecosystem services is further dependent on the presence of beneficiaries, communities or economic sectors, in the landscape.

Figure 192 illustrates how aquatic ecosystem services are provided to communities directly (through the provisioning services), which are able to influence human wellbeing and to the economy directly through the provision of, as an example, raw water. Economic production may have a negative impact on ecological infrastructure through activities such as over abstraction or pollution, which in turn has an impact on the delivery of ecosystem services. The same relationship exists with communities and ecological infrastructure, but to a lesser degree. The relationship between human wellbeing and economic production can be described in economic terms, with households providing labour into economic sectors, which provide goods and services in return.

The Decision Support Framework represents a significant simplification of the assessment process, and although still complex, and requires transdisciplinary collaboration. The classification and scenario assessment process requires an understanding at a catchment level of various components (social, economic and environmental) within the Decision Analysis Framework. This is done through a stepwise process whereby the primary characteristics within each component are identified and changes thereof are analysed against various scenarios. An overview of tasks presented in this process is given in Figure 192.

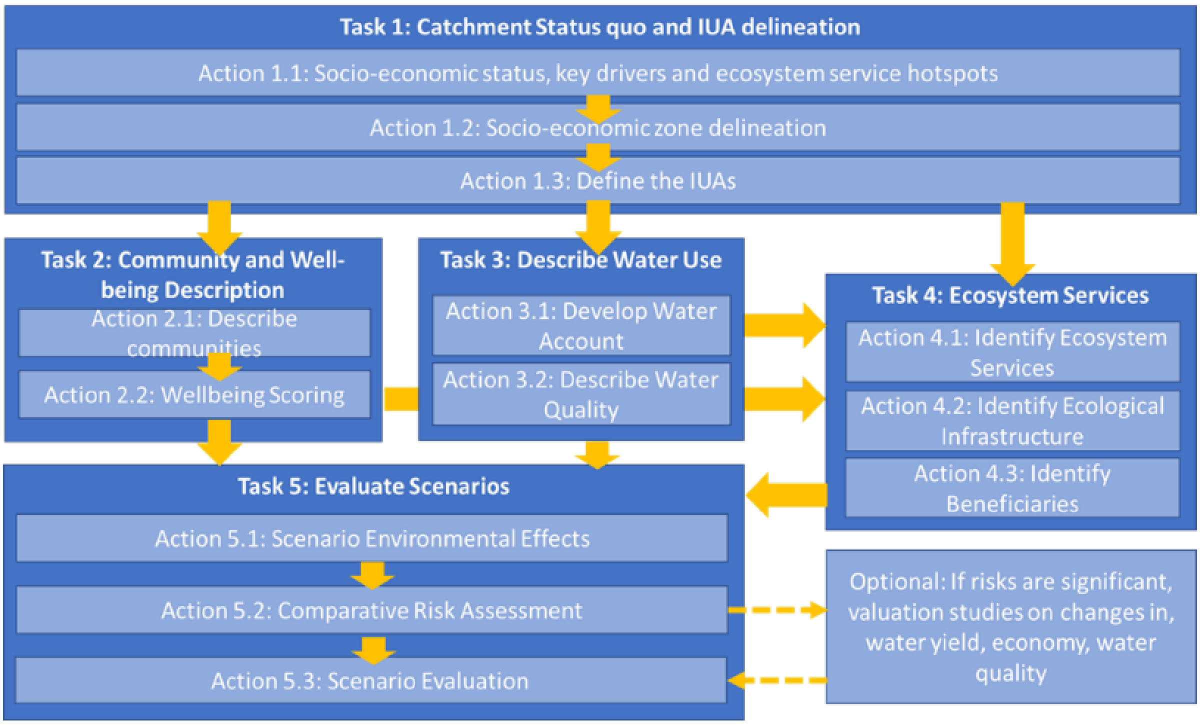


Figure 192: Overview of Tasks with corresponding actions for the Socio-economic Guidelines

The Socio-Economic Comparison Tool (SeCT) (as described in Naidoo *et al*. 2017) complements the Decision Support Framework as a method for assessing, comparing, ranking and describing formally, the risks to ecosystem services and therefore the benefits they provide based on changing scenarios.

The SeCT is a Microsoft Excel based tool that ensures standardised inputs and outputs to simplify the process and ensure that classifications are transparent and comparable in the figure above. This user-friendly model allows the socio-economic practitioners to systematically work through the framework and input data from other classification processes into a format suitable for further analysis. In this manner the SeCT also serves a repository for information improving transparency and legal defensibility. The analysis culminates in a comparative risk assessment to evaluate scenarios and inform the larger classification process.

13 CONCLUSION

This report has presented the findings of the status quo assessment for the water resources of the Thukela catchment. Based on the available information and literature, data assessment and analysis, review of previous studies and discussions held with DWS personnel a perspective of the characteristics, nature, attributes, condition and key aspects of the Thukela water resources have been provided. This has formed a basis for the understanding of the catchment, the status and use of water resources and the assessment of the socio-economic profile that exists.

Based on the detailed evaluations that underlie the above, delineation of Socio-Economic Zones, IUAs have been delineated and biophysical nodes have been proposed, as the basis for the determination of water resource classes.

Based on the feedback and comment obtained from stakeholders on the IUAs presented in this report, have been finalised for the process of quantifying the EWRs and setting water resource classes.

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APPENDIX 1:

DWS WATER QUALITY MONITORING SITES WITHIN THE THUKELA CATCHMENT

Table A1: Water Quality Monitoring Points within the Thukela Catchment with Data Availability since 2008

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
Upper Thukela River catchment						
102713	V1H033Q01 TUGELA RIVER AT WAN HOOP/CLIFFORD CHAMBERS	-28.6528	29.0444	V11A	2013/04/23	2013/12/17
188282	WAN HOOP D/S OF HLALANATHI STW ON TUGELA	-28.6558	29.0422	V11A	2008/01/16	2011/07/12
188283	TRILBY D/S MOUNT AUX SOURCES HOTEL U/S HLALANATHI STW ON TUGELA	-28.6686	29.0219	V11A	2008/01/16	2017/01/24
188292	UPSTREAM OF ROYAL NATIONAL PARK STW ON GOLIDE	-28.6861	28.9533	V11A	2008/01/16	2017/01/24
188293	AT ROAD BRIDGE D/S ROYAL NATIONAL PARK STW & U/S MOUNT AUX SOUR RCES HOTEL STW ON TUGELA	-28.6825	28.9767	V11A	2008/01/16	2017/01/24
188294	ROYAL NATIONAL PARK STW			V11A	2008/03/26	2017/01/24
188295	MOUNT-AUX-SOURCES HOTEL STW FINAL EFFLUENT			V11A	2008/01/16	2017/01/24
191681				V11B	2009/03/24	2018/06/20
103323	KILBURN DAM: NEAR DAM WALL	-28.5914	29.1009	V11C	2014/07/09	2014/12/02
102722	V1H048Q01 TUGELA RIVER AT WAN HOOP/UP STREAM WOODSTOCK DAM	-28.6397	29.0672	V11C	2008/02/21	2017/01/24
188305	KRUISFONTEIN BERGVILLE HARRISMITH ROAD BRIDGE U/S WOODSTOCK DAM ON MAJANE ENI	-28.6272	29.1214	V11C	2008/02/21	2017/01/24
102716	V1H036Q1			V11C	2008/02/18	2018/04/14
102715	V1H035Q1 Tugela Canal at Second			V11D	2008/01/15	2018/04/18
102720				V11D	2008/02/17	2018/04/17
188306	GRANSMOOR BERGVILLE HARRISMITH ROAD BRIDGE U/S OF WOODSTOCK DAM ON MPA ANDWENI	-28.6431	29.1644	V11D	2008/02/21	2017/01/24
102732	V1R003Q01 UPPER TUGELA 4794 WOODSTOCK 2189 - WOODSTOCK DAM ON TUGELA RIVER: NEAR DAM WALL	-28.7608	29.2444	V11E		
102733	V1R003Q02 WOODSTOCK DAM ON TUGELA RIVER: POINT IN DAM	-28.7608	29.2444	V11E	2014/07/09	2014/12/02
102711	V1H031Q01 AT KLEINE WATERVAL BERGVILLE ON SANDSPRUIT	-28.7225	29.3514	V11F	2011/04/05	2018/04/17
188844	HOPETON UPSTREAM OF CATHEDRAL PEAK HOTEL STW FINAL EFFLUENT DISCHARG GE ON MLAMBONJA	-28.9459	29.2100	V11G	2008/01/29	2017/01/19
188861	HOPETON DOWNSTREAM OF CATHEDRAL PEAK HOTEL STW FINAL EFFLUENT DISCHA ARGE ON MLAMBONJA	-28.9459	29.2101	V11G	2008/01/29	2017/01/19

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
188853	CATHEDRAL PEAK OTEL STW FINAL EFFLUENT DISCHARGE TO MLAMBONJA			V11G	2008/01/29	2017/01/19
102721	V1H041Q01 MLAMBONJA RIVER AT KLEINERIVIER	-28.8117	29.3119	V11H	2008/01/15	2018/04/17
188297	BERGVILLE STW FINAL EFFLUENT			V11J	2008/01/17	2017/01/13
102731	V1R002Q01 DRIEL BARRAGE ON TUGELA RIVER: NEAR BARRAGE WALL	-28.7633	29.2908	V11J	2008/01/15	2018/04/17
102708	V1H026Q01 TUGELA RIVER @ KLEINE WATERVAL	-28.7219	29.3757	V11J	2008/01/15	2018/04/17
102727	V1H058Q01 DRIEL BARRAGE ON TUGELA RIVER: DOWN STREAM WEIR	-28.7622	29.2925	V11J	2008/01/15	2018/04/17
188298	BERGVILLE U/S OF BERGVILLE STW FINAL EFFLUENT DISCHARGE ON SANDSPRUIT	-28.7289	29.3572	V11J	2008/01/17	2017/01/23
188299	BERGVILLE D/S OF BERGVILLE STW FINAL EFFLUENT DISCHARGE ON SANDSPRUIT	-28.7278	29.3592	V11J	2008/01/17	2017/01/23
102728	V1R001Q01 RHENOSTER FONTEIN 1051 - SPIOENKOP DAM ON TUGELA RIVER: NEAR DAM WALL	-28.6815	29.5161	V11L	2008/01/16	2017/08/08
102730	V1R001Q03 SPIOENKOP DAM ON TUGELA RIVER: POINT IN DAM	-28.6811	29.5167	V11L	2012/11/28	2018/04/16
102726	V1H057Q01 SPIOENKOP DAM ON TUGELA RIVER: DOWN STREAM WEIR	-28.6787	29.5201	V11M	2008/01/16	2018/04/16
102704	V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON	-28.8181	29.5450	V13C	2008/02/12	2018/04/16
102725				V13C	2012/03/06	2018/04/16
188847	EMMAUS MISSION STATION HOSPITAL STW FINAL EFFLUENT			V13D	2016/09/29	2017/01/19
189139	WINTERTON STW FINAL DISCHARGE TO LITTLE TUGELA			V13D	2008/01/30	2016/12/19
189136	WINTERTON D/S OF WINTERTON STW FINAL DISCHARGE ON LITTLE TUGELA	-28.8095	29.5353	V13D	2008/01/30	2017/01/18
189140	WINTERTON U/S OF WINTERTON STW FINAL DISCHARGE ON LITTLE TUGELA	-28.8112	29.5343	V13D	2008/01/30	2017/01/18
188302	COLENSO BULWER BRIDGE U/S OF COLENSO FINAL EFFLUENT DISCHARGE ON TUG GELA	-28.7364	29.8208	V14A	2008/01/09	2017/01/25
102695	V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO	-28.7356	29.8206	V14B	2009/01/22	2018/03/14
188303	COLENSO D/S OF COLENSO FINAL EFFLUENT DISCHARGE ON TUGELA	-28.7344	29.8406	V14B	2008/01/09	2017/01/25
188301	COLENSO STW FINAL EFFLUENT			V14B	2008/01/09	2017/01/25
102703	V1H009Q01 BLOUKRANS RIVER AT FRERE	-28.8914	29.7706	V14D	2008/01/28	2018/04/16
Klip River Catchment						
102718	V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP	-28.5617	29.7525	V12F	2008/04/22	2018/01/23

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
188288	LADYSMITH WAGON BRIDGE UPSTREAM OF STW FINAL EFFLUENT DISCHARGE ON KLI IP RIVER	-28.5678	29.7711	V12G	2008/01/09	2017/01/25
188289	LADYSMITH DOWNSTREAM OF STW DISCHARRGE ON KLIP REVER	-28.5794	29.8014	V12G	2008/01/09	2018/06/05
100001155	KLIPRIVER U/S EZAKHENI SEWAGE TREATMENT WORKS FINAL EFFLUENT	-28.6356	29.9217	V12G	2008/01/09	2017/01/25
100001156	KLIPRIVER D/S EZAKHENI SEWAGE TREATMENT WORKS FINAL EFFLUENT	-28.6419	29.9306	V12G	2008/01/09	2017/11/29
188287	LADYSMITH STW FINAL EFFLUENT			V12G	2008/01/09	2017/01/25
100001160	EZAKHENI SEWAGE TREATMENT WORKS FINAL EFFLUENT			V12G	2008/01/09	2018/06/05
Sundays River Catchment						
102783	V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER	-28.4044	30.0131	V60B	2008/06/04	2018/03/20
102784	V6H006Q01 SUNDAYS RIVER AT WATERFALL	-28.2397	29.7544	V60B	2008/01/30	2018/04/17
187716	#2 PLAT BERG NATAL STEAM COAL DECANT	-28.3538	30.0177	V60B	2008/01/29	2017/12/12
187722	#3 PLAT BERG DOWN STREAM OF NATAL STEAM COAL DECANT	-28.3539	30.0174	V60B	2008/01/09	2017/12/12
187726	#1 PLAT BERG AT R602 ROAD BRIDGE ON SUNDAYS	-28.3609	30.0112	V60B	2008/02/06	2017/12/12
188372	WATERKLOOF D/S FORT MISTAKE AND PIGGARY ON NKUNZI	-28.2067	29.9586	V60B	2008/01/24	2014/10/21
188772	QUAGGAS KIRK UPSTREAM OF PIGGERY ON NKUNZI	-28.1794	29.9564	V60B	2008/01/24	2014/10/21
188773	GARTMORE AT N11 BRIDGE ON NKUNZI	-28.2351	29.9671	V60B	2008/01/24	2014/10/21
188843	ROODE POORT AT R23 BRIDGE ON SUNDAYS	-28.3481	29.9681	V60B	2008/01/24	2014/10/21
102786	V6H009Q01 WASBANK RIVER AT BURNSIDE ESTATE	-28.1789	30.0761	V60D	2008/03/27	2013/07/23
102787	V6H010Q01 MANZIMNYAMA AT BURNSIDE ESTATE - U/S WASBANK CONF	-28.1731	30.0914	V60D	2008/03/27	2013/07/23
102788	V6H011Q01 WASBANK RIV AT UITHOEK - U/S UITHOEK SPRUIT D/S M	-28.2125	30.1242	V60D	2008/03/27	2013/07/23
102789	V6H012Q01 UITHOEK SPRUIT AT UITHOEK - U/S WASBANK CONFLUENC	-28.2044	30.1322	V60D	2008/03/27	2013/07/23
102790	V6H013Q01 WASBANK RIV AT WASBANK - D/S BUSANA & DNDEE ROAD	-28.2914	30.1222	V60D	2008/04/30	2013/07/23
102791	V6H014Q01 @ KWEEKVLEI DE KROON U/S OF WASBANK ON BIGGARSGAT	-28.3000	30.1556	V60D	2008/01/09	2017/12/13
187700	#6 BIGGARSGAT UPSTREAM OF INDUMENI DECANT	-28.2539	30.1925	V60D	2008/01/09	2009/03/10
187701	#11 BURNSIDE DECANT	-28.1782	30.0907	V60D	2008/01/09	2017/11/14
187702	#10 BURNSIDE UPSTREAM DECANT	-28.1781	30.0904	V60D	2008/01/09	2016/02/09

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187705	#12 BURNSIDE DOWNSTREAM DECANT	-28.1909	30.0970	V60D	2008/01/09	2017/11/14
187709	#5 BIGGARSGAT INDUMENI POP DECANT	-28.2546	30.1918	V60D	2008/01/09	2017/12/13
189041	VLEI POORT DOWNSTREAM OF NORTHFIELD PRISON ON MANZIMNYAMA	-28.1629	30.1071	V60D	2008/01/23	2014/12/04
189043	VALKENBURG U/S OF NORTHFIELD PRISON ON TRIBUTARY OF MANZIMNYAMA	-28.1435	30.1238	V60D	2008/01/23	2014/12/04
189045	VLKENBURG NORTHFIELD (GLENCOE) PRISON FINAL EFFLUENT			V60D	2008/01/23	2014/12/04
102782	V6H003Q01 WASBANK RIVER AT KUICK VLEI	-28.3094	30.1481	V60E	2008/03/27	2018/03/20
102792	V6H016Q01 MKOMAZANA RIV AT WASBANK - U/S WB CONFL D/S WB VI	-28.3172	30.1278	V60E	2008/03/27	2013/07/23
102795	V6H019Q01 WASBANK RIVER AT VAALKOP - D/S THOLENI CONFLUENCE	-28.4586	30.1792	V60E	2012/12/11	2017/02/02
102781	V6H002Q01 AT TUGELA FERRY ON TUGELA	-28.7500	30.4428	V60J	2008/01/16	2018/04/19
Mooi River Catchment						
188045	GAME PASS E 5596 KAMBERG NATURE RESERVE ON MOOI RIVER	-29.3756	29.6396	V20A	2008/02/09	2017/12/13
102737				V20A	2008/01/14	2018/04/20
102738	V2H006Q01 LITTLE MOOI RIVER AT DARTINGTON	-29.2653	29.8680	V20B	2008/01/14	2018/03/22
102739	V2H007Q01 HLATIKULU RIVER AT BROADMOOR	-29.2386	29.7883	V20C	2008/01/15	2018/03/22
195009	MEARNS DAM- MEARNS MAIN BASIN INTEGRATED	-29.2471	29.9701	V20D	2013/01/08	2017/03/28
195010	SPRING GROVE DAM- SPRING GROVE MAIN BASIN INTEGRATED	-29.3201	29.9648	V20D	2013/06/28	2017/03/31
177645	V2H009Q01 MEARNS	-29.2458	29.9706	V20D	2012/01/08	2017/03/17
195005	MOOI AT SPRING GROVE (OUTFLOW)- DOWNSTREAM OF DAM WALL	-29.3179	29.9670	V20D	2013/01/08	2017/03/17
195006	LITTLE MOOI AT CONNINGTON ROAD BRIDGE (UPSTREAM OF MEARNS)	-29.2320	29.9253	V20D	2013/07/09	2017/03/28
195007	MOOI AT ROSETTA BRIDGE- AT BRIDGE	-29.3010	29.9636	V20D	2013/01/08	2017/03/07
195008	MOOI 0.7KM D/S OF MEARNS- AT LOW LEVEL BRIDGE	-29.2379	29.9828	V20D	2013/01/08	2017/03/07
177646				V20D	2013/08/12	2017/02/20
87982				V20D	2015/01/19	2015/02/20
102735	V2H002Q01 @ MOOIRIVIER ON MOOIRIVIER	-29.2194	29.9936	V20E	2008/01/14	2018/04/19

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
102736	V2H004Q01 MOOI RIVER AT DOORNKLOOF	-29.0708	30.2458	V20E	2008/01/17	2018/04/19
189112	MOOIRIVIER DOWNSTREAM OF N3 ROAD BRIDGE & STW ON MOOIRIVIER	-29.2097	30.0034	V20E	2008/01/14	2016/10/27
188882	MOOIRIVER SEWAGE TREATMENT WORKS FINAL DISCHARGE TO MOOIRIVER			V20E	2008/01/14	2016/10/27
102745	V2R001Q01 RIETVLEI 3281 - CRAIGIE BURN DAM ON MNYAMVUBU RIVER: NEAR DAM WALL	-29.1635	30.2866	V20F	2009/04/09	2017/10/24
102748	V2R001Q04 CRAIGIE BURN DAM ON MNYAMVUBU RIVER: POINT IN DAM	-29.1631	30.2868	V20F	2012/07/02	2018/04/23
102744	V2H016Q01 CRAIGIE BURN DAM ON MNYAMVUBU RIVER: DOWN STREAM	-29.1631	30.2881	V20F	2009/04/09	2017/10/11
102740	V2H008Q01 MOOI RIVER AT KEATE S DRIFT	-28.8594	30.5000	V20H	2008/01/16	2018/04/19
Buffalo River Catchment						
102778	V3R003Q01 ZAAIHOEK 377 - ZAAIHOEK DAM ON SLANG RIVER: NEAR DAM WALL	-27.4397	30.0599	V31B	2008/01/30	2018/04/18
102771	V3H028Q01 ZAAIHOEK DAM: DOWN STREAM WEIR	-27.4375	30.0611	V31B	2008/01/30	2018/04/18
189704	SCHUILKLIP 109 @ ROAD BRIDGE 1911 ON BUFFELSRIVIER	-27.5782	29.9204	V31B	2008/01/21	2017/02/08
100000982				V31B	2008/01/17	2010/02/25
100000983				V31B	2008/01/17	210/02/25
102750	V3H002Q01 AT SCHURVEPOORT ON BUFFELS RIVER	-27.6022	29.9428	V31C	2008/01/30	2018/06/26
189701	WHITE HOUSE 14178 @ MAIN ROAD 186 BRIDGE UPSTREAM OF INGOGO ON HARTS RIVIER	-27.5814	29.8733	V31C	2008/01/21	2017/02/08
189702	WHITE HOUSE 14178 @ MAIN ROAD 186 BRIDGE UPSTREAM OF HARTS ON NGOGO	-27.5824	29.8751	V31C	2008/01/21	2017/02/08
189703	DUMBANY 15101 @ NEWCASTLE VOLKSRUST ROAD BRIDGE ON NGOGO	-27.5918	29.9249	V31C	2008/01/21	2017/02/08
102772	V3R001Q01 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE: NEAR WALL	-27.9531	29.9481	V31E	2008/01/30	2018/04/20
102770	V3H027Q01 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: DOWN STREAM W WEIR	-27.9536	29.9489	V31E	2008/01/17	2018/05/18
1000011639	KALBAL RIVER ON THE NOMANDEEN ROAD BRIDGE	-28.0569	29.9553	V31E	2008/01/16	2017/02/07
1000011641	MAZAMYAMA RIVER ON THE NOMANDEEN ROAD BRIDGE	-28.0778	29.9314	V31E	2008/01/16	2017/02/07
1000011643	MHLONYANA RIVER ON THE NOMANDEEN ROAD BRIDGE	-28.0636	29.8433	V31E	2008/01/16	2017/02/07
1000011645	KLIP RIVER ON THE OLD NEWCASTLE ROAD BRIDGE	-27.9875	29.7783	V31E	2008/01/16	2017/02/07
1000011646	NGAGANE RIVER ON THE OLD NEWCASTLE ROAD BRIDGE	-28.0408	29.7867	V31E	2008/01/16	2017/02/07

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102754	V3H009Q01 HORN RIVER AT BALLENGEICH	-27.8958	29.9514	V31F	2008/01/30	2018/04/20
187707	#24 HORN RIVER DOWN STREAM OF NATAL COAL EXPLORATION	-27.8957	29.8806	V31F	2008/01/08	2017/11/09
187708	#22 HORN RIVER UP STREAM OF NATAL COAL EXPLORATION	-27.8986	29.8709	V31F	2008/01/09	2017/11/09
187717	#23 HORN RIVER KNOWESLEY NATAL COAL EXPLORATION SEEPAGE	-27.8970	29.8785	V31F	2008/01/08	2013/01/22
188866	KILBARCHAN D/S OF HORN AND NGAGANE CONFLUENCE U/S OF KILBARCHAN ON INGA AGANE	-27.8843	29.9753	V31G	2008/03/25	2017/01/23
188867	BALLENGEICH 3299 - U/S SILTECH @ BRIDGE TO NTSHINGWAYO DAM ON INGAGANE	-27.9235	29.9681	V31G	2008/01/17	2017/01/23
188868	BALLENGEICH 3299 - D/S SILTECH & U/S OF HORN @ RAILWAY BRIDGE ON INGAGANE	-27.8900	29.9781	V31G	2008/01/17	2017/01/23
188872	BALLENGEICH @ WEIR U/S OF NGAGANE ON HORN	-27.8851	29.9742	V31G	2008/03/25	2017/01/23
102753	V3H007Q01 NCANDU RIVER AT RUST	-27.8494	29.8408	V31H	2008/01/30	2018/04/19
102777	V3R002Q01 AMCOR DAM ON NCANDU RIVER: NEAR DAM WALL	-27.7364	29.9864	V31J	2008/01/30	2018/04/17
189028	BOSCH HOEK LENNOXTON D/S OF WEIR & U/S OF TAXI RANK ON NCANDU	-27.7854	29.8971	V31J	2008/01/22	2016/09/26
189029	NEWCASTLE RIVERSIDE U/S OF AMCOR DAM ON NCANDU	-27.7446	29.9686	V31J	2008/01/22	2015/11/24
189030	NEWCASTLE DOWNSTREAM OF TAXI RANK AND ALLEN STREET BRIDGE ON NCANDU	-27.7498	29.9319	V31J	2008/01/22	2016/09/26
102768	V3H024Q01 AT PARKLANDS DOWN STREAM OF BRIDGE ON NGAGANE	-27.7267	30.0550	V31K	2016/02/11	2016/06/29
188917	NEWCASTLE TOWNSHIP - AT WEIR ON NGAGANE	-27.7698	30.0171	V31K	2008/01/21	2010/12/23
188918	ROY POINT @ UTHUKELA ABSTRACTION POINT ON INGAGANE	-27.7986	29.9884	V31K	2008/01/23	2015/10/27
189366	SHAKESPEARE D/S OF NEWCASTLE STW EFFLUENT & MITTAL STEEL WORKS & U/S MIT TTAL STEEL EFFLUENT	-27.7219	30.0215	V31K	2008/01/22	2017/01/26
1000011731	MADADENI 15961 HT U/S MITTAL STEEL (ISCOR) EFFLUENT DISCHAR AT WEIR ON NGAGANE	-27.7217	30.0208	V31K	2008/01/22	2017/01/26
1000011734	MADADENI 15961 HT D/S MITTAL STEEL (ISCOR) EFFLUENT DISCHARGE POINT ON NGAGANE	-27.7266	30.0546	V31K	2008/01/22	2017/01/26
188953	NEWCASTLE TOWNSHIP KARBOCHEM AFRICAN AMIDES EFFLUENT DISCHARGE			V31K	2008/01/21	2016/06/30
188954	NEWCASTLE TOWNSHIP KARBOCHEM UPSTREAM REFERENCE			V31K	2008/01/21	2016/02/29
189389	NEWCASTLE STW @SHAKESPEARE EFFLUENT BEFORE DISCHARGE INTO INGAGANE			V31K	2008/01/22	2017/01/26
188951	NEWCASTLE TOWNSHIP KARBOCHEMSPRUIT U/S OF CONFLUENCE WITH NGAGANE			V31K	2008/01/21	2016/06/30

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
189204	PARKLANDS BEFORE CONFLUENCE WITH BUFFALO D/S OF FLOOD PANS & IRRIGATIO ON CIRCLES ON INGAGANE	-27.7246	30.0804	V32B	2008/01/22	2017/01/26
189205	UPSTREAM OF MADADENI STW ON BUFFELSRIVIER	-27.7262	30.0867	V32B	2008/01/24	2009/06/09
189373				V32B	2008/01/24	2009/06/29
1000003525				V32B	2008/01/24	2009/06/29
102760	V3H015Q01 AT VAALBANK RAIL BRIDGE ON BUFFELS RIVER	-27.7375	30.2039	V32C	2012/12/21	2018/04/18
188825	WATERVAL D/S OF OSIZWENI STW & U/S OF WATERVAL STW ON BUFFELSRIVIER	-27.8041	30.2482	V32C	2008/01/24	2017/02/13
188835	WITTEKLIP UPSTREAM OF OSIZWENI STW FINAL EFFLUENT DISCHARGE ON BUFFELS SRIVIER	-27.7400	30.2034	V32C	2008/01/24	2017/02/13
188842	WATERVAL DOWNSTREAM OF WATERVAL STW ON BUFFELSRIVIER	-27.8072	30.2594	V32C	2008/01/24	2017/02/13
188827	WATRVAL PRISON STW FINAL EFFLUENT			V32C	2008/03/12	2017/02/13
188837	OSIZWENI STWFINAL EFFLUENT DISCHARGE TO UNNAMED TRIBUTARY OF BUFFELS RIVIER			V32C	2008/01/24	2017/02/13
102755	V3H010Q01 AT TAYSIDE ON BUFFELS RIVER	-28.0589	30.3736	V32D	2008/01/15	2018/04/19
189163	DE JAGERSDRIFT NORTH @ R33 DUNDEE VRYHEID BRIDGE ON BUFFELSRIVI IER	-28.0038	30.3861	V32D	2008/01/15	2017/02/07
187697	#9 BANNOCKBURN DOWNSTREAM DECANT	-28.1591	30.1835	V32E	2008/01/09	2015/04/13
187698	#7 BANNOCKBURN UPSTREAM DECANT	-28.1611	30.1724	V32E	2008/01/09	2015/05/12
187706	#18 GLADSTONE UPSTREAM OF GLADSTONE SEEPAGE	-28.0714	30.2860	V32E	2008/01/09	2014/08/12
187711	#25 KLIP RAND KLIPRAND DAM ON TRIBUTARY OF MZINYASHANA	-27.9972	30.1562	V32E	2008/01/08	2016/07/13
187714	#13 DALRY DOWN STREAM OF CORBY ROCK	-28.1387	30.3807	V32E	2008/01/29	2014/06/05
187715	#14 CORBY ROCK UPSTREAM OF CORBY ROCK DOWNSTREAM OF DAM	-28.1561	30.3833	V32E	2008/01/09	2014/06/05
187719	#21 PIETERSDALE OF IGNUSDALE DOWNSTREAM OF NNC2 AND NNC3	-28.0402	30.1713	V32E	2008/12/18	2016/12/09
187721	#19 SWISS VALLEY UPSTREAM OF NNC2 NNC3	-28.0641	30.1825	V32E	2008/12/18	2015/07/21
187723	#15 CORBY ROCK SEEPAGE FROM CORBY ROCK	-28.1543	30.3832	V32E	2008/01/09	2014/06/05
187724	#20 SWISS VALLEY SEEPAGE FROM NNC2	-28.0648	30.1681	V32E	2009/02/19	2015/07/21
187725	#17 COTSWOLD DOWNSTREAM OF GLADSTONE	-28.0963	30.3168	V32E	2008/01/09	2017/12/11
187940	#27 AT SWISS VALLEY D/S OF NNC2 U/S OF OLD BRIGDE ON NGOBIYA	-28.0634	30.1716	V32E	2009/02/19	2013/09/04

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
188884	CRAIGSIDE U/S DUNDEE STW FINAL EFFLUENT DISCHARGE POINT ON STERKSTROOM	-28.1309	30.2353	V32E	2008/01/08	2017/01/26
188888	CRAIGSIDE D/S DUNDEE STW FINAL EFFLUENT DISCHARGE POINT ON STERKSTROOM	-28.1297	30.2364	V32E	2008/01/08	2016/12/07
192150	STERKSTROOM @U/S AVOCA	-28.1447	30.2283	V32E	2008/11/25	2017/01/30
192151	MZIMYASHANA D/S SOLMAR @ D/S SOLMAR	-28.0467	30.2039	V32E	2008/11/25	2017/01/30
192153	SANDSPRUIT ON NQUTU ROAD BRIDGE	-28.1397	30.3317	V32E	2008/11/04	2017/01/30
192154	SANDSPRUIT/STERKSPRUIT ON VRYHEID ROAD BRIDGE	-28.0963	30.3168	V32E	2008/11/04	2017/01/30
192466	SANDSPRUIT @U/S CONFLUENCE BUFFALO RIVER	-28.0874	30.3907	V32E	2008/11/04	2017/01/30
1000010650	UBHOBHOJANE RIVER U/S NQUTHU STW	-28.1234	30.4047	V32E	2008/02/11	2010/08/10
1000010651	UBHOBHOJANE RIVER D/S NQUTHU SEWAGE TREATMENT WORKS	-28.1231	30.4047	V32E	2008/02/11	2010/08/10
88497	ZBAN001 BANNOCKBURN COLL. REED BEDS: INFLOW TO UPPER BED	-28.1600	30.1783	V32E	2008/02/06	2017/11/14
1000010652				V32E	2008/2/11	2010/08/10
188887	CRAIGSIDE DUNDEE STW FINAL EFFLUENT DISCHARGE TO STERKSTROOM			V32E	2008/01/08	2017/01/26
1000010323				V32E	2008/07/15	2013/04/11
1000010562	UGOQO RIVER D/S MONDLO S.T.W	-28.0147	30.4480	V32F	2008/02/11	2016/07/04
1000010565	UGOQO RIVER U/S MONDLO S.T.W	-28.0144	30.4477	V32F	2008/02/11	2016/07/04
1000010567	MONDLO SEWAGE WORKS			V32F	2008/02/11	2016/07/04
188946	KANDAS PRISON U/S OF NCOME PRISON STW FIN EFF DISCHARGE ON MDLENERU U	-27.9233	30.6519	V32H	2008/01/22	2017/01/26
188947	BEDROG DOWNSTREAM OF NCOME PRISON STW FINAL DISCHARGE ON MDLENERU (NDHLEVENU)	-27.9336	30.6145	V32H	2008/01/22	2017/01/26
194844	VANTS DRIFT - ON BUFFELSRIVIER	-28.2435	30.5153	V32H	2016/02/03	2016/06/02
188945	KANDAS PRISON NCOME PRISON STW FINAL EFFLUENT			V32H	2008/01/22	2016/10/05
102749	V3H001Q01 @ VANT S DRIFT ST PETERS MISSION ON BUFFELSRIVIER	-28.2456	30.5094	V33A	2008/01/15	2017/02/07
189586	MCHJEAANE 2254 RORKE S FERRY D/S NQUTU STW ON BUFFELSRIVIER	-28.3457	30.5384	V33A	2008/01/15	2017/02/07
195401	ISANDLWANA - ON NGXOBONGO TRIBUTARY	-28.3564	30.6323	V33B	2016/02/03	2016/06/02
Bushmans River Catchment						
102799	V7H017Q01 BOES,AMSRIVIER RIVER AT DRAKENSBERG NO 1			V70A	2008/01/15	2018/04/20

Monitoring Point ID	Monitoring Point Name	Latitude	Longitude	Drainage Region	First Sample Date	Last Sample Date
102798	V7H016Q01 BUSHMANSRIVIER AT DRAKENSBERG NO 1			V70B	2008/01/15	2018/03/22
102803	V7R001Q01 WAGENDRIFT 798 - WAGENDRIFT DAM ON BUSHMANS RIVER: NEAR DAM WALL			V70C	2013/03/05	2018/04/18
102802	V7H020Q01 WAGENDRIFT DAM ON BUSHMANS RIVER: DOWN STREAM WEIR			V70C	2008/02/12	2018/04/18
102797	V7H012Q01 LITTLE BUSHMANS RIVER AT ESTCOURT			V70D	2008/01/15	2018/04/18
188808	BOROUGH OF ESTCOURT U/S ESTCOURT STW DISCHARGE ON BUSHMANSRIVIER			V70E	2008/01/15	2016/10/27
188807	BOROUGH OF ESTCOURT D/S ESTCOURT STW DISCHARGE ON BUSHMANSRIVIER			V70F	2008/01/15	2016/09/22
188370	ESTCOURT STW FINAL EFFLUENT DISCHARGE TO BUSHMANSRIVER			V70F	2008/01/15	2016/10/27
Lower Tugela Catchment						
188875	KRANSKOP STW FINAL DISCHARGE TO TRIBUTARY OF MANDLENI			V40E	20014/07/09	2016/10/12
188878	NTUNJAMBILI HOSPITAL STW FINAL EFFLUENT DISCHARE TO TRIBUTARY OF EKHATHA			V50A	2014/07/09	2016/10/12
194574	TH-01 ESTUARY MOUTH @ THUKELA ESTUARY	-29.2235	31.5004	V50D	2015/10/07	2018/10/07
194575	TH-02 ULTIMATUM TREE @THUKELA ESTUARY	-29.2141	31.4356	V50D	2015/10/09	2018/10/06
194576	TH-03 ESTUARY HEAD @THUKELA ESTUARY	-29.1767	31.4422	V50D	2015/10/09	2018/09/05
102779	V5H002Q01 AT MANDINI ON TUGELA RIVER	-29.1406	31.3919	V50D	2008/01/31	2018/05/17
188472	SUNDUMBILI U/S OF STW FINAL DISCHARGE ON MANDENI	-29.1310	31.4084	V50D	2015/08/11	2018/05/17
188473	JOHN ROSS BRIDGE D/S OF SAPPI MANDINI FINAL EFFLUENT DISCHARGE ON N TUGELA	-29.1733	31.4385	V50D	2014/12/08	2018/05/17
188475	SUNDUMBILI D/S OF SUNDUMBILI STW ON MANDENI	-29.1371	31.4063	V50D	2015/08/11	2018/05/17
188474				V50D	20018/01/10	2018/05/17
1000003827				V50D	2008/01/10	2018/05/17
188471				V50D	2014/05/13	2018/05/17