water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

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

PROJECT STEERING COMMITTEE (PSC) MEETING 1

Presented by:
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Golder Associates

Date: 16 July 2020

Study objective

- To determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) for all significant water resources in the Thukela River catchment area
  - that would facilitate sustainable use of the water resources while maintaining ecological integrity,
  - specifically maintaining or improving the present ecological state of the water resources.

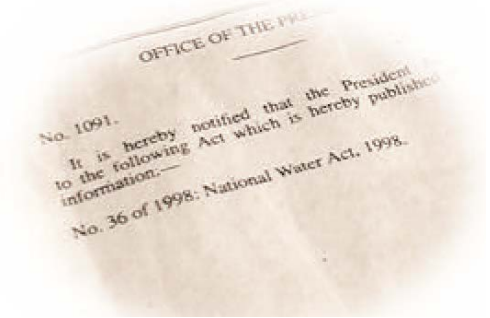
Legal Foundation

- *Water Resources* need to be managed so that they may **protected** on one hand and,

- to enable the water to be **utilised** for social and economic development on the other hand.

- **The National Water Act** provides decision-making tools to achieve a balance between protecting and utilising water resources.

Protect **Utilise**



What does this mean?

IWRM FRAMEWORK

Fundamental Principles and Framework: Water Policy and the National Water Act

Resource Directed Measures

Key Approaches under NWA

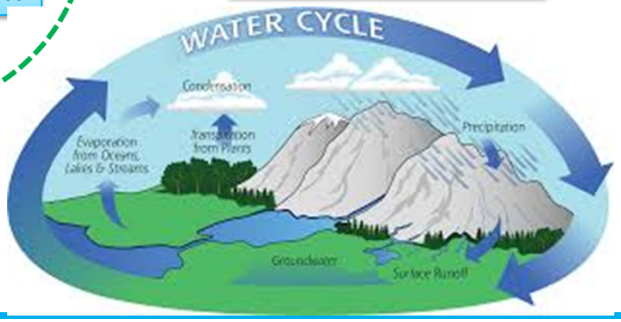
Source Directed Measures

- Protection
- Use
- Development
- Management
- Conservation
- Control

In its

WATER RESOURCES

Water courses, surface and groundwater, wetlands and estuaries

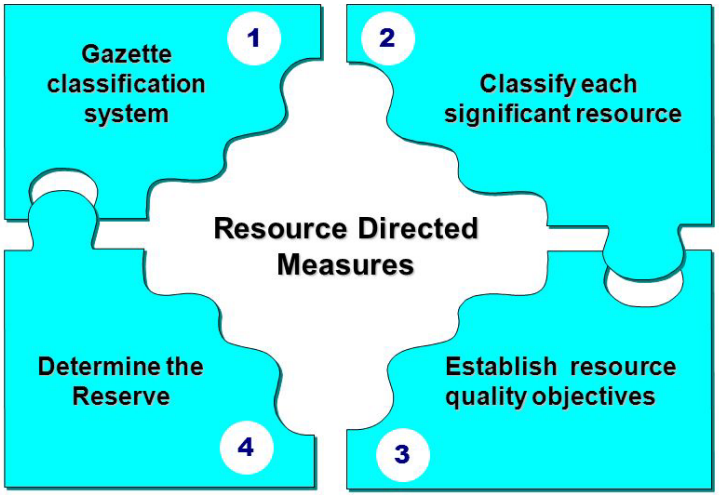


- Basic human needs of present and future generations
- Need to protect water resources
- Need to share water resources with other countries
- Need to promote socio-economic development through the use of water
- Establishment of suitable institutions

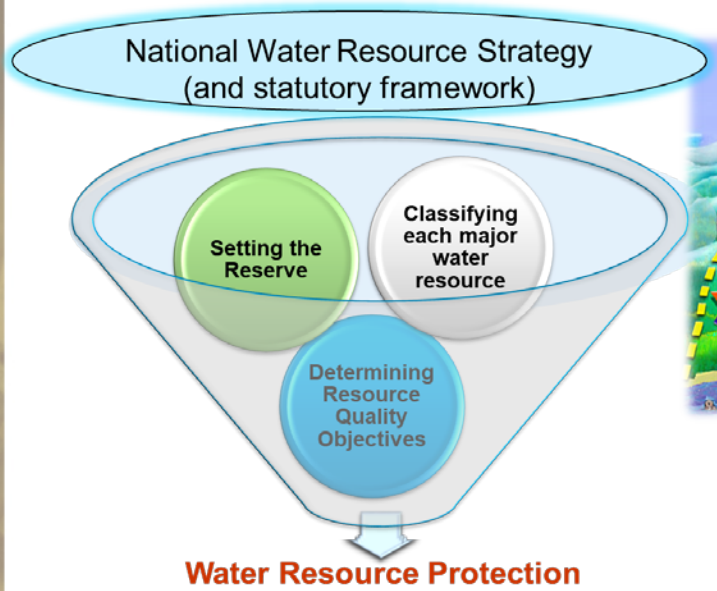
How does national government determine the level of protection required for a particular water resource?

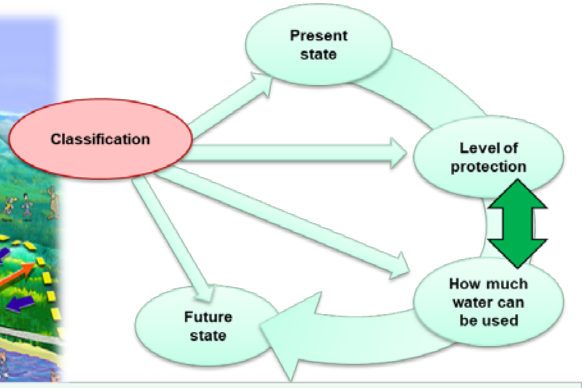
- Very few water sources that are in a natural state and therefore our water resources require protection.
- Protection is aimed at ensuring current and future use of water resources
- Quantity and quality (overall health)
- Different water resources require different levels of protection.

Chapter 3 - Resource Directed Measures (RDM) which together are intended to ensure the comprehensive protection of all water resources. These include:



Achieving integration

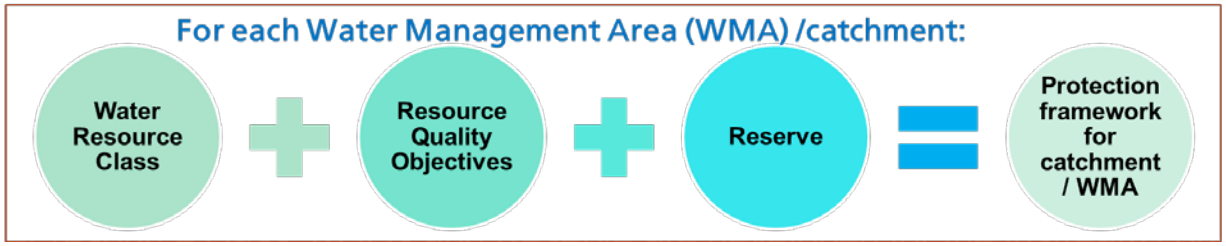




Classification is used in two ways:

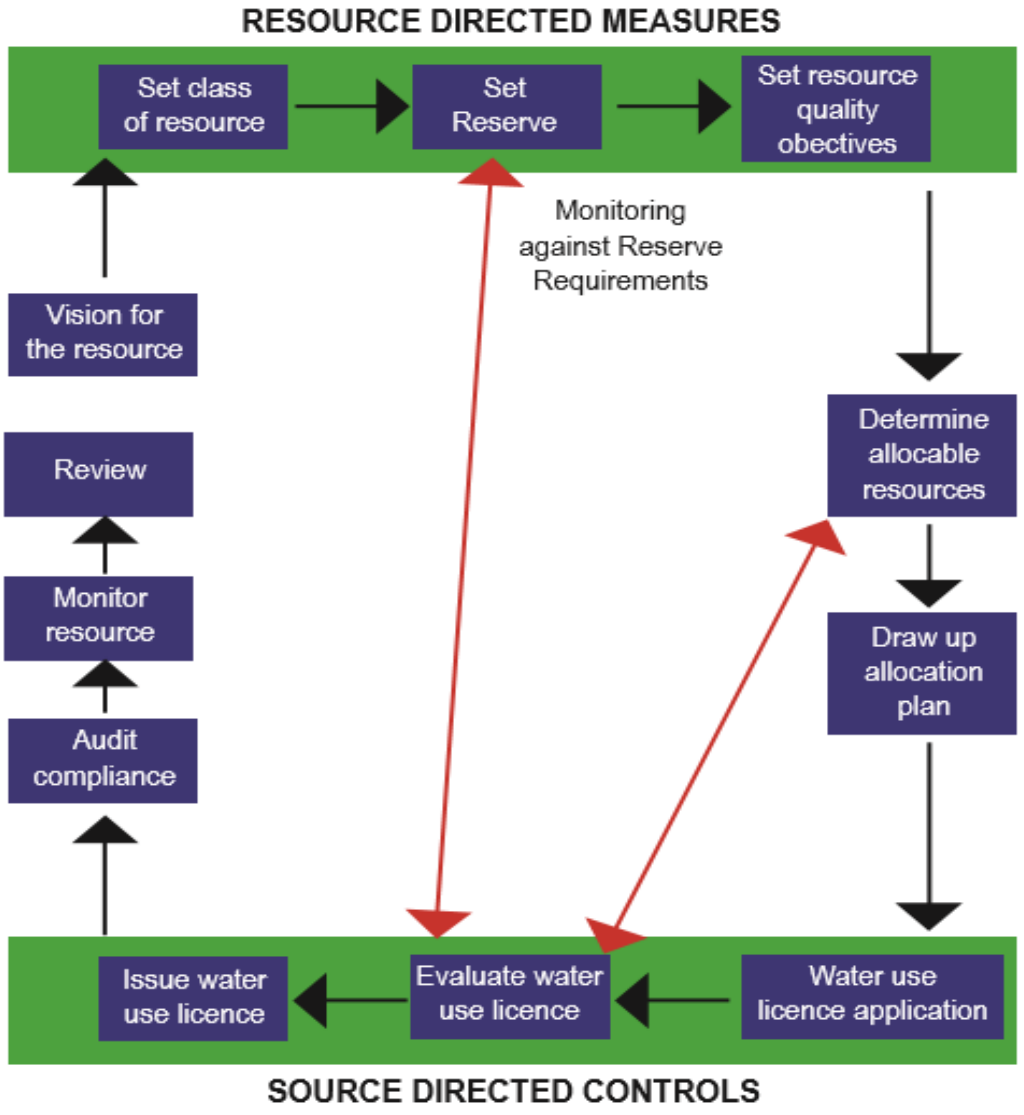
- To define the present status of the water resource
- To define the state towards which the water resource needs to be managed sustainably (future use).

The water resource class, RQOs and Reserve are developed for the instream condition of the water resource and implemented within the context of national water resource strategy and respective catchment management strategies.



Balancing Use and Protection

Integrated Water Resource Management Framework



Classifying each major resource

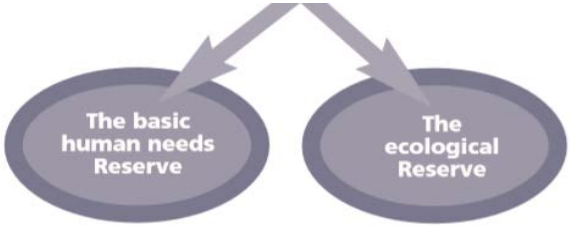
- Rivers,
- Groundwater;
- Wetlands and estuaries.

Each class represents:

- A different level of protection that is required for the water resource, and
- The extent to which water can be used.

	Description of use	Ecological Category	Description of resource
Class I	Minimally used	A-B	Minimally altered
Class II	Moderately used	C	Moderately altered
Class III	Heavily used	D	Heavily altered

Setting the Reserve

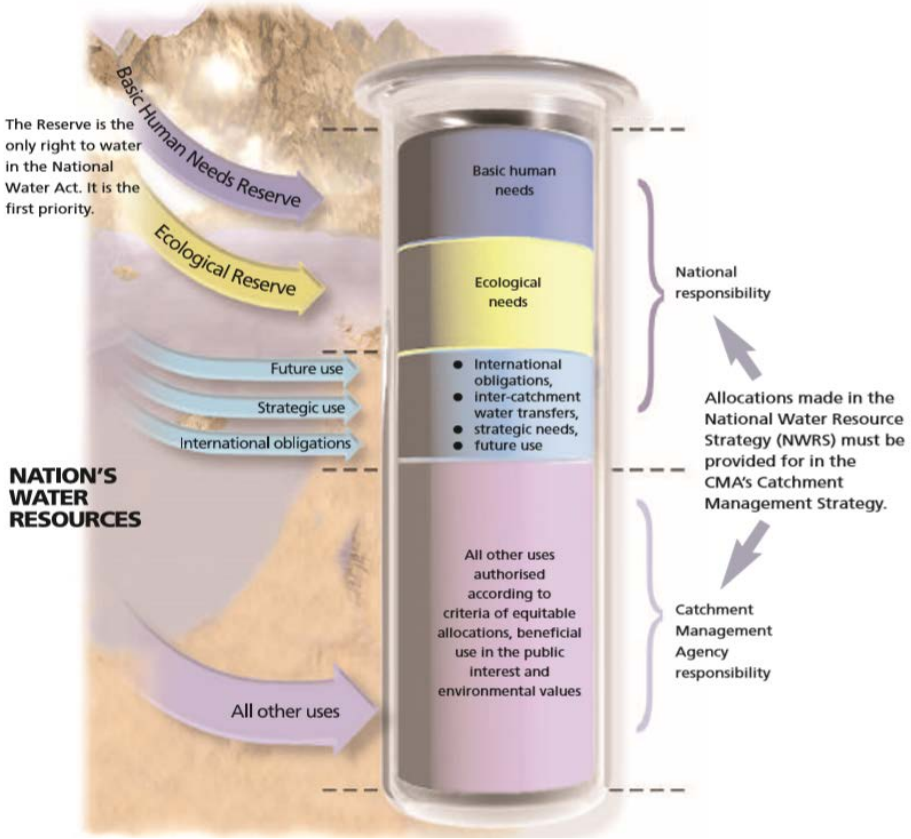


Only *RIGHT* in NWA

The Reserve is part of the water resource that is under the direct control of the Minister.

It has priority over all other water use.

Reserve must be met before water resources can be allocated to other water users



Determining Resource Quality Objectives

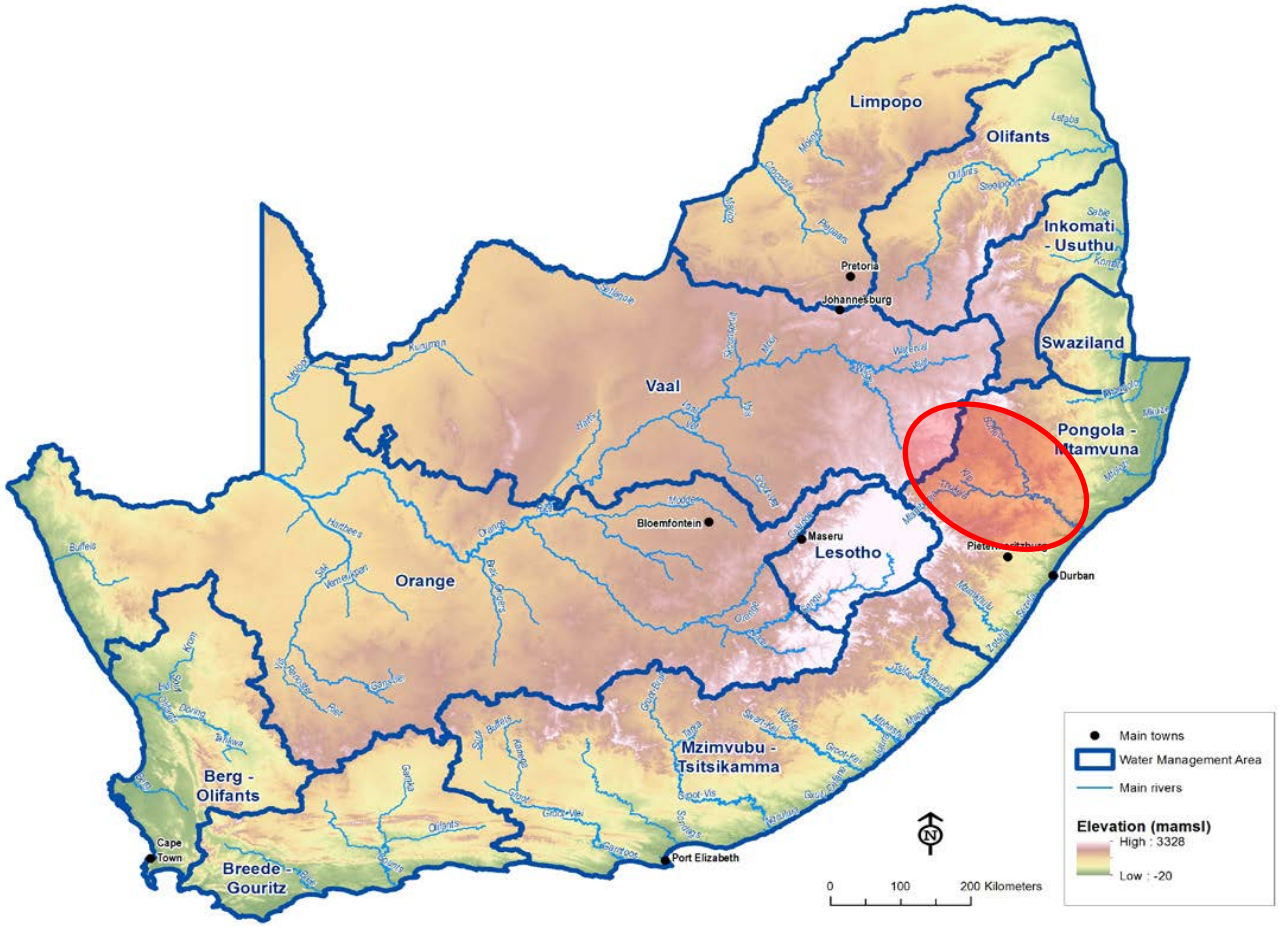
Resource quality objectives provide statements about:

- what the quantity of water should be (water level, pattern, timing)
- what the water quality should be (physical, chemical, biological)
- what the condition of the instream and riparian (river bank) habitat should be
- what the condition of the aquatic (water) animal and plant life should be.

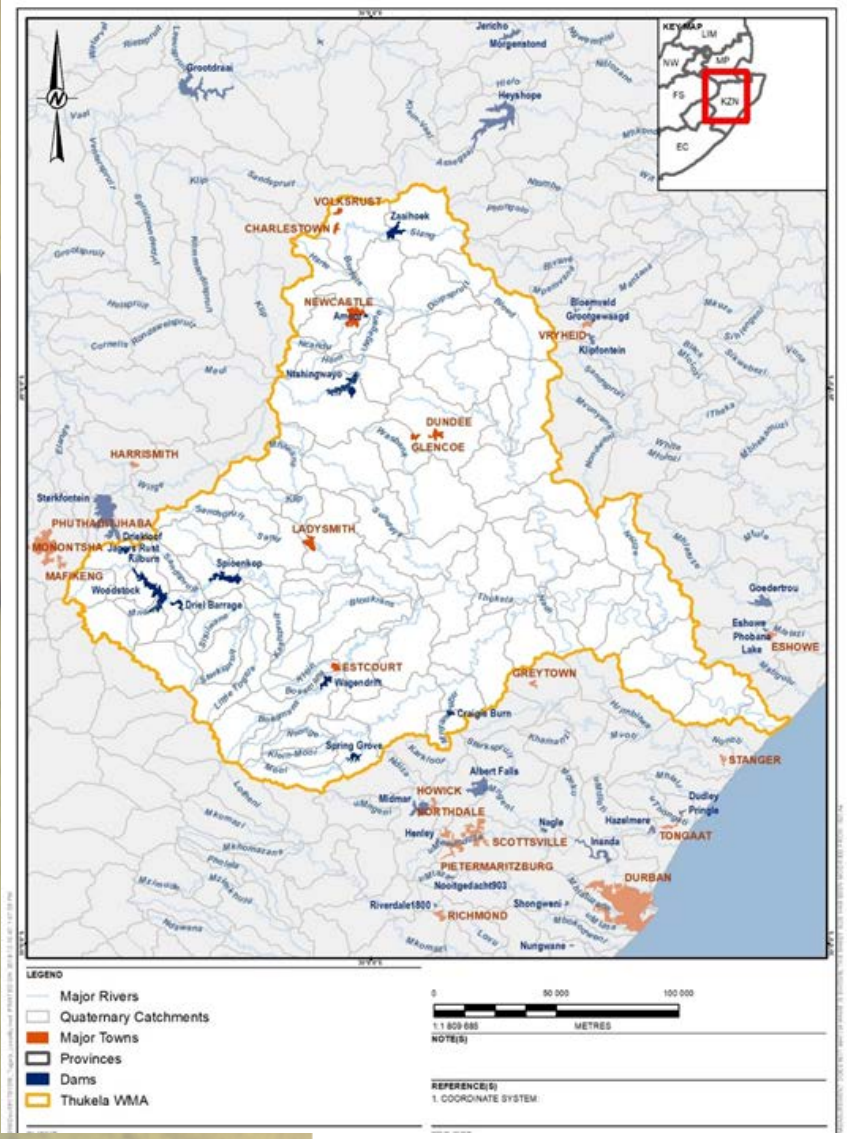
STUDY AREA

Thukela catchment

- Pongola to Mtamvuma Water Management Area (WMA 4)
- Largest river system within the WMA
- Catchment drains an area of 29 040km^2
- Two main drainage systems: Upper Thukela and Buffalo rivers

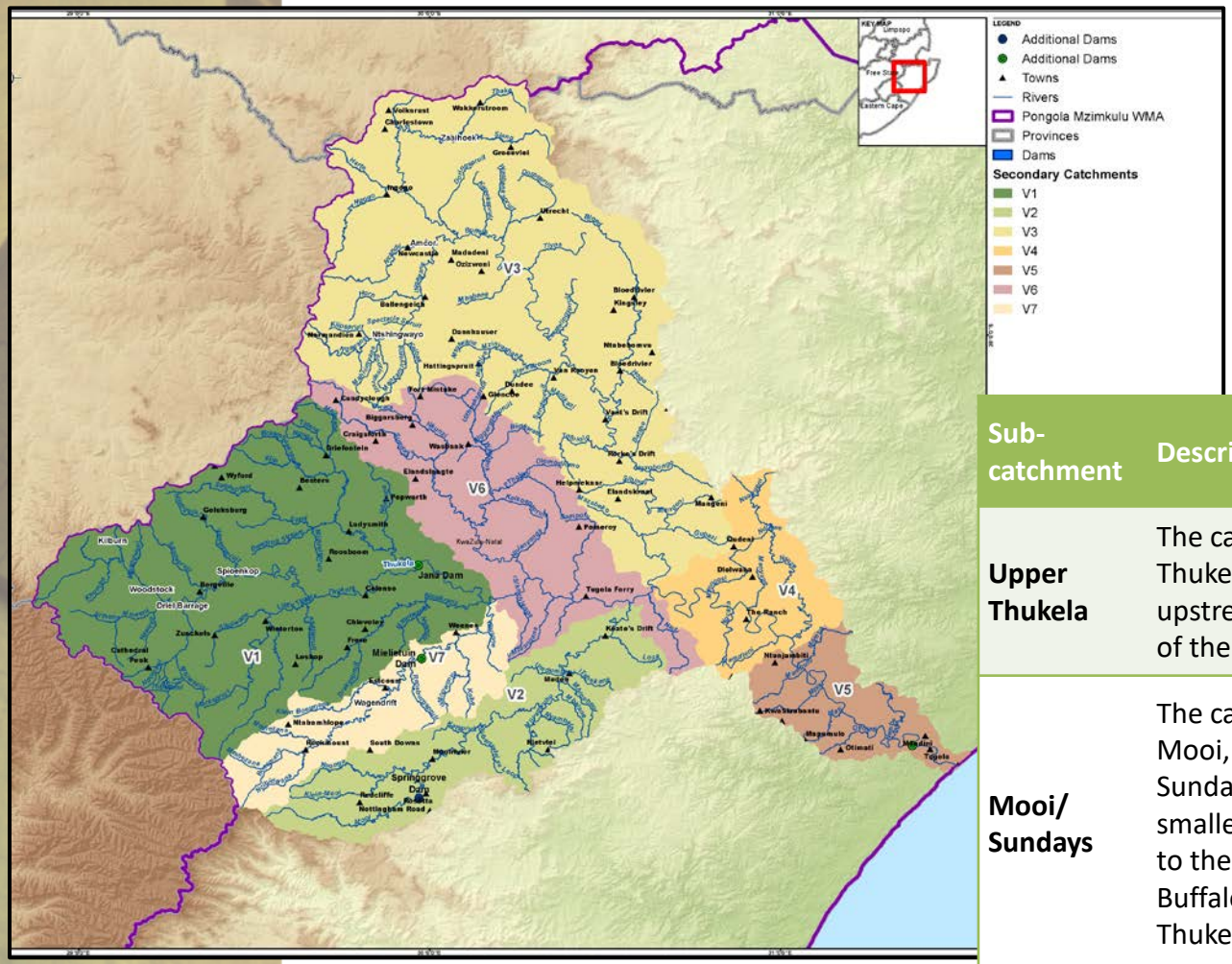


Water Resources



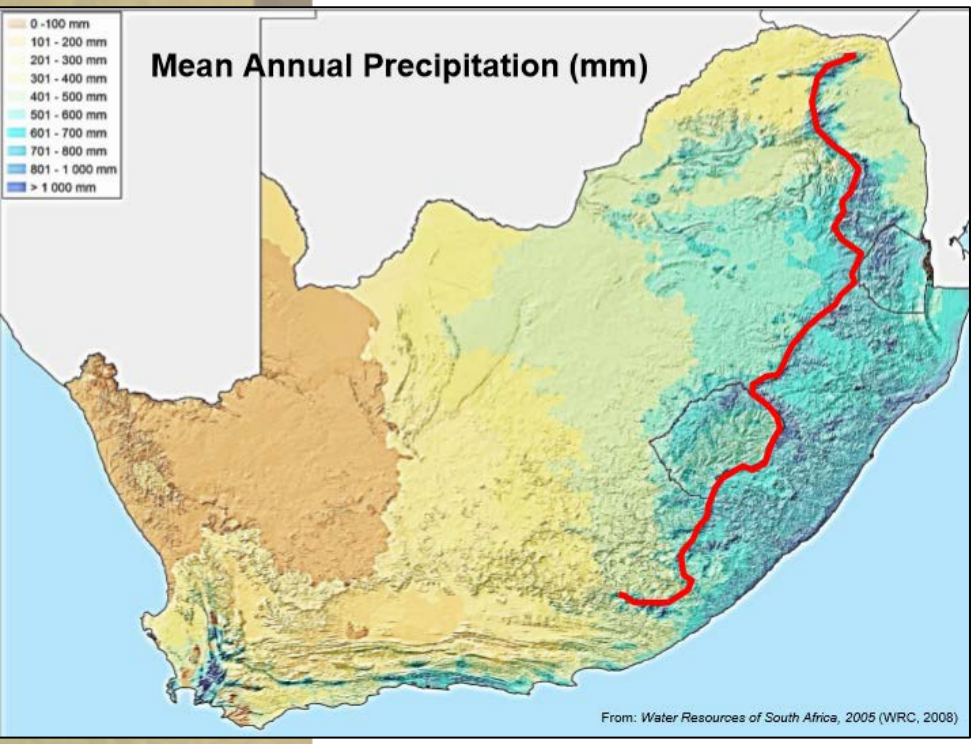
- Tugela River – primary river
- Major surface water resource of SA
- Originates on the 3050 m high Mont-aux-Sources plateau in the Drakensberg Mountain Range along the border between Lesotho and the KZN
- a funnel shaped catchment with several tributaries
- discharge into the Indian Ocean on the eastern side of catchment (512 km).
- 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.
- Thukela Estuary
- Aquifers – weathered and fractured hard rock systems
- Protected Wetlands

Key sub-catchments



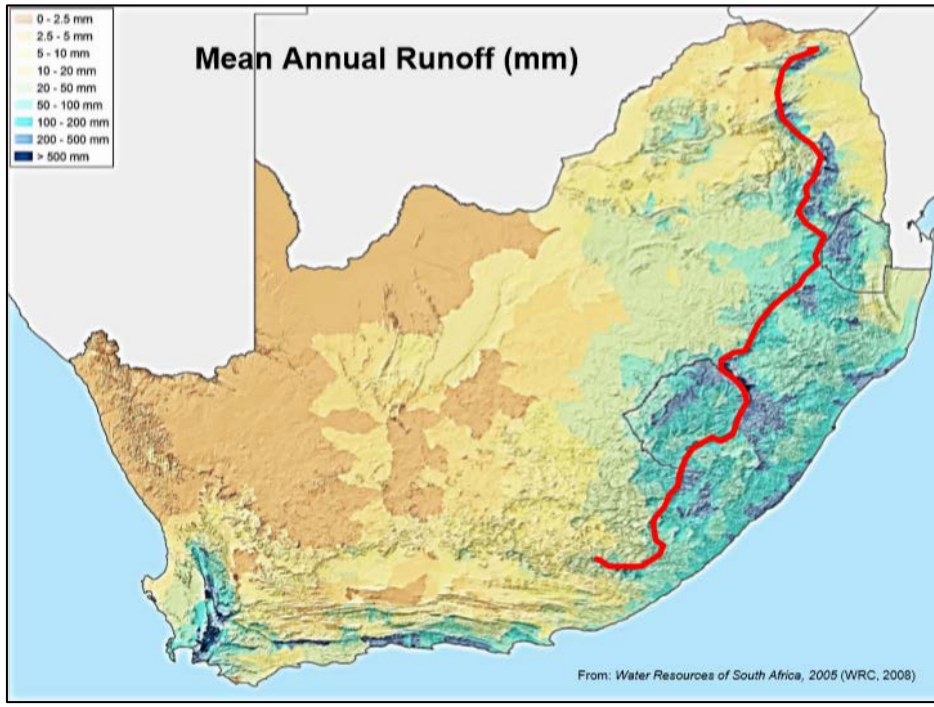
Sub-catchment	Description	Tertiary drainage regions	Catchment area[1] (km^2)
Upper Thukela	The catchment of the Thukela River to just upstream of the confluence of the Bushmans River.	V11, V12, V13 and V14	7645
Mooi/ Sundays	The catchment of the Mooi, Bushmans and Sundays River as well as of smaller 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

Hydrological characteristics



- Rainfall average SA = 450mm
- Thukela ranges = 800 to 1500 mm

- Second highest MAR of 3799 Mm^3/a,
- 9.9% of South Africa's total runoff after the Orange/ Gariep River
- Transfers - 60 to 70 % of yield



OVERVIEW OF TECHNICAL PROCESS

Key aims of this study

- co-ordinating the implementation of the Water Resource Classification System (WRCS); and
- undertaking the implementation of the RQO determination procedure (7 step process)

- It is noted that the study is linked to the previous Reserves studies and other water resource management initiatives.
- Where the preliminary Reserve is available and relevant, this information is to be adopted and where needed, gaps will be filled.

Water Resource Classes and RQOs

Integrated Process

Reserve

- Step 1: Confirm, quantify and finalise EWRs
- Step 2: Describe status quo and delineate Integrated Units of Analysis (IUA)s and Resource Units (RUs)
- Step 3: Identify and model scenarios within IWRM, and evaluate with stakeholders
- Step 4: Determine water resource class
- Step 5: Determine RQOs (narrative and numerical limits)
- Step 6: Agree on classes and RQOs with stakeholders
- Step 7: Finalise and prepare for gazette

Status quo - water resources and systems, water use, economy, river and wetland ecology, water quality problems and ecosystem services and attributes

Integrated units of analysis (IUAs) - spatial units that will be defined as significant water resources

Resource Units (RUs) and biophysical nodes identified for different levels of Ecological Water Resource Requirements (EWR) assessment and setting of RQOs

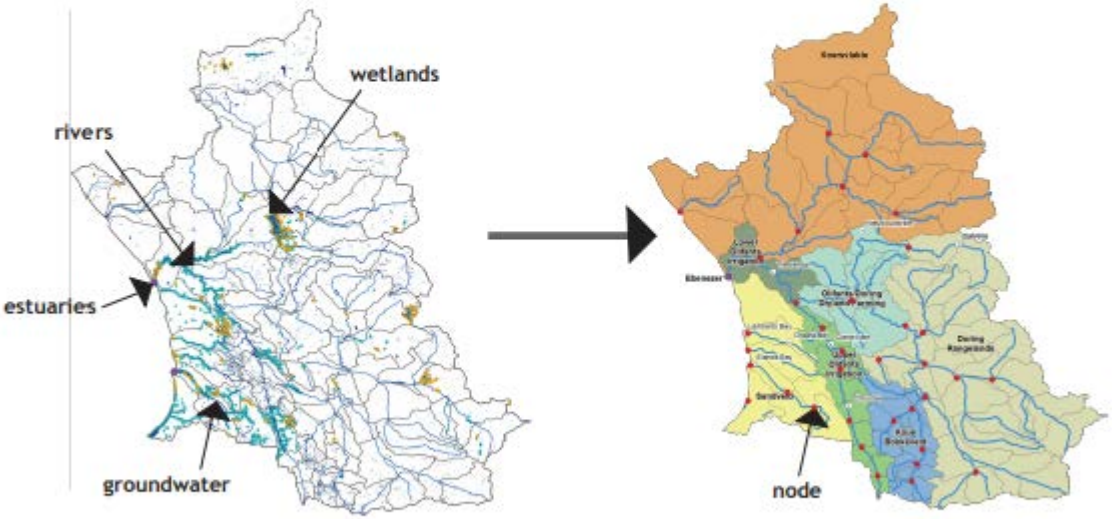
Water Resource Classification

Step 2: Describe the status quo and delineate IUAs and RUs

- Identify a network of significant resources, describe water resource infrastructure and identify water user allocations.
- Define a network of significant resources and establish biophysical nodes.
- Define Integrated Units of Analysis.

STEP 1. DELINEATE THE CATCHMENT AND DESCRIBE THE STATUS QUO

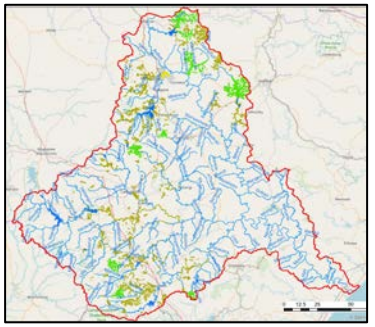
Outcome: Integrated Units of Analysis with nested sub-units (Nodes)



Base layer		Quaternary Catchments
TIER I	Addition	Ecoregions level I
TIER II	Addition	Hydrological index
TIER III	Addition	Geomorphological zones
TIER IV	Addition	Tributaries
TIER V	Addition	Ecological Importance and Sensitivity
TIER VI	Addition	Present Ecological Status/ Habitat Integrity
TIER VII	Removal/ Addition	Infrastructure
TIER VIII	Addition	RDM data
TIER IX	Removal	***First level rationalisation***
TIER X	Addition	Water management/planning/allocation
TIER XI	Addition	IWAs and BHN

Minimum

Sub-quaternary level



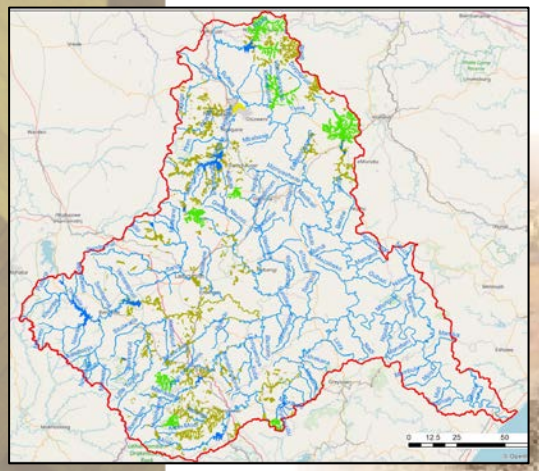
Water Resource Classification

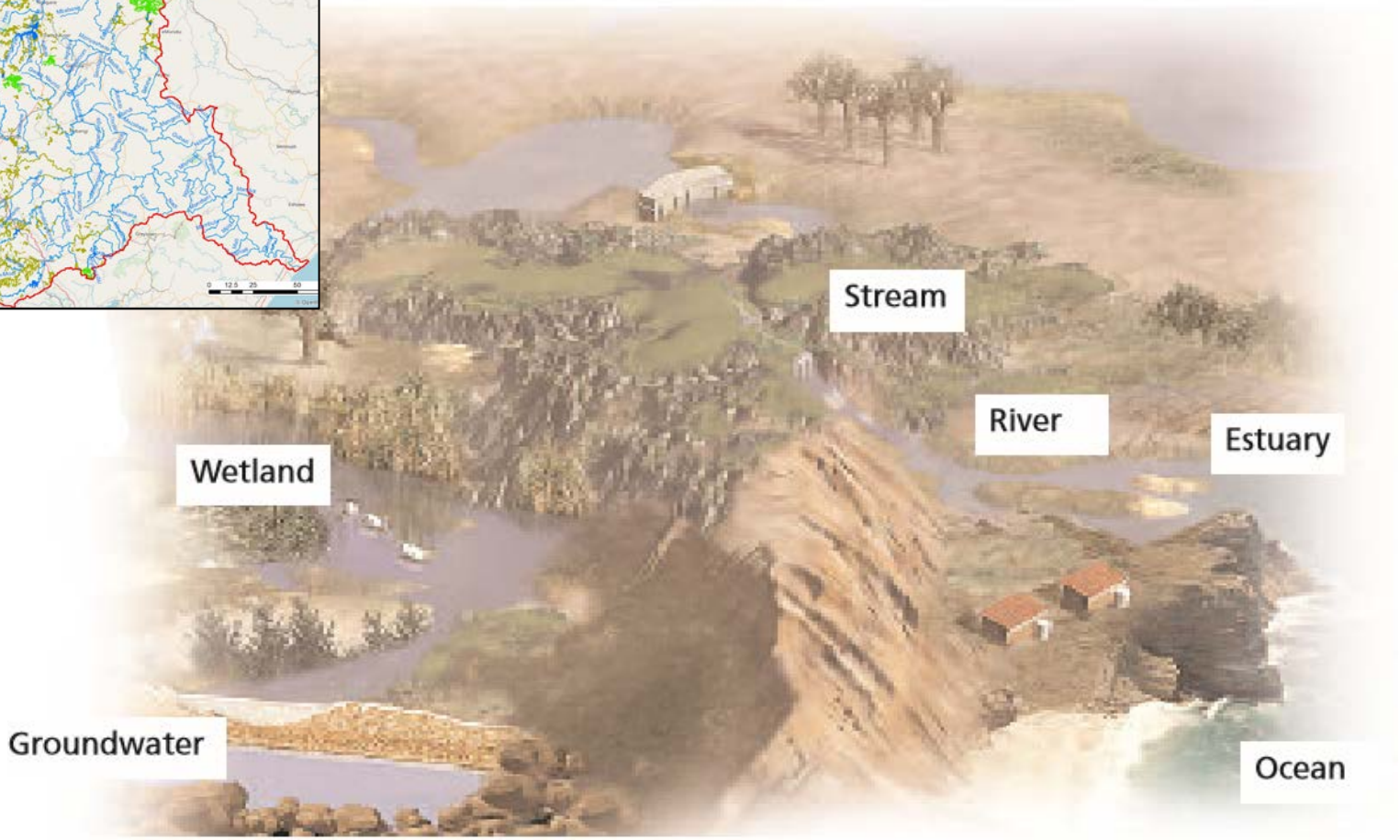
Step 2: Describe the status quo and delineate IUAs and RUs

- 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 proposed IUA.
- Present status of water resources.
- Stakeholder input.

STEP 2: DESCRIBE THE STATUS QUO AND DELINEATE IUAs AND RUs

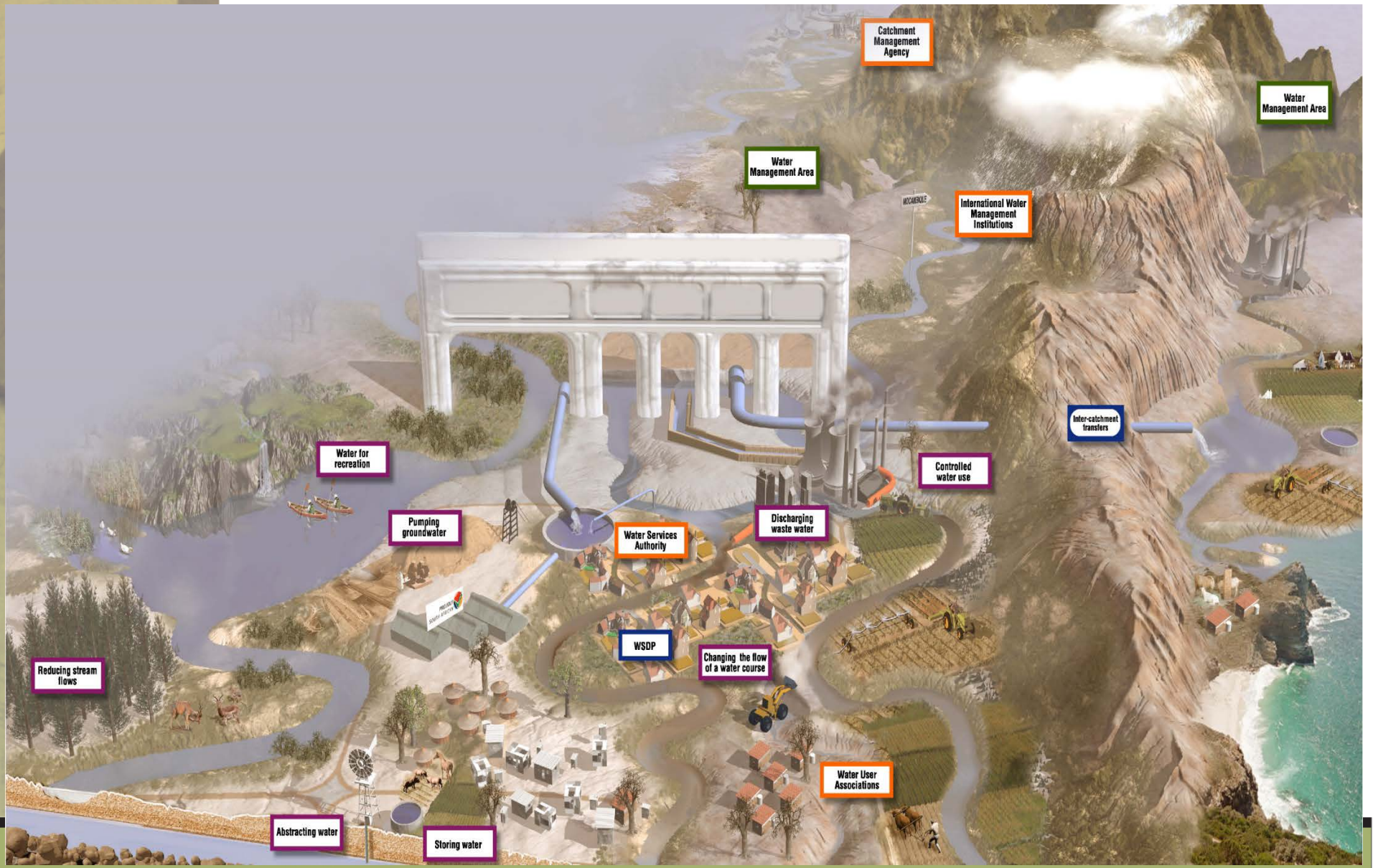
Network of Significant Water Resources





STEP 2: DESCRIBE THE STATUS QUO AND DELINEATE IUAs AND RUs

Location of Significant Water Resource Infrastructure and Uses

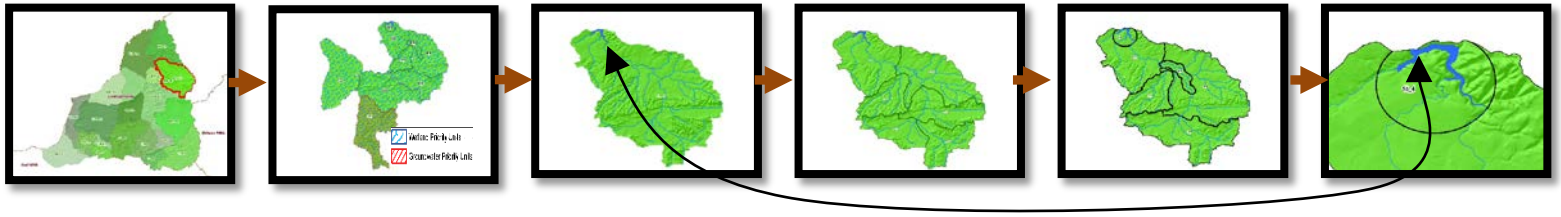


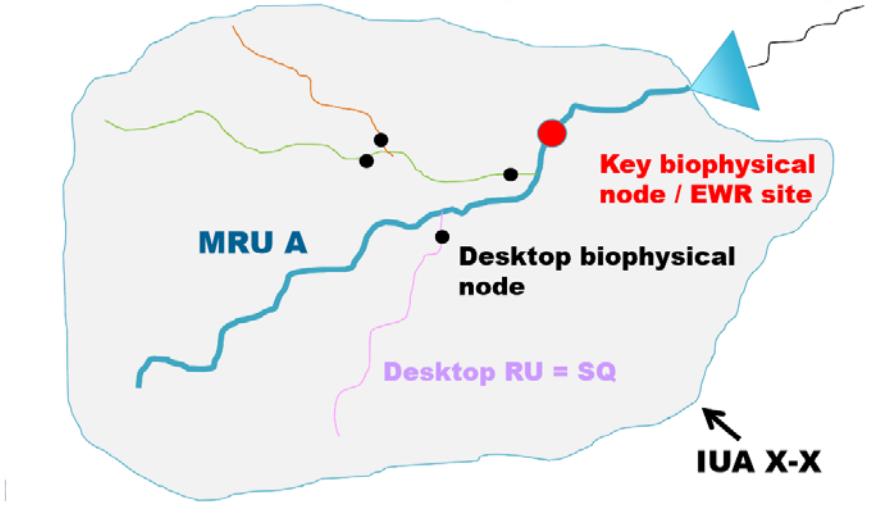
STEP 2: DESCRIBE THE STATUS QUO AND DELINEATE IUAs AND RUs

Resource Units

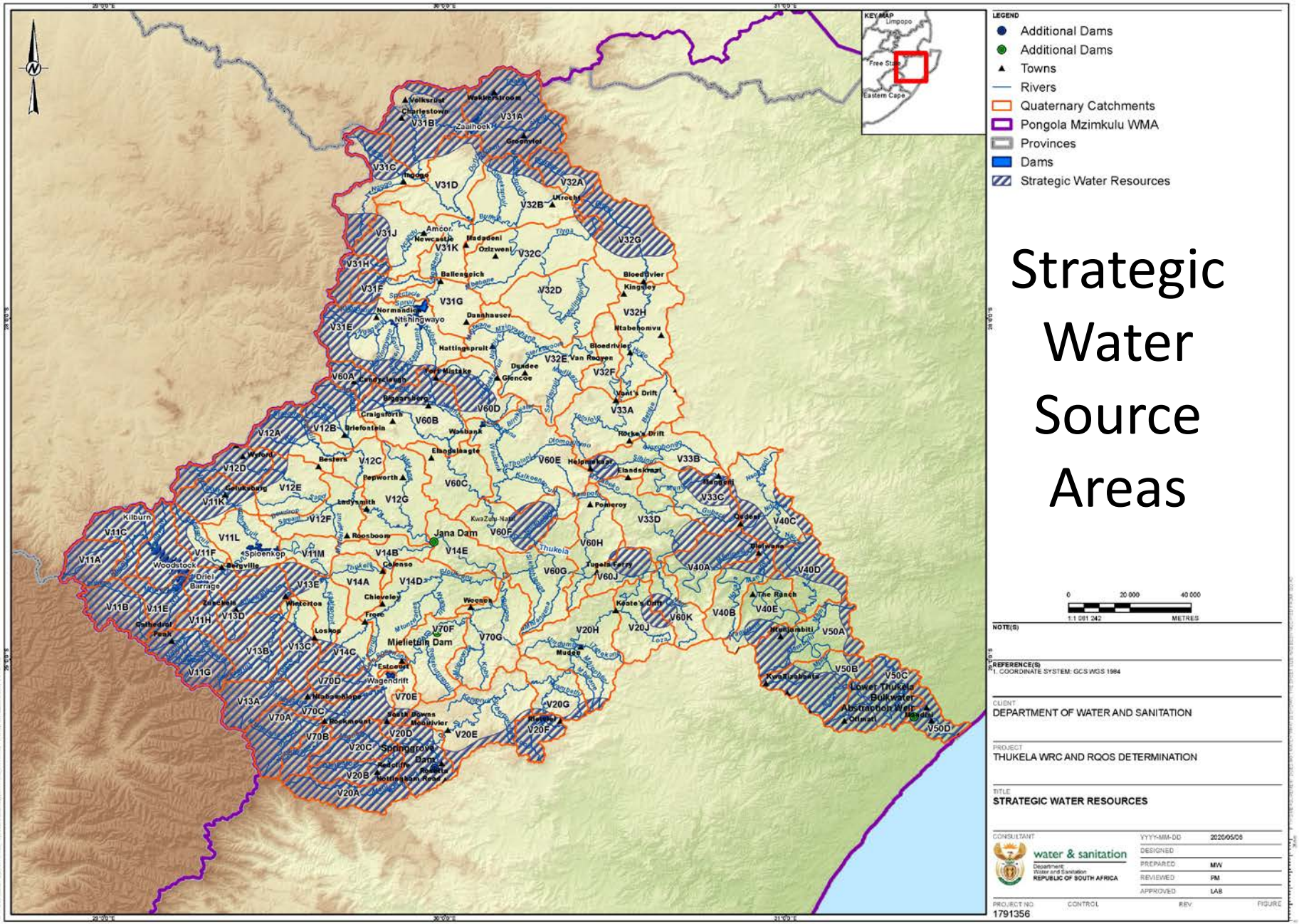
RIVERS | **WETLANDS** | **GROUNDWATER** | **DAMS**

IUAs in catchment → Priority Wetland and Groundwater areas in IUAs → Rivers and nodes → Sub Quaternaries → Rivers RUs → Important Dam RUs



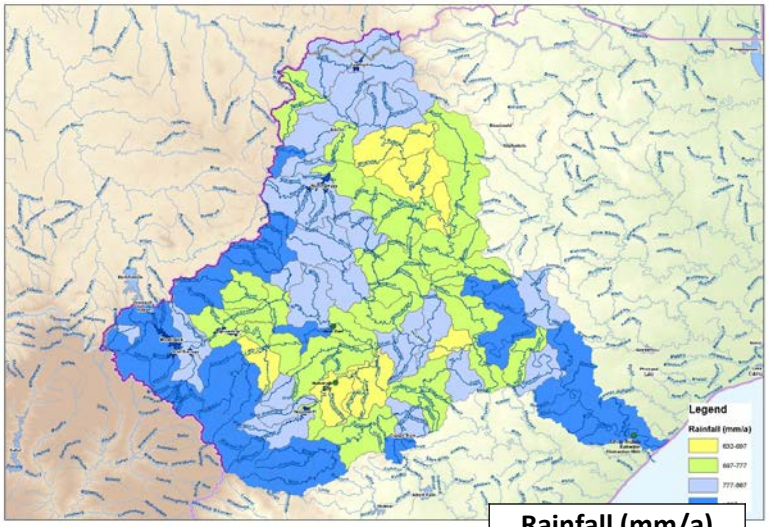


STATUS QUO


KEY MAP
Limpopo
Free State
Eastern Cape
LEGEND
Additional Dams
Additional Dams
Towns
Rivers
Quaternary Catchments
Pongola Mzimkulu WMA
Provinces
Dams
Strategic Water Resources
Strategic Water Source Areas
Jana Dam
Mielietuin Dam
Springgrove Dam
Lower Thukela Bulkwater Abstraction Weir
0 20 000 40 000
1:1 081 242 METRES
NOTE(S)
REFERENCE(S)
1. COORDINATE SYSTEM: GCS WGS 1984
CLIENT
DEPARTMENT OF WATER AND SANITATION
PROJECT
THUKELA WRC AND RQOS DETERMINATION
TITLE
STRATEGIC WATER RESOURCES
CONSULTANT
water & sanitation
Department: Water and Sanitation
REPUBLIC OF SOUTH AFRICA
YYYY-MM-DD 2020/05/08
DESIGNED
PREPARED MW
REVIEWED PM
APPROVED LAB
PROJECT NO 1791356
CONTROL
REV
FIGURE

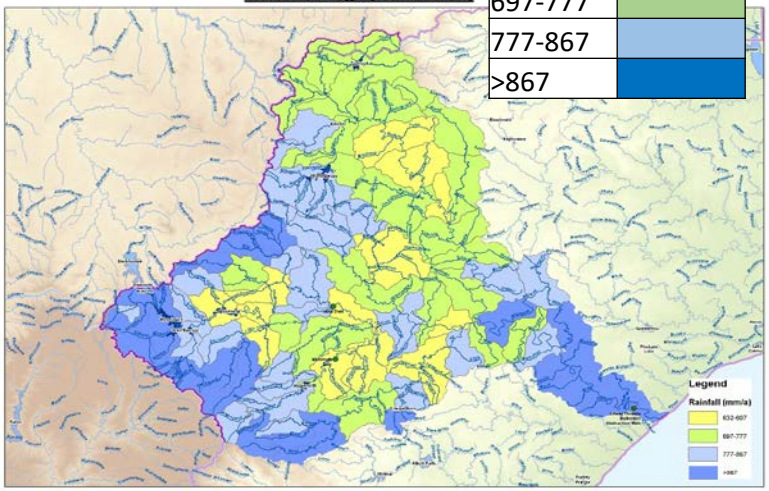
Climate change: rainfall (NIWIS)

Rainfall Range (1975 - 2006)

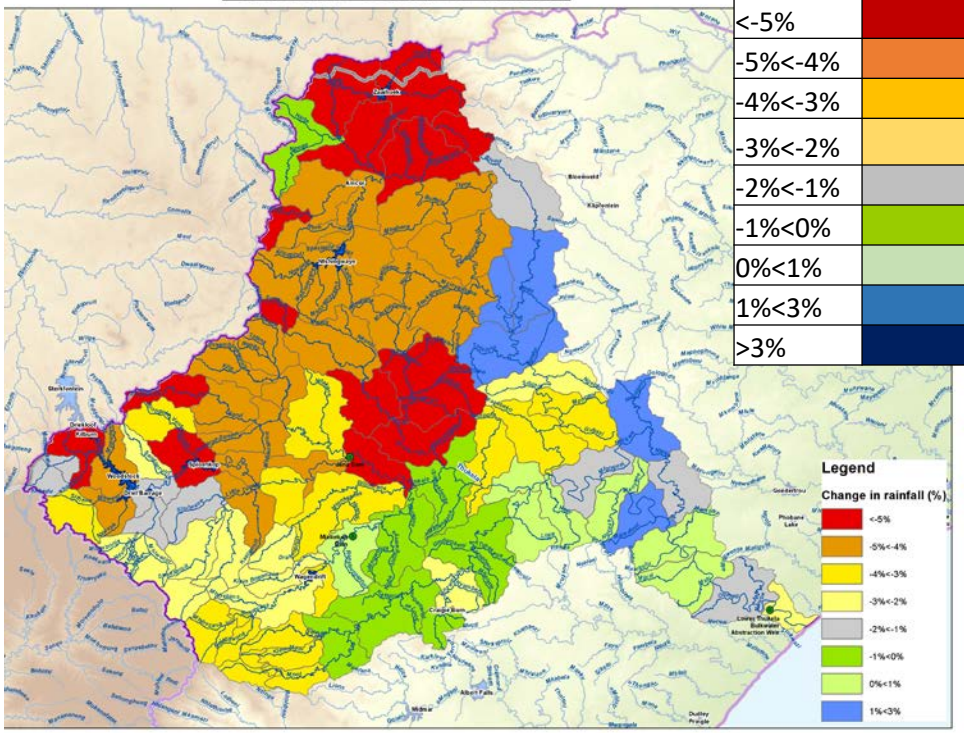


Rainfall (mm/a)	
632-697	
697-777	
777-867	
>867	

Rainfall Range (2016 - 2045)

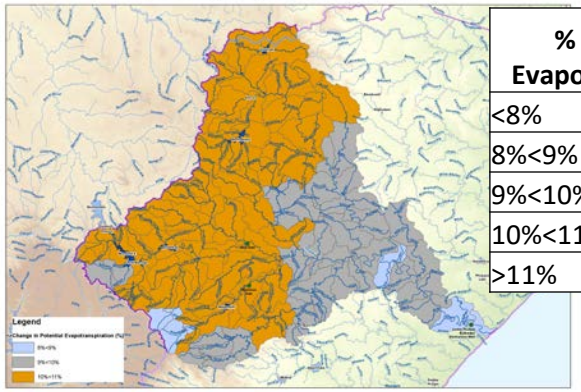


Percentage Change in Rainfall



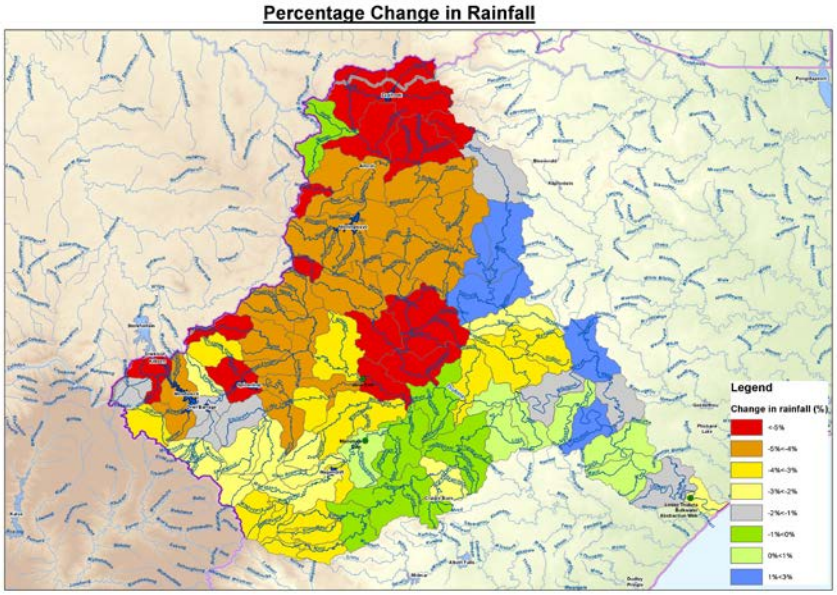
% rainfall change	
<-5%	
-5%<-4%	
-4%<-3%	
-3%<-2%	
-2%<-1%	
-1%<0%	
0%<1%	
1%<3%	
>3%	

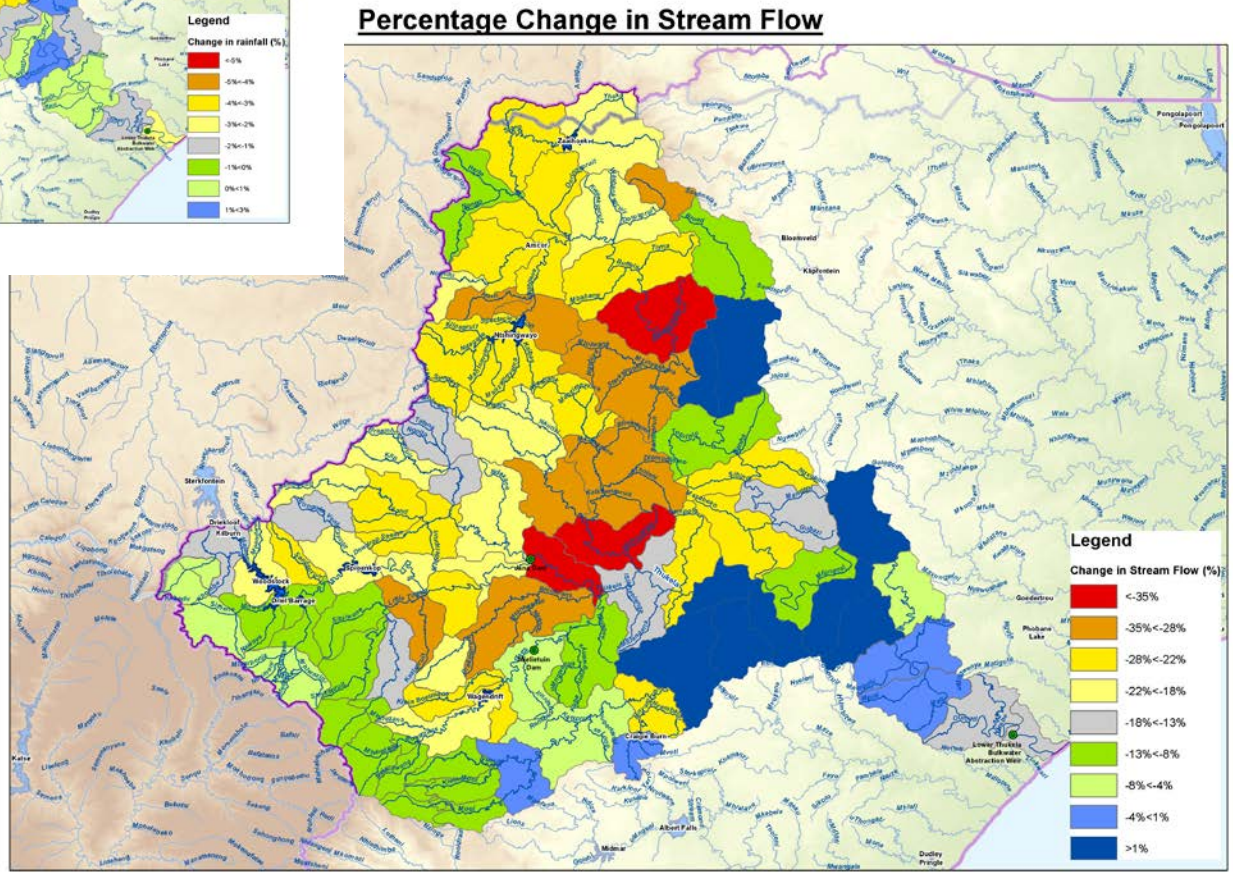
Percentage Evapotranspiration change



% Change in Evapotranspiration	
<8%	
8%<9%	
9%<10%	
10%<11%	
>11%	

Climate change: rainfall and streamflow changes





Water Resource Systems Analysis

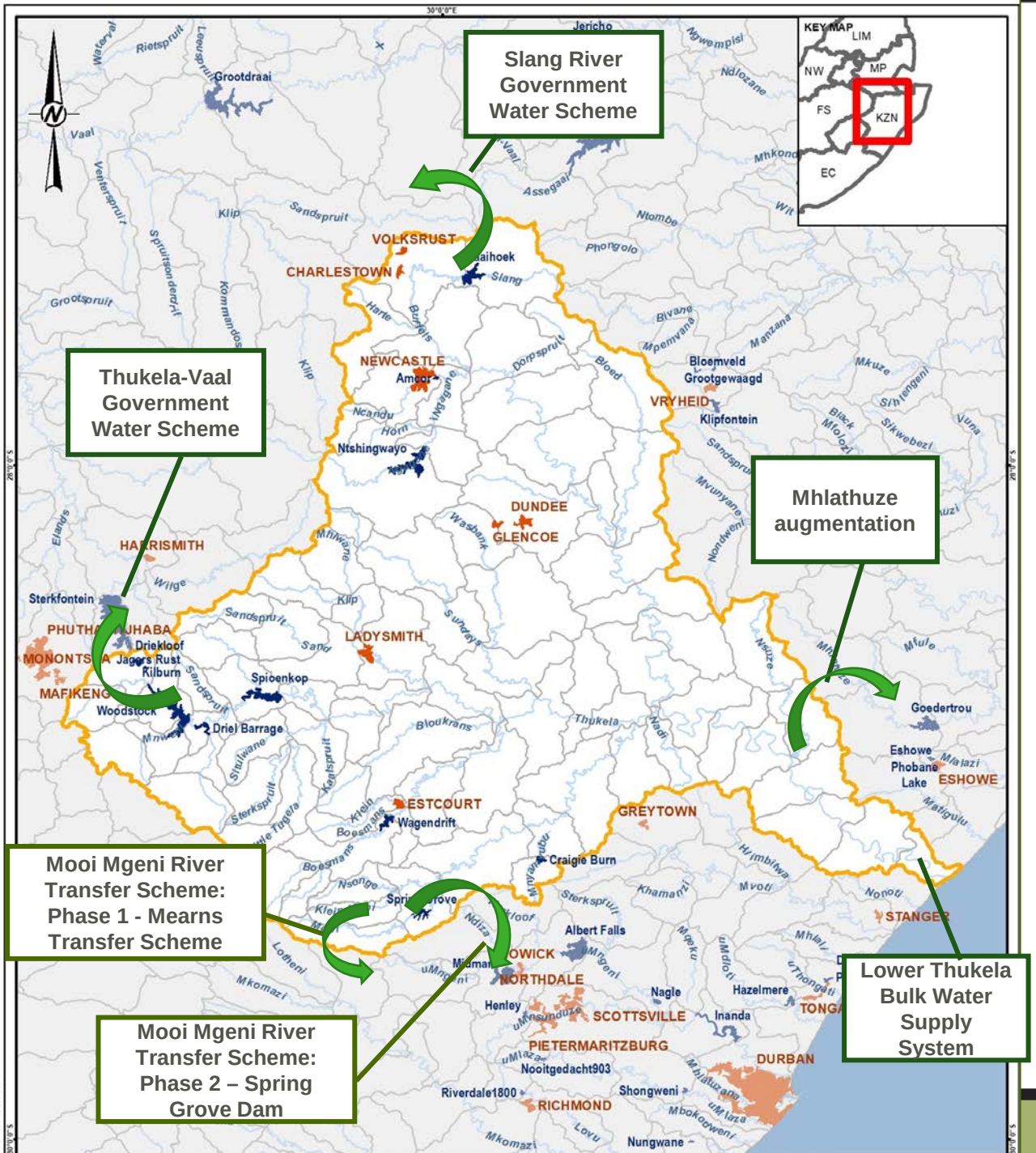
Major Dams

Dam name	Sub - catchment	Purpose	Capacity (million m3)
Woodstock	Upper Thukela	Water transfer	373.25
Spioenkop	Upper Thukela	water supply and irrigation	270.64
Qedusizi	Upper Thukela	Flood Control (operated empty)	±200
Zaaihoek	Buffalo	Water transfer	184.63
Ntshingwayo	Buffalo	Water supply and irrigation	194.56
Spring Grove	Mooi	Water Transfer and Irrigation	139.46
Mearns Weir	Mooi	Water Transfer and Irrigation	5.12
Craigieburn	Mooi	Water supply and irrigation	22.47
Wagendrift	Boesmans	Water supply and irrigation	55.90

Water Resource Systems Analysis

Minor Dams

Quaternary catchment	River Catchment	Total surface area of small dams (km^2)	Total capacity of small dams (million m^3)
TM05 (U/S Spioenkop)	Upper Tugela River	6.21	22.9
TM02 (U/S Woodstock)		3.82	14.1
TM08		9.77	36.2
TM11	Klip River	13.2	48.9
TM10	Upper and Middle Tugela River, Klip River	11.28	41.8
TM06	Upper Tugela River	2.54	9.4
TM14	Sundays River	11.28	41.8
TM28A	Middle Buffalo	12.32	38.2
TM28B	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**



Inter-basin Transfers

Scheme	Capacity#	Operating rules*
Thukela Vaal Scheme	20 m^3/s (1 700 ML/d)	To fill Sterkfontein Dam and support Vaal System.
Buffalo Vaal Scheme	2.16 m^3/s (186 ML/d)	To supply Majuba PS and support Grootdraai Dam.
Mooi Mgeni Transfer Scheme (phase 1 and 2)	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)	1.0 m3/s (86 ML/d)	Support Mhlathuze by pumping until Goedetrouw Dam > 60%
Lower Thukela Bulk Water Supply Scheme (phase 1)	0.63 m^3/s (55 ML/d)	To supply users along North coast (KwaDukuza)

Sub-systems water availability

Upper Thukela

	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%

Mooi Sundays

	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%

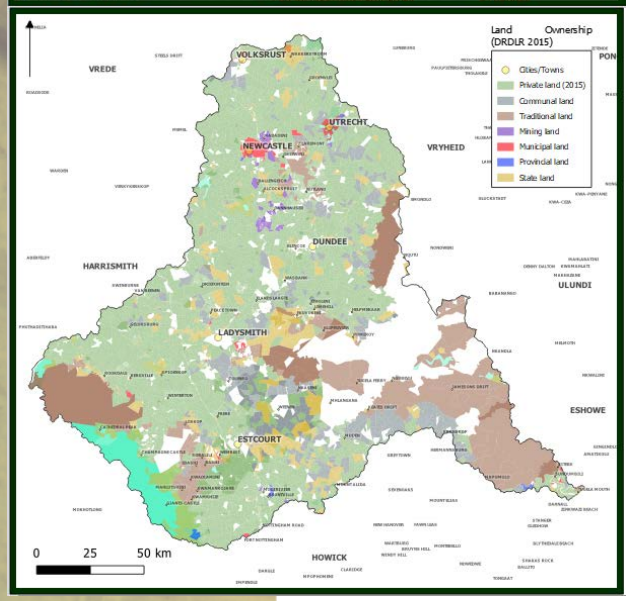
Buffalo

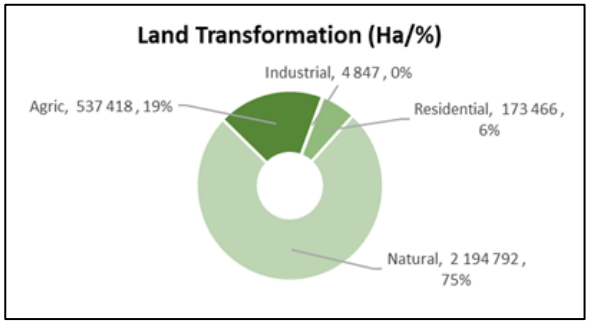
	Volumes as per 2015 projection (million m^3/a)		
Sector	Requirement	Supply	Percentage Supply
Irrigation	66.9	50.2	75%
Afforestation	16.7	14.2	85%
Rural / Urban / Industrial	57.1	56.5	99%
Transfer	31.6	31.6	100%
Total	172.3	152.5	89%

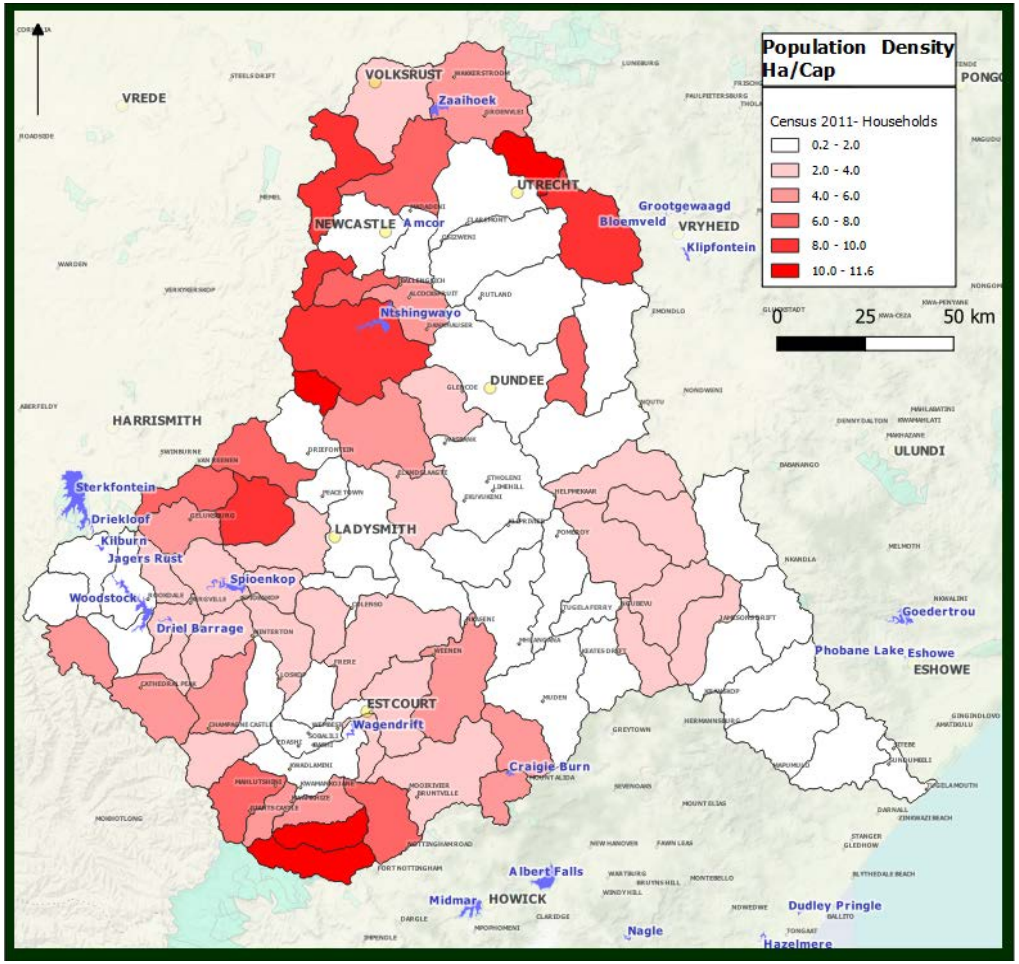
Lower Thukela

	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%

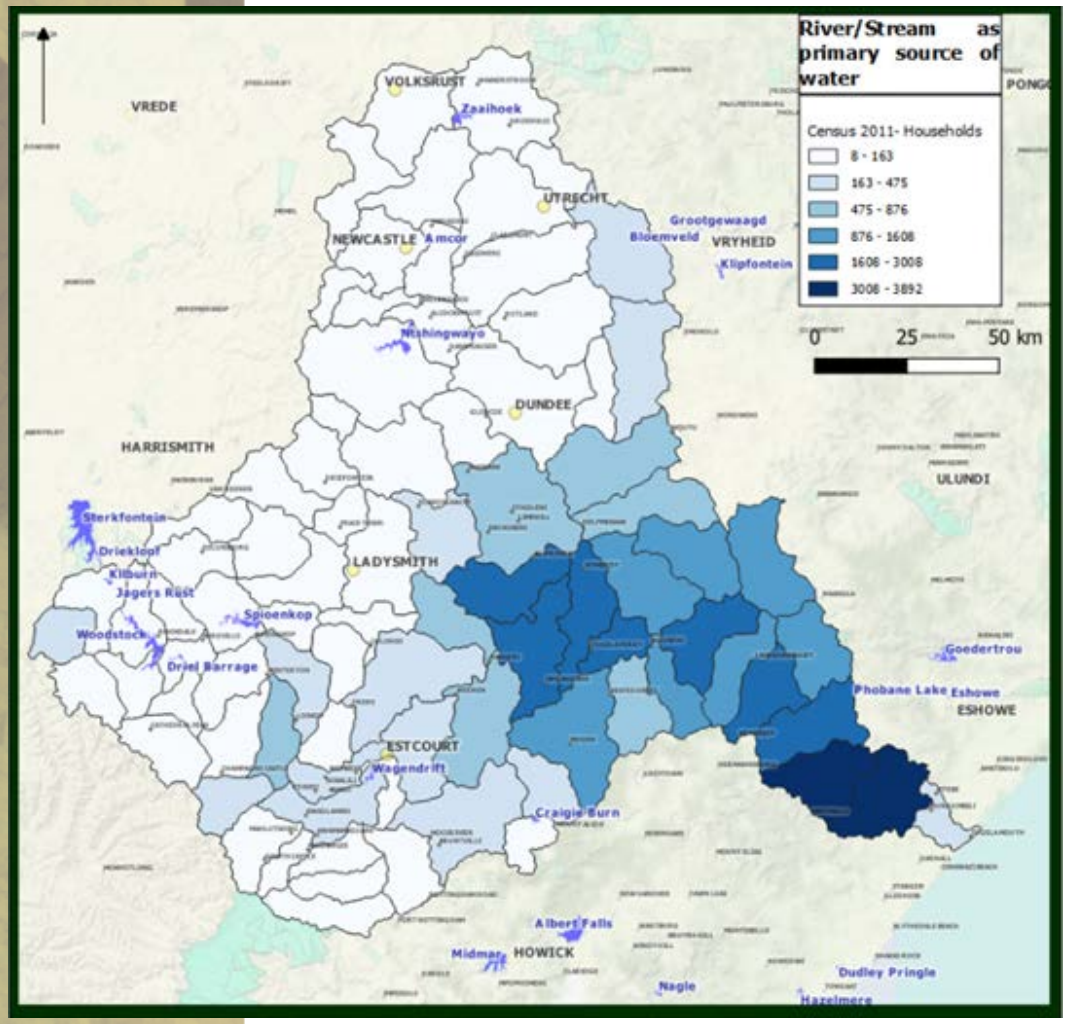
Socio-economics

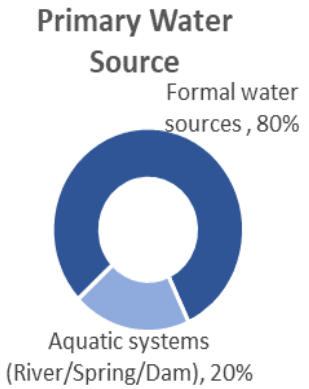


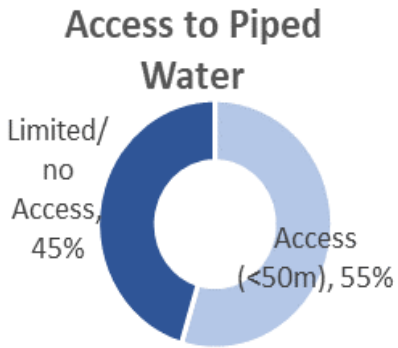




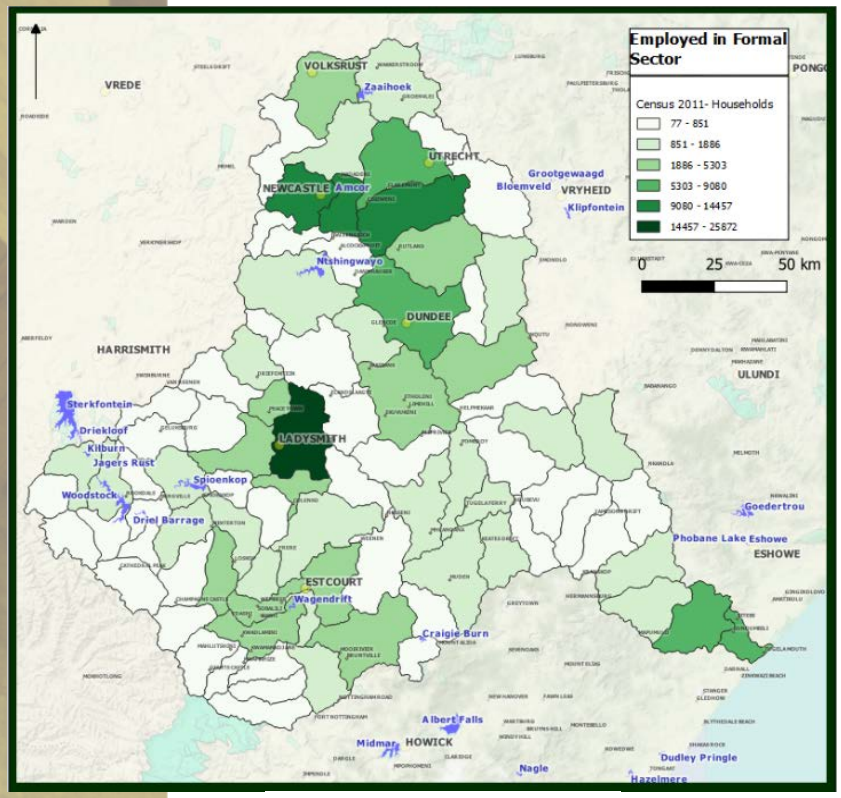
Reliance on rivers, streams, and dams as primary source

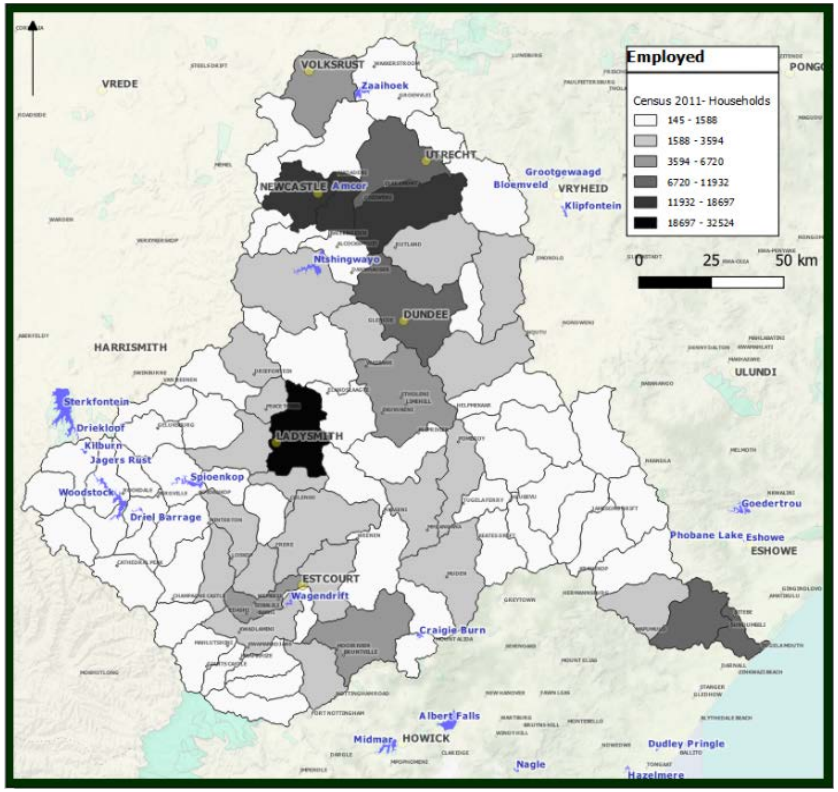




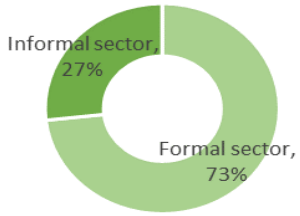


Employment statistics

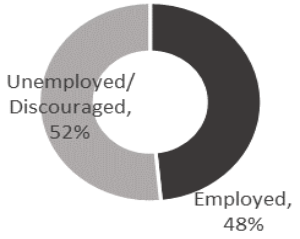




Employment Sector



Employment



Economic Sectors

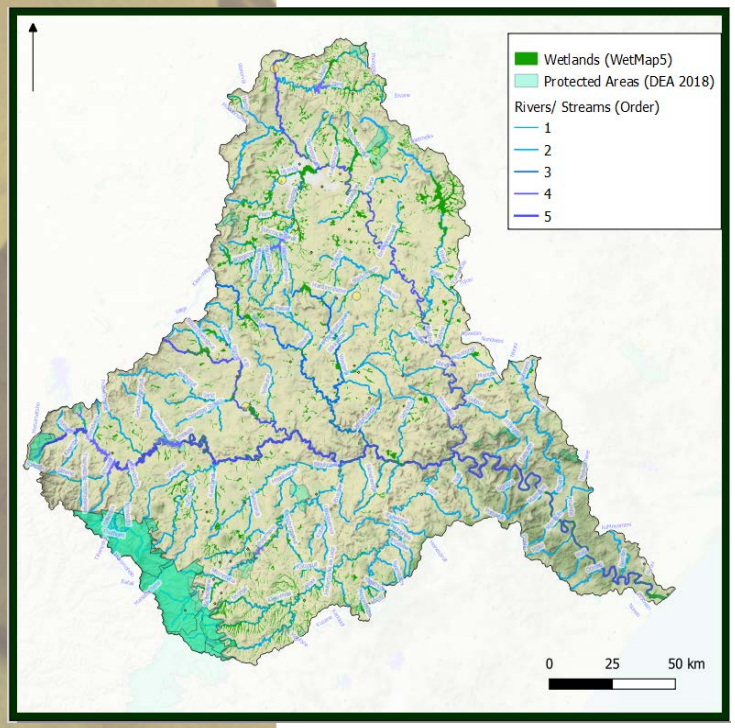
Sources of income

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%

Estimated GDP and salaries

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

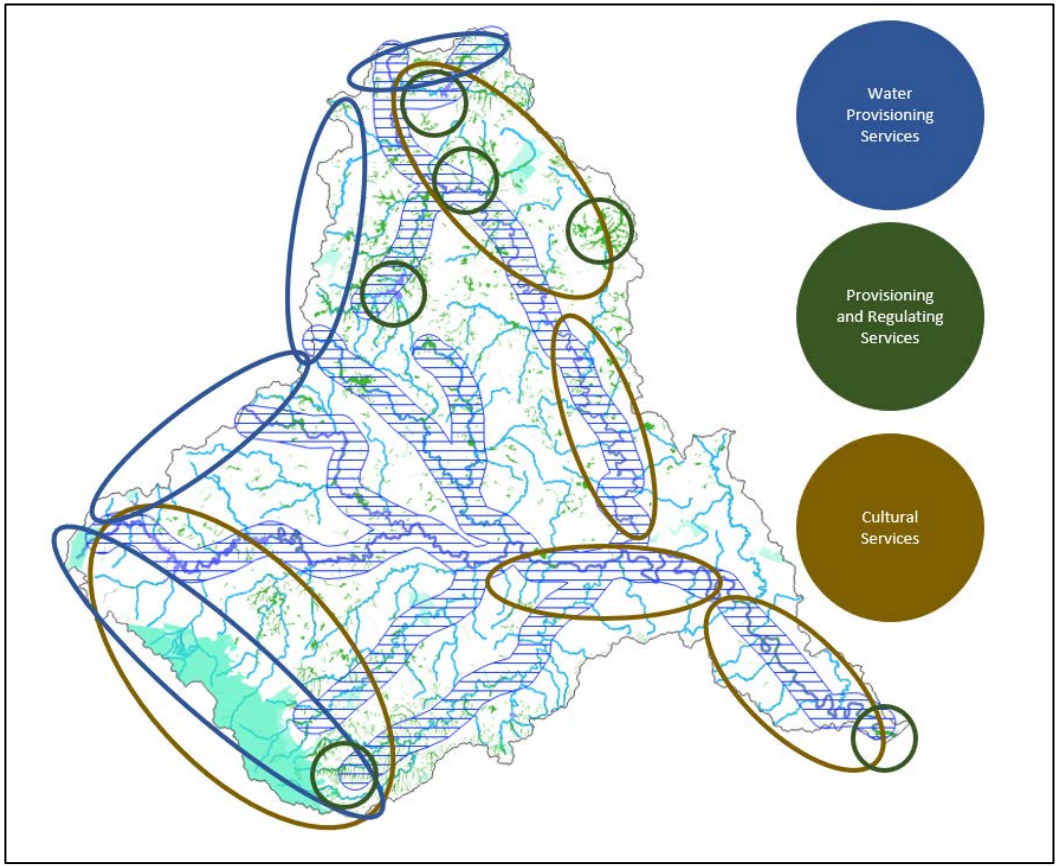
Ecological Infrastructure



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.

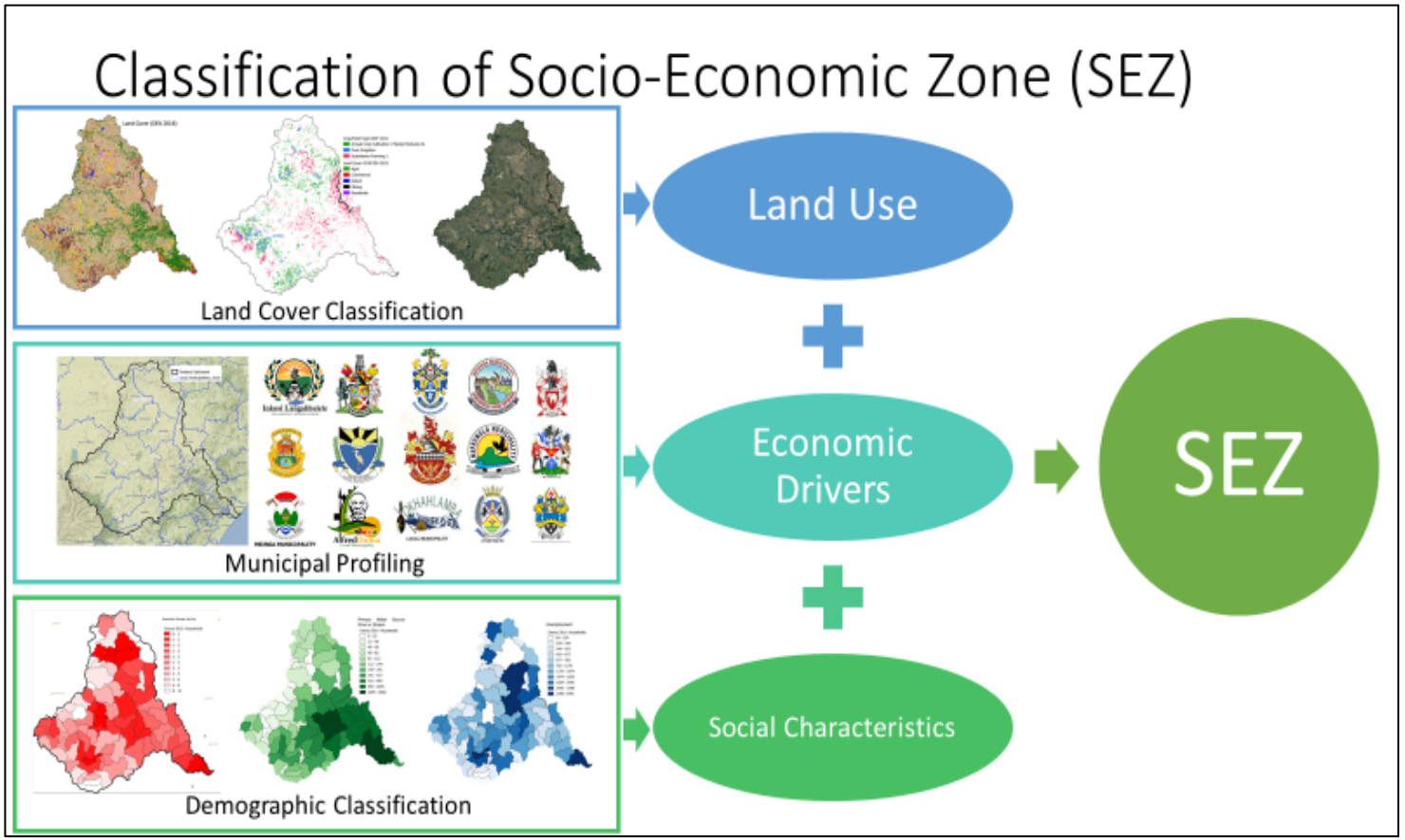
Ecosystem Service Sensitivity



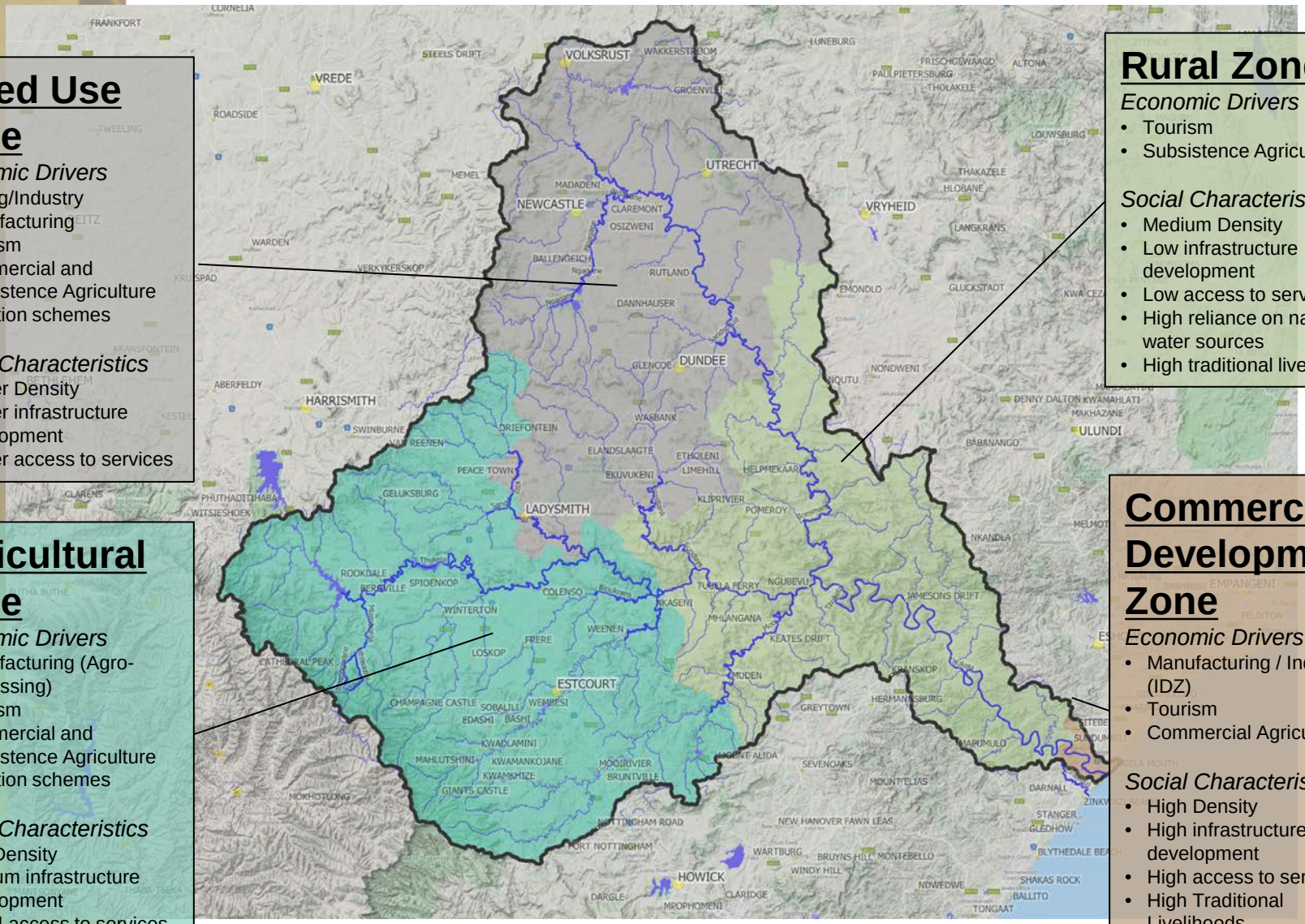
Water Provisioning Services provided by network of rivers, dams and impoundments and Strategic Water Source Areas (SWSA) along upper catchment escarpment
Provisioning and regulating services provided by complex ecosystems. Identified in the Thukela as major wetlands and the Tugela Mouth estuary. Provisioning 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

Socio-economic zones

- Zones of relatively homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems



Socio-economic zones (SEZ)



Mixed Use Zone

Economic Drivers

- Mining/Industry
- Manufacturing
- Tourism
- Commercial and Subsistence Agriculture
- Irrigation schemes

Social Characteristics

- Higher Density
- Higher infrastructure development
- Higher access to services

Rural Zone

Economic Drivers

- Tourism
- Subsistence Agriculture

Social Characteristics

- Medium Density
- Low infrastructure development
- Low access to services
- High reliance on natural water sources
- High traditional livelihoods

Agricultural Zone

Economic Drivers

- Manufacturing (Agro-processing)
- Tourism
- Commercial and Subsistence Agriculture
- Irrigation schemes

Social Characteristics

- Low Density
- Medium infrastructure development
- Mixed access to services

Commercial Development Zone

Economic Drivers

- Manufacturing / Industry (IDZ)
- Tourism
- Commercial Agriculture

Social Characteristics

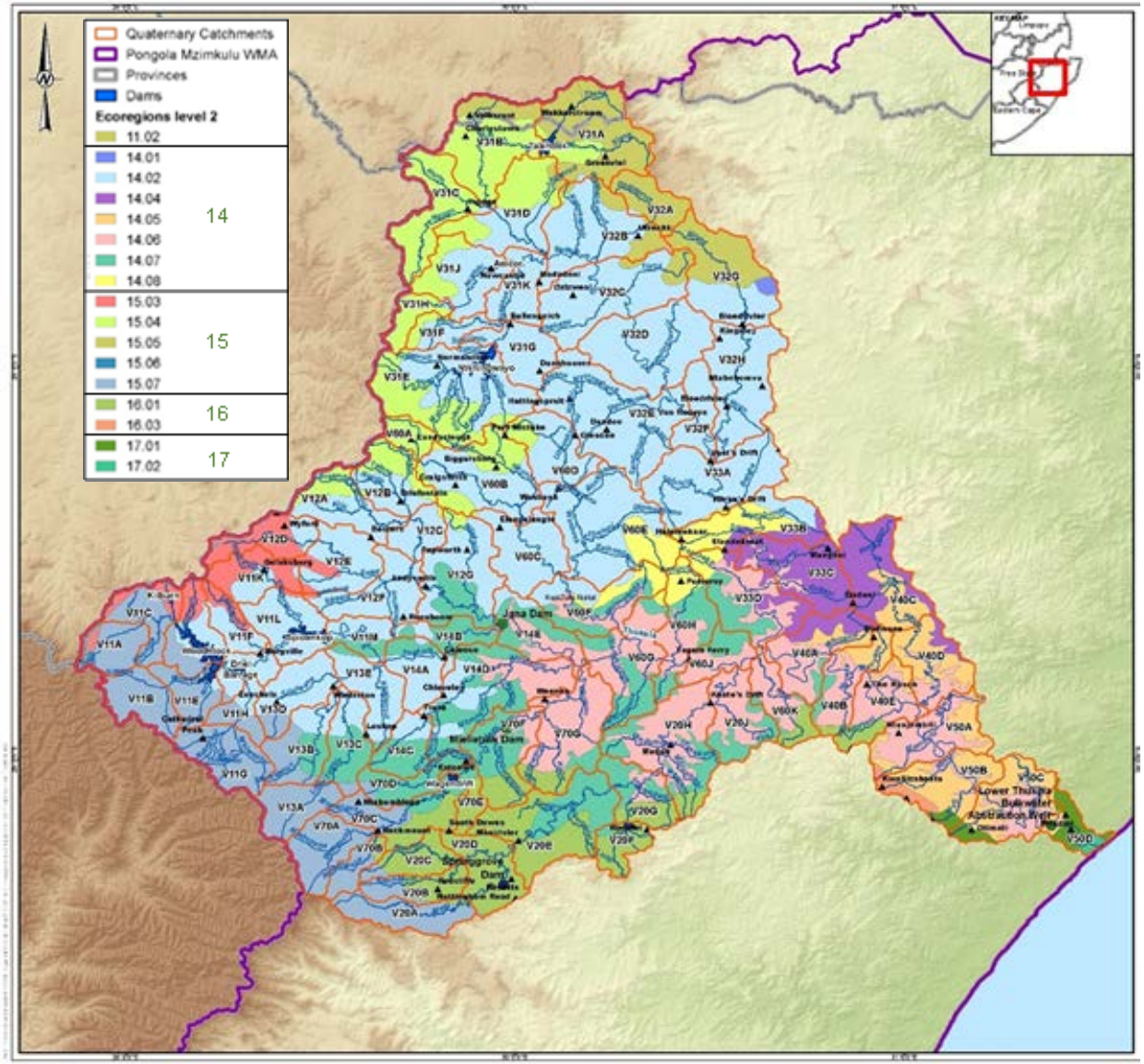
- High Density
- High infrastructure development
- High access to services
- High Traditional Livelihoods

Rivers

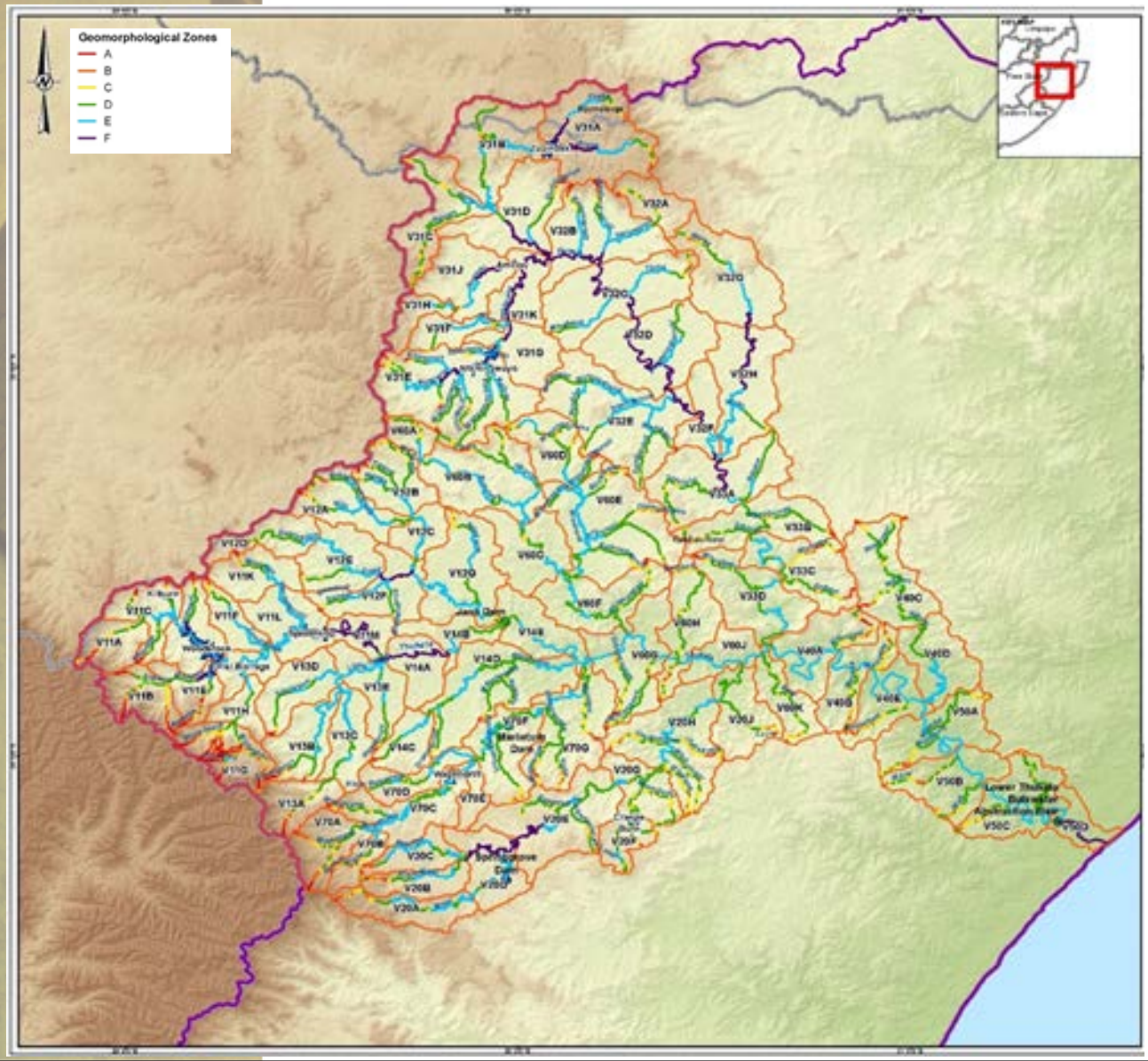
Sub-catchment	Quaternary	Main river	Major Tributaries
V10	V11A-V11M, V12A-V12G, V13A-V13E, V14A-V14E	Upper Tugela River	Little Tugela, Putterill, Majaneni, Khombe, Mnweni; Mpandweni, Njongola, Venterspruit, Sandspruit, Mlambonja, Sterkspruit, Situlwane; Klip (and tributaries), Bloukrans (and tributaries)
V20	V20A-V20J	Mooi River	Klein-Mooi, Nsonge, Katspruit, Joubertsvlei, Mnyamvubu, Mbalane, Mhlopheni, Umdumbeni, iTshekana, Loza
V30	V31A-V31K, V32A–V32H, V33A–V33D	Buffalo	Ngogo River, Harte River, Thaka River, Slang River, Doringspruit, Ngagane (and tributaries), Kweekspruit, Wasbankpruit, Mbabane, Blood River, Tiyna, Eesteling, Sand, Totololo, Batse, Sibindi, Ngxobongo, Mangeni, Gubazi, Mazabeko
V40	V40A-V40E	Lower Tugela	Nadi, Mfongosi, Ngcaza, Manyane, Mamdleni, Nsuze and tributaries
V50	V50A-V50D		Mamba, Mambulu, Mpisi, Mati, Otimati, Nembe, Mandeni
V60	V60A-V60F	Sundays	Dwars, Nkunzi, Wasbank (and tributaries), Nhlanyanga
	V60G-V60K	Tugela	Sundays, Sikhehlenga, uMhlangana, Sampofu, Nadi, Mooi, Buffalo
V70	V70A-V70G	Bushmans	Mtshezana, Ncibidwana, Klein Bushmans, Rensburgspruit, uMngwenya, Busone

River characterisation: Eco-regions

Eco region	Description
11: Highveld	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	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.
15: Eastern Escarpment Mountains	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	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	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.



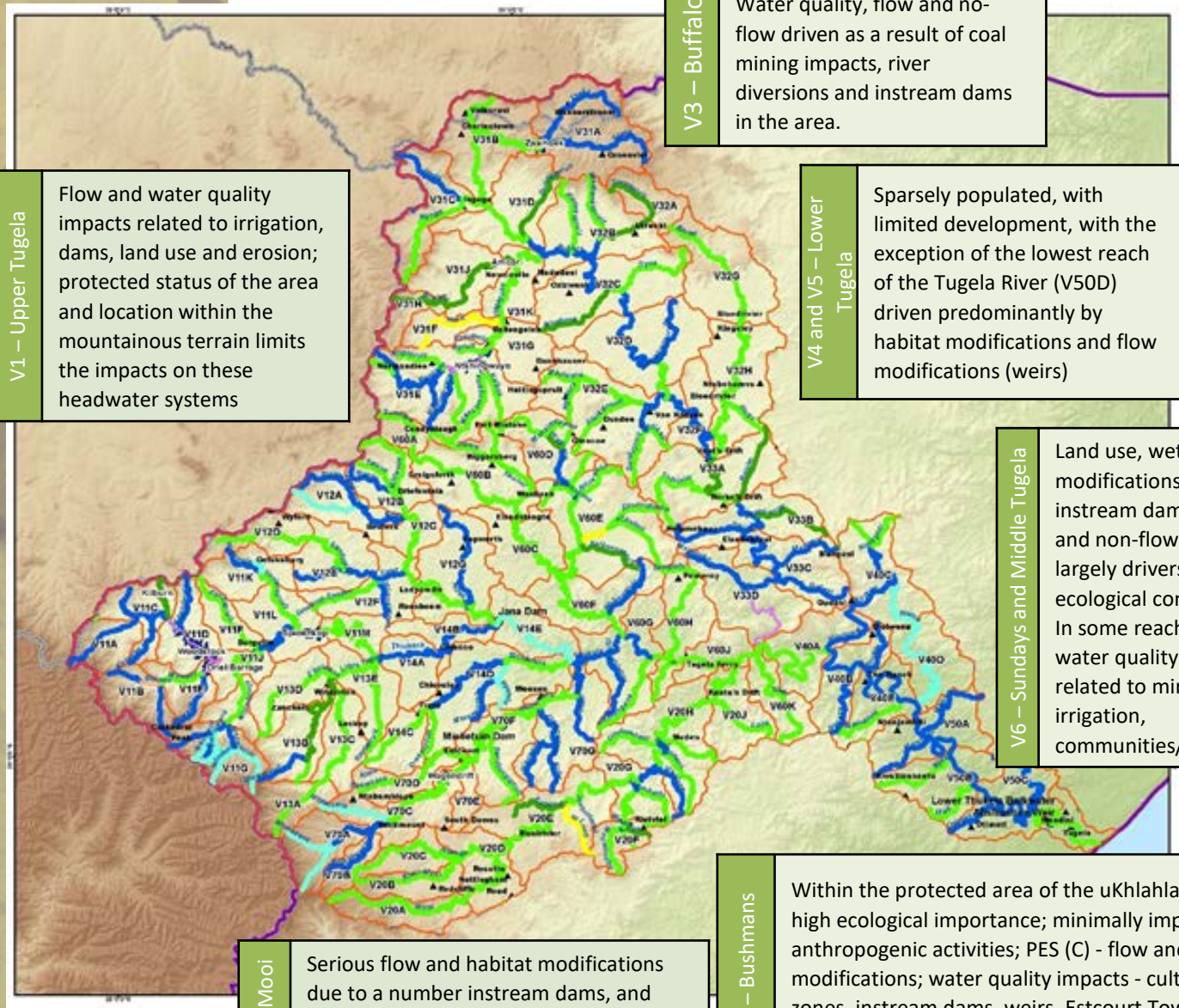
Geomorphology



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.

	Class A: Mountain Headwater Stream
	Class B: Mountain Stream
	Class C: Transitional
	Class D: Upper Foothills
	Class E: Lower Foothills
	Class F: Lowland River

Present Ecological Status and impacts/ drivers



V1 – Upper Tugela

Flow and water quality impacts related to irrigation, dams, land use and erosion; protected status of the area and location within the mountainous terrain limits the impacts on these headwater systems

V3 – Buffalo

Water quality, flow and no-flow driven as a result of coal mining impacts, river diversions and instream dams in the area.

V4 and V5 – Lower Tugela

Sparsely populated, with limited development, with the exception of the lowest reach of the Tugela River (V50D) driven predominantly by habitat modifications and flow modifications (weirs)

V6 – Sundays and Middle Tugela

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,

V2 – Mooi

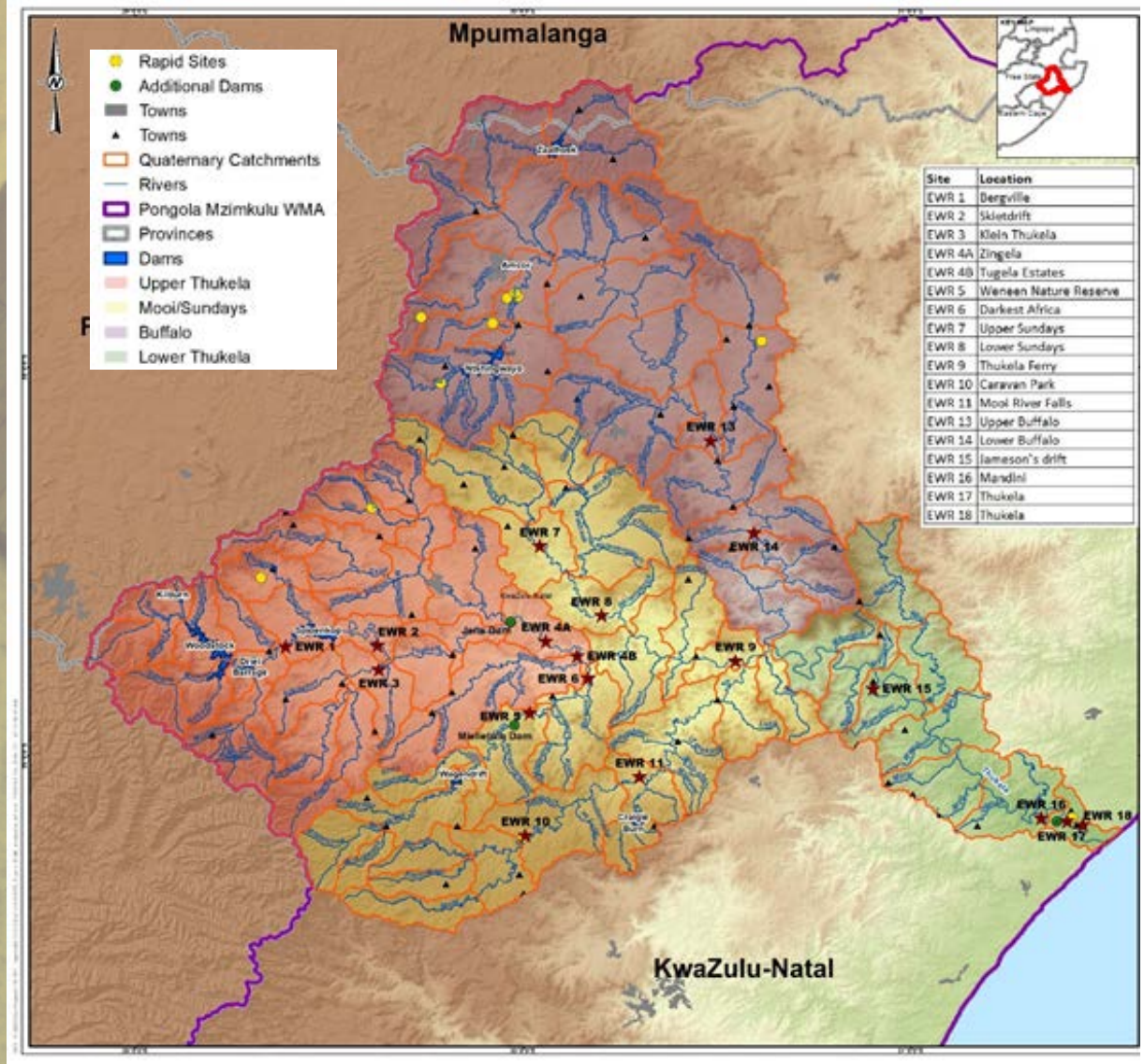
Serious flow and habitat modifications due to a number instream dams, and impacts associated with irrigation, forestry, and erosion

V7 – Bushmans

Within the protected area of the uKhlahlamba Drakensberg; high ecological importance; minimally impacted by any anthropogenic activities; PES (C) - flow and non-flow modifications; water quality impacts - cultivation in riparian zones, instream dams, weirs, Estcourt Town activities, sand mining and irrigation

EC	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. Modified completely with an almost complete loss of natural habitat and biota.

EWR Site information



Thukela preliminary Reserve: 17 EWR sites:

- upper Thukela Catchment (9); Lower Thukela (8) .
- A number of rapid Reserve determinations were undertaken between 2002 and 2005 - no reports available for these studies.

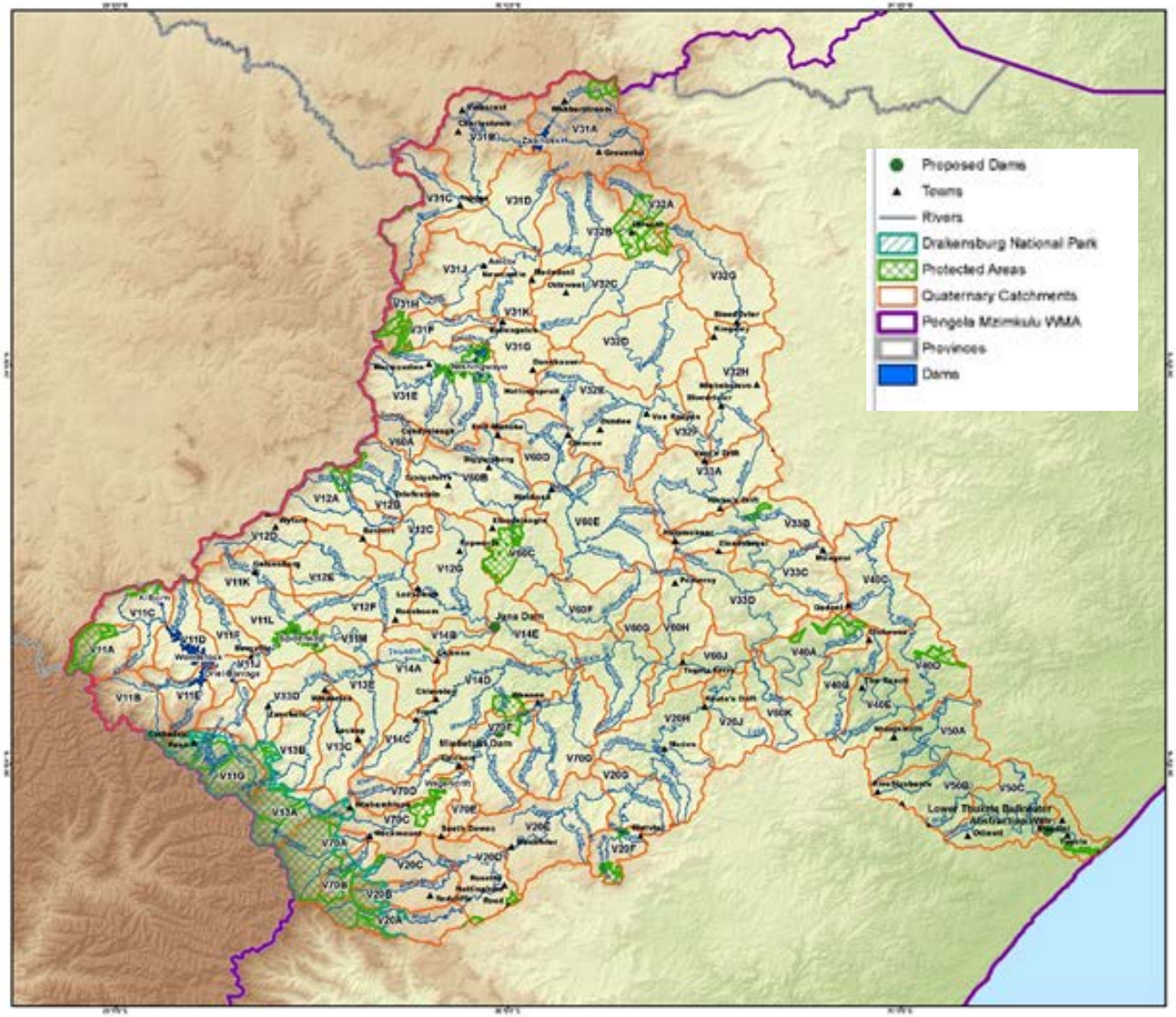
Rapid assessments - Ngagane, Horn, Ncandu and Ncone rivers in 2013 and for the Mooi River just upstream of the existing comprehensive site, Thukela_10, in V20E during 2019.

Intermediate assessment - 2017 for the lower Thukela River at Thukela_16, and two additional sites just downstream of the new abstraction weir in quaternary catchment V50D.

Hydrological character

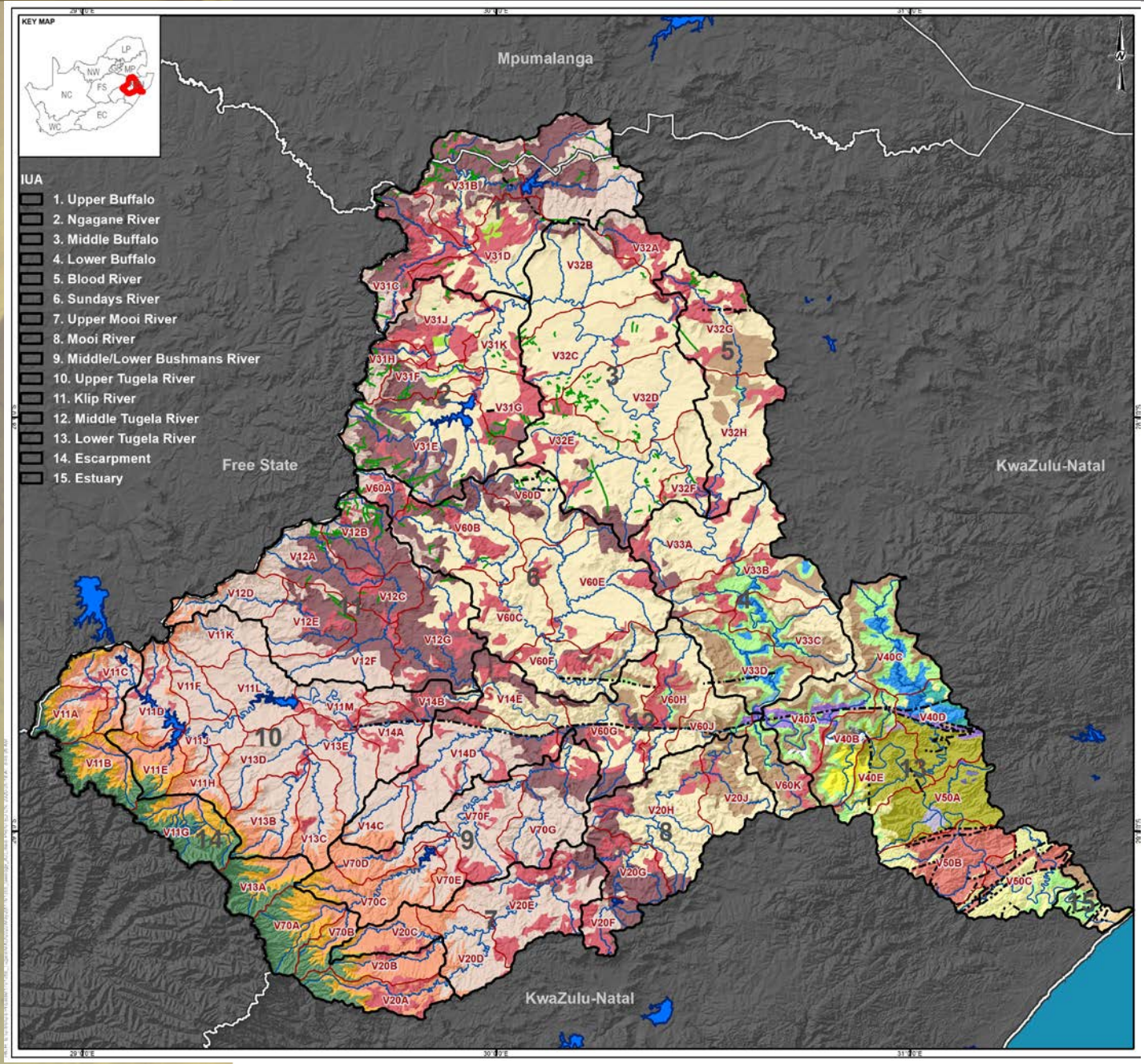
Class	Coefficient of Variation Index	Hydrological character
Class 1	CV_Index 1-4	Perennial
Class 2	CV_Index 5	Seasonal
Class 3	CV_Index 6-9	Ephemeral

Protected Areas



- Thukela catchment includes a number of protected conservation areas (approximately 35) of high biodiversity, cultural heritage, water and landscape importance
- uKhahlamba-Drakensberg Park is the most prominent conservation area designated as a World Heritage Site by UNESCO in 2000;
- Others: 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.
- 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

Geology

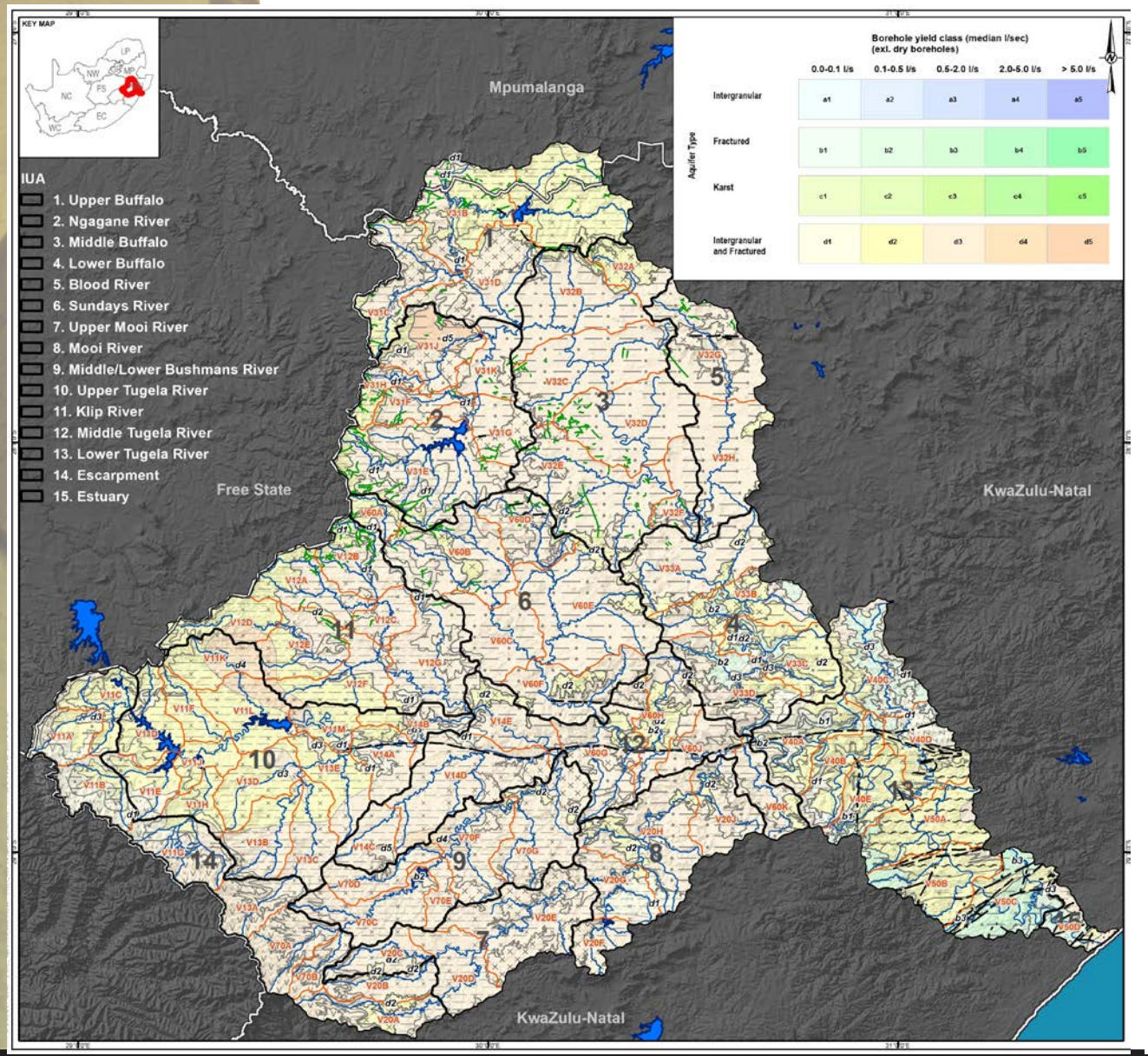


- Quaternary Catchments
- Dams
- Faults
- Dykes
- Tugela/Thukela River
- Rivers

Lithology

- C-Pd: Tillite
- Jd: Dolerite
- Jdr: Basalt
- Nma: Gabbro
- Nmf: Schist
- Nmp: Gneiss
- Nnt: Conglomerate
- Nsi: Serpentinite
- Ntr: Peridotite
- Ntu: Amphibolite
- O-S: Arenite
- Pa: Mudstone
- Pp: Shale
- Pv: Arenite
- Pvo: Shale
- Q: Sedimentary
- Qb: Arenite
- TRmc: Arenite
- TRt: Mudstone
- ZB: Granite
- Zn: Greenstone
- Zns: Basalt

Geohydrology

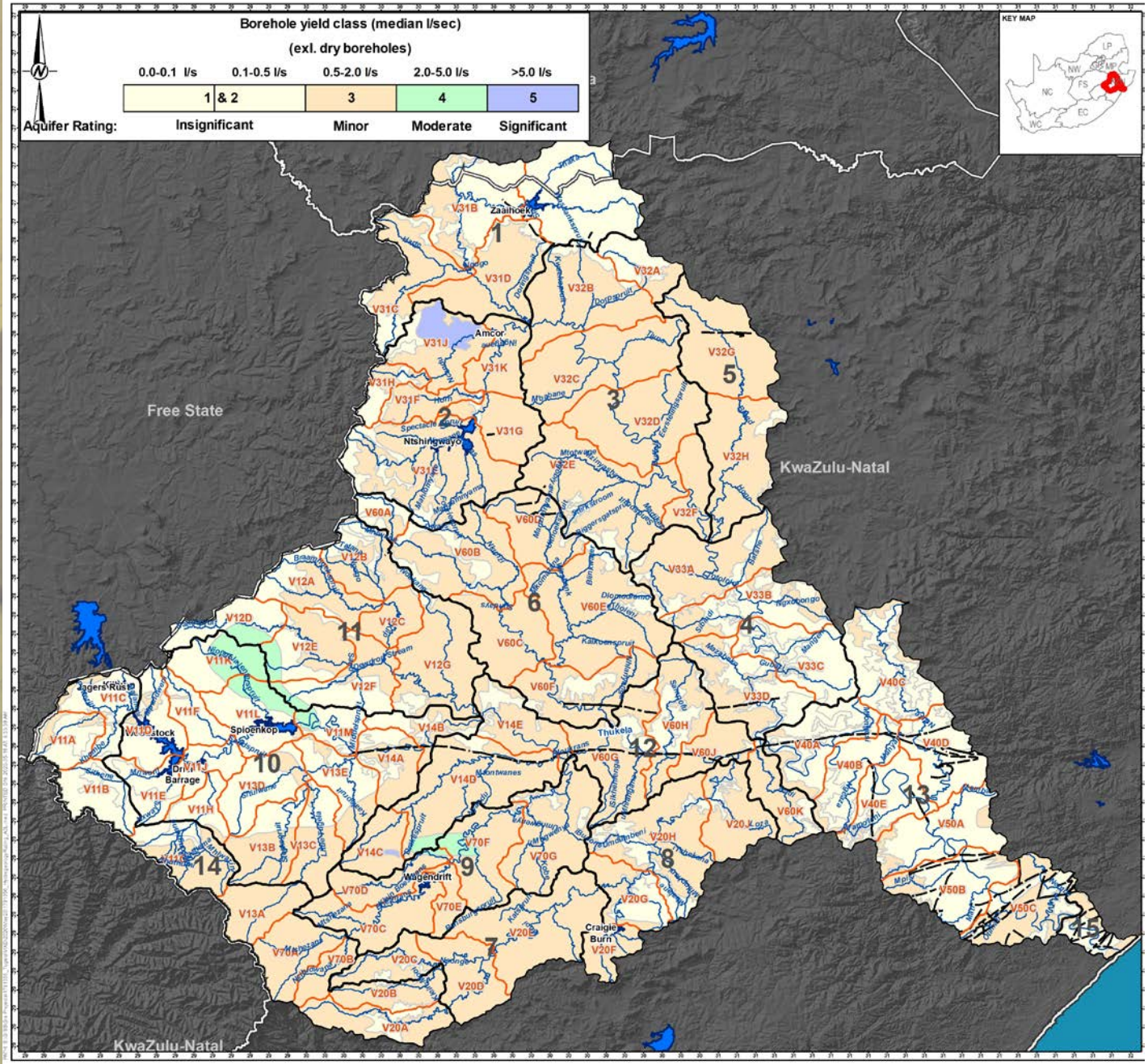


- Quaternary Catchments
- Dams
- Faults
- Dykes
- Tugela/Thukela River
- Rivers

Hydrogeology Lithology (2009)

- 21, Alluvium (clay, sand, gravel, boulders)
- 22, Undifferentiated coastal and inland deposits (unconsolidated to semi-concolidated sediments including sand, calcrete, calarenite, aeolianite, conglomerate, clay, silcrete, limestone ect.)
- 32, Mafic/ultra mafic intrusive rocks (dolerite, diabase, diorite, gabbro, dunite, pyroxenite, norite, anorthosite, hornblendite, carbonatite)
- 34, Mafic/ultra mafic extrusive rocks (basalt, andesite)
- 41, Predominantly argillaceous rocks (shale, carbonaceous shale, claystone, mudstone, siltstone)
- 42, Predominantly arenaceous rocks (sandstone, feldspathic sandstone, arkose)
- 43, Argillaceous and arenaceous rocks (approximately equal proportions)
- 46, Predominantly diamictite
- 50, Mafic/ultra mafic intrusive rocks (dolerite, diabase, diorite, gabbro, dunite, pyroxenite, norite, anorthosite, hornblendite, carbonatite)
- 51, Acid/Intermediate/Alkaline intrusive rocks (various granitoids)
- 52, Mafic/ultra mafic extrusive rocks (basalt, andesite)
- 54, Predominantly meta-argillaceous rocks (slate, phyllite, meta-pelite, schist, serpentine, amphibolite, hornfels)
- 55, Predominantly meta-arenaceous rocks (quartzite, gneiss, migmatite, granulite)
- 58, Undifferentiated rocks and various mixed lithologies

Borehole Yield Class



- Provinces
- Quaternary Catchments
- Dams
- Faults
- Tugela/Thukela River
- Rivers

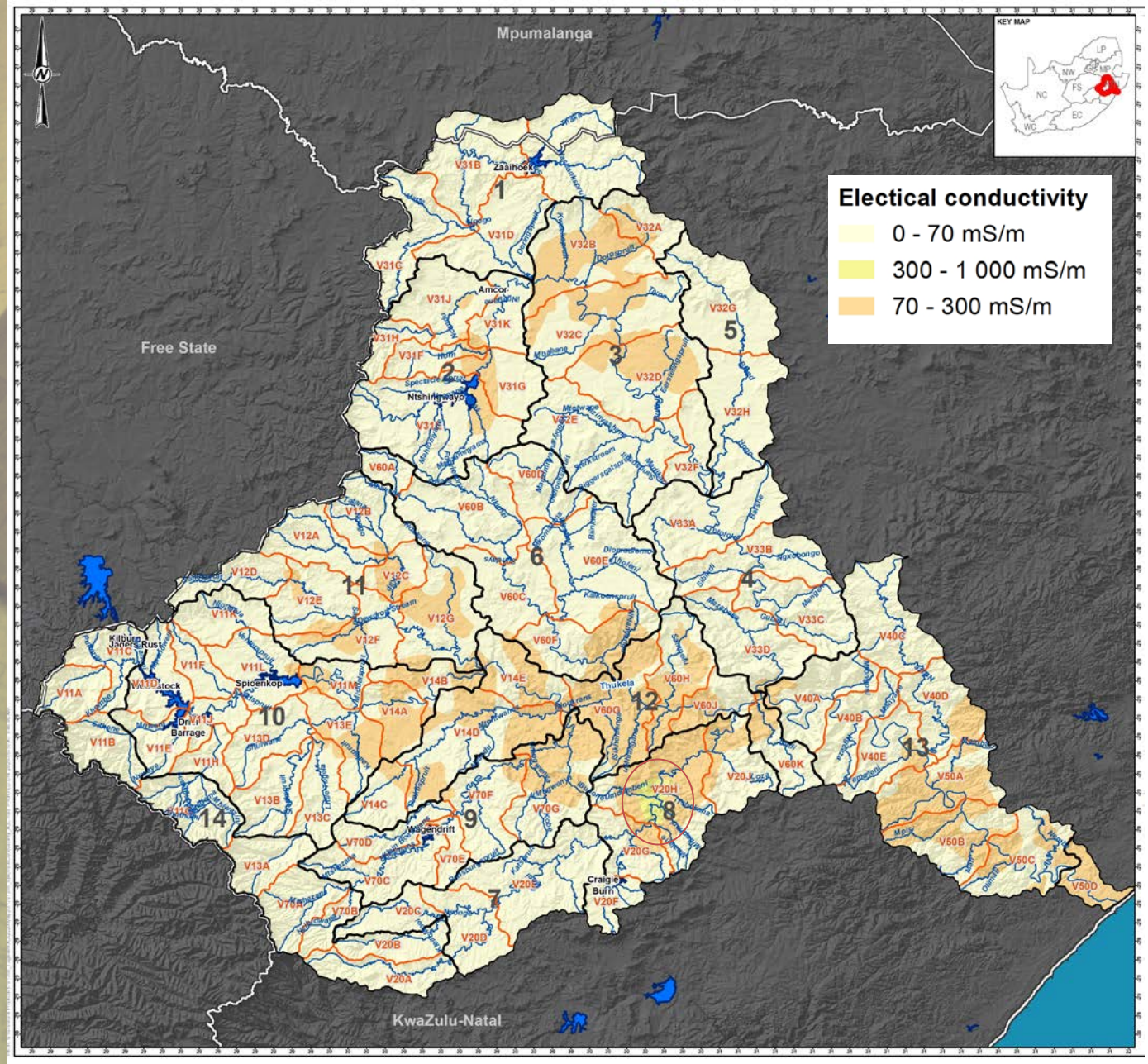
IUA

1. Upper Buffalo
2. Ngagane River
3. Middle Buffalo
4. Lower Buffalo
5. Blood River
6. Sundays River
7. Upper Mooi River
8. Mooi River
9. Middle/Lower Bushmans River
10. Upper Tugela River
11. Klip River
12. Middle Tugela River
13. Lower Tugela River
14. Escarpment
15. Estuary

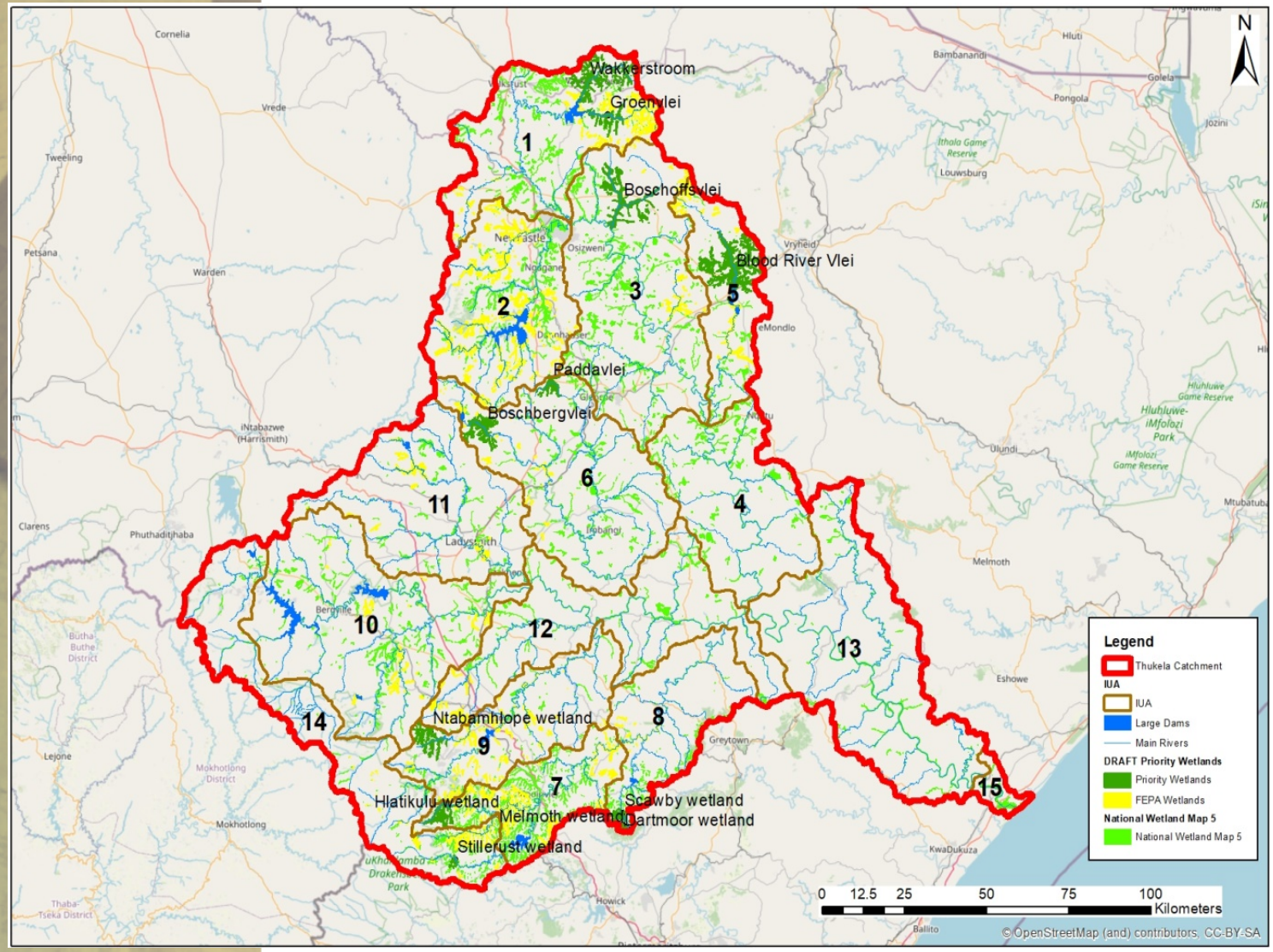
Groundwater Status

- Recharge:
  - Average recharge values vary between ~15 and 45 mm·a^{-1}, or between 1 and 6% of MAP
  - The bulk (~85%) of the catchment recharge figures of ~3% of MAP (~750 mm) =~25 mm·a^{-1}
- Water Levels: monitoring data limited
  - Long term Water level trends are of the same order/pattern for period assessed 2007 to 2019
  - A clear water table recession is noticeable - 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).
- Contribution to baseflow
  - 2009 baseflow values from Reserve study still applicable
  - Wetlands identified – clear hydraulic connection to groundwater
  - Significant land use changes will result in an increase in baseflow (assessment of catchment)
- Groundwater use
  - Data limited; WARMS - under registration
  - Estimated total groundwater use in order of 435 Mm^3·a^{-1}
- Quality
  - Generally good – best quality in higher rainfall regions. Poorest quality in lower rainfall regions
  - TDS content in the range of 90 to 200 mg/l. Can exceed 500 mg/l in lower portions of catchment

Groundwater Quality



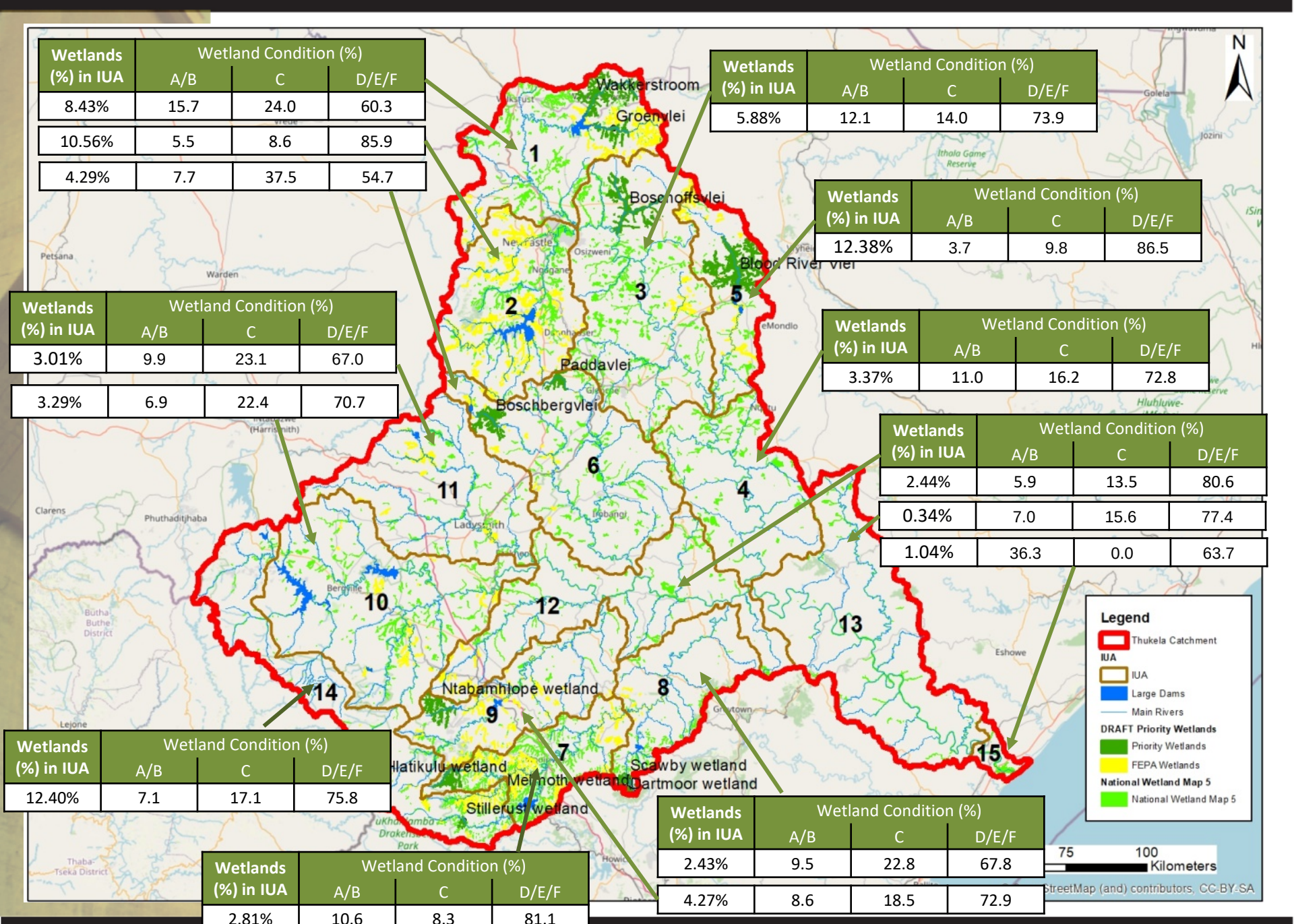
Prioritised Wetlands



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

Wetland extent (area) and percentage of area per IUA for Depressions, Floodplains, Seeps, and Channelled and Unchanneled Valley Bottom systems

IUA	IUA Area (ha)	Area of wetlands in IUA (ha)	% Wetland area in IUA	Depression		Floodplain		Seep		Channelled VB		Unchanneled VB		Preliminary List of Priority Wetlands
				ha	%	ha	%	ha	%	ha	%	ha	%	
1	198 465	16 728	8.4	155	0.9	862	5.2	9 950	59.5	3 327	19.9	2 434	14.5	Wakkerstroom and Groenvlei
2	195 658	20 669	10.6	113	0.5	2 334	11.3	11 622	56.2	2 226	10.8	4 373	21.2	
3	295 660	17 390	5.9	526	3.0	0	0.0	11 249	64.7	3 051	17.5	2 564	14.7	Boschoffsvlei
4	183 601	6 185	3.4	28	0.5	0	0.0	5 219	84.4	190	3.1	747	12.1	
5	105 978	13 117	12.4	51	0.4	137	1.0	2 898	22.1	9 478	72.3	553	4.2	Blood River Vlei
6	248 088	10 645	4.3	2 484	23.3	207	1.9	6 256	58.8	587	5.5	1 112	10.4	Paddavlei, Boschberg Vlei
7	108 604	13 465	12.4	8	0.1	610	4.5	4 435	32.9	6 062	45.0	2 350	17.5	Hlatikulu
8	132 507	3 219	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
9	151 444	6 471	4.3	33	0.5	10	0.2	4 705	72.7	983	15.2	740	11.4	Ntabamhlope
10	311 639	10 266	3.3	35	0.3	9	0.1	8 814	85.9	254	2.5	1 154	11.2	
11	215 393	6 473	3.0	36	0.6	641	9.9	3 730	57.6	176	2.7	1 890	29.2	
12	234 469	5 721	2.4	13	0.2	0	0.0	4 893	85.5	162	2.8	653	11.4	
13	295 293	1 015	0.3	6	0.6	0	0.0	869	85.6	104	10.2	36	3.6	
14	211 417	5 942	2.8	13	0.2	436	7.3	1 583	26.6	3 658	61.6	252	4.2	Many headwater wetlands including the Natal Drakensberg Park Ramsar Site and Stillerust being one of the larger wetlands in the Ramsar Site
15	14 581	152	1.0	1	0.7%	11	7.3%	140	92.0%	0	0.0	0	0.0	
	2 902 800	**137 458**	**4.7**	**3 504**	**2.5%**	**5 258**	**3.8%**	**77 734**	**56.6%**	**30 989**	**22.5%**	**19 973**	**14.5%**	



Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
8.43%	15.7	24.0	60.3
10.56%	5.5	8.6	85.9
4.29%	7.7	37.5	54.7

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
5.88%	12.1	14.0	73.9

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
12.38%	3.7	9.8	86.5

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
3.01%	9.9	23.1	67.0
3.29%	6.9	22.4	70.7

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
3.37%	11.0	16.2	72.8

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
2.44%	5.9	13.5	80.6
0.34%	7.0	15.6	77.4
1.04%	36.3	0.0	63.7

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
12.40%	7.1	17.1	75.8

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
2.81%	10.6	8.3	81.1

Wetlands (%) in IUA	Wetland Condition (%)		
	A/B	C	D/E/F
2.43%	9.5	22.8	67.8
4.27%	8.6	18.5	72.9

Water Quality: fitness for use assessment

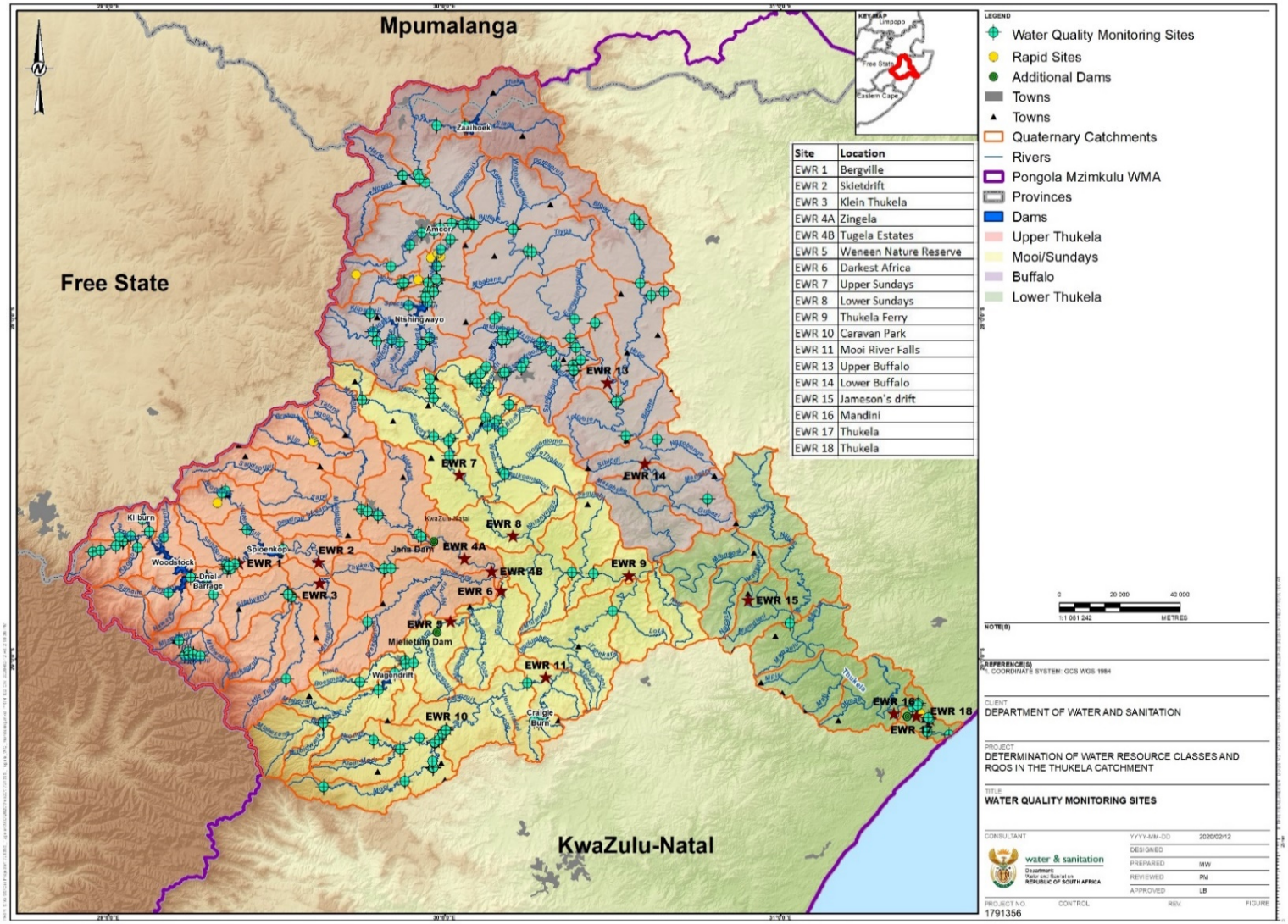
- Historical data - National Chemical Monitoring Programme (NCMP)(2008 to 2018) - limited and inconsistent

The variables assessed included (95th and 50th percentile values):

- 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)

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

WQ monitoring sites (DWS WMS)



Summary of Water Quality Compliance per Secondary Catchment
(number the monitoring sites)

Sub-catchment	Calcium (mg/l)	Chloride (mg/l)	Total Dissolved Salts (mg/l)	Electrical Conductivity (mS/m)	Flouride (mg/l)	Magnesium (mg/l)
V1 - Upper Tugela	55% 40% 5%	95% 5%	88% 6% 6%	36% 9% 40% 15%	100%	95% 5%
V2 - Mooi River	80% 20%	100%	86% 7% 7%	85% 5% 5% 5%	100%	100%
V3 - Buffalo River	17% 67% 15%	83% 13% 4%	25% 28% 30% 18%	19% 8% 46% 27%	60% 29% 5% 7%	86% 10% 4%
V4/V5 - Lower Tugela	100%	100%	100%	8% 8% 17% 67%	100%	100%
V6 - Sundays River	5% 71% 24%	71% 14% 14%	5% 30% 15% 50%	3% 24% 17% 55%	60% 10% 15% 15%	67% 14% 19%
V7 - Bushmans River	80% 20%	100%	80% 20%	63% 25% 13%	80% 20%	100%
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)	pH	Orthophospate (mg/l)	Sulphate (mg/l)
V1 - Upper Tugela	100%	54% 11% 7% 28%	100%	47% 34% 19%	40% 2% 15% 43%	100%
V2 - Mooi River	100%	90% 5% 5%	100%	36% 41% 23%	91% 9%	100%
V3 - Buffalo River	7% 57% 15% 20%	62% 7% 1% 30%	92% 5% 3%	40% 28% 33%	24% 28% 11% 36%	37% 33% 9% 20%
V4/V5 - Lower Tugela	100%	86% 14%	92% 8%	42% 33% 25%	8% 25% 67%	100%
V6 - Sundays River	42% 4% 54%	85% 15%	100%	7% 28% 66%	55% 24% 3% 17%	30% 30% 10% 30%
V7 - Bushmans River	100%	63% 13% 25%	100%	62% 38%	50% 25% 25%	100%
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

Water Quality hotspots

Quaternary catchment	River	Impact Rating	Water Quality Issue/Impact
V11A (lower)	Tugela	Moderate	WWTW discharges, elevated nutrients/salts, rural towns and tourist resorts
V11C	Majaneni/Tugela	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	LittleTugela (lower)	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Winterton)
V14A	Tugela	Moderate	Elevated nutrients, intensive agriculture
V14B	Tugela	Moderate	Elevated nutrients, intensive agriculture; WWTW discharges (Colenso)
V20D	Mooi/Klein Mooi	Moderate	elevated nutrients, irrigated agriculture
V20E	Mooi	Moderate	Elevated nutrients/salts, intensive agriculture, WWTW discharges (Mooi River)
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
V40E	Tugela	Moderate	elevated nutrients,/salts, rural communities, subsistence agriculture, over-grazing
V50A	Tugela	Small	elevated nutrients/salts, rural communities, subsistence agriculture, dryland sugarcane, over-grazing, erosion (sediments); small scale sand mining on Mamba
V50D	Tugela	Moderate	WWTW discharges (Mandini), industrial discharges (per mill); urban impacts; high nutrients and salinity
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	Tugela	Small	WWTW discharges (Tugela Ferry); nutrients
V70D	Little Bushmans	Serious	WWTW discharges (Escourt 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 (Weenen); extensive irrigation; erosion

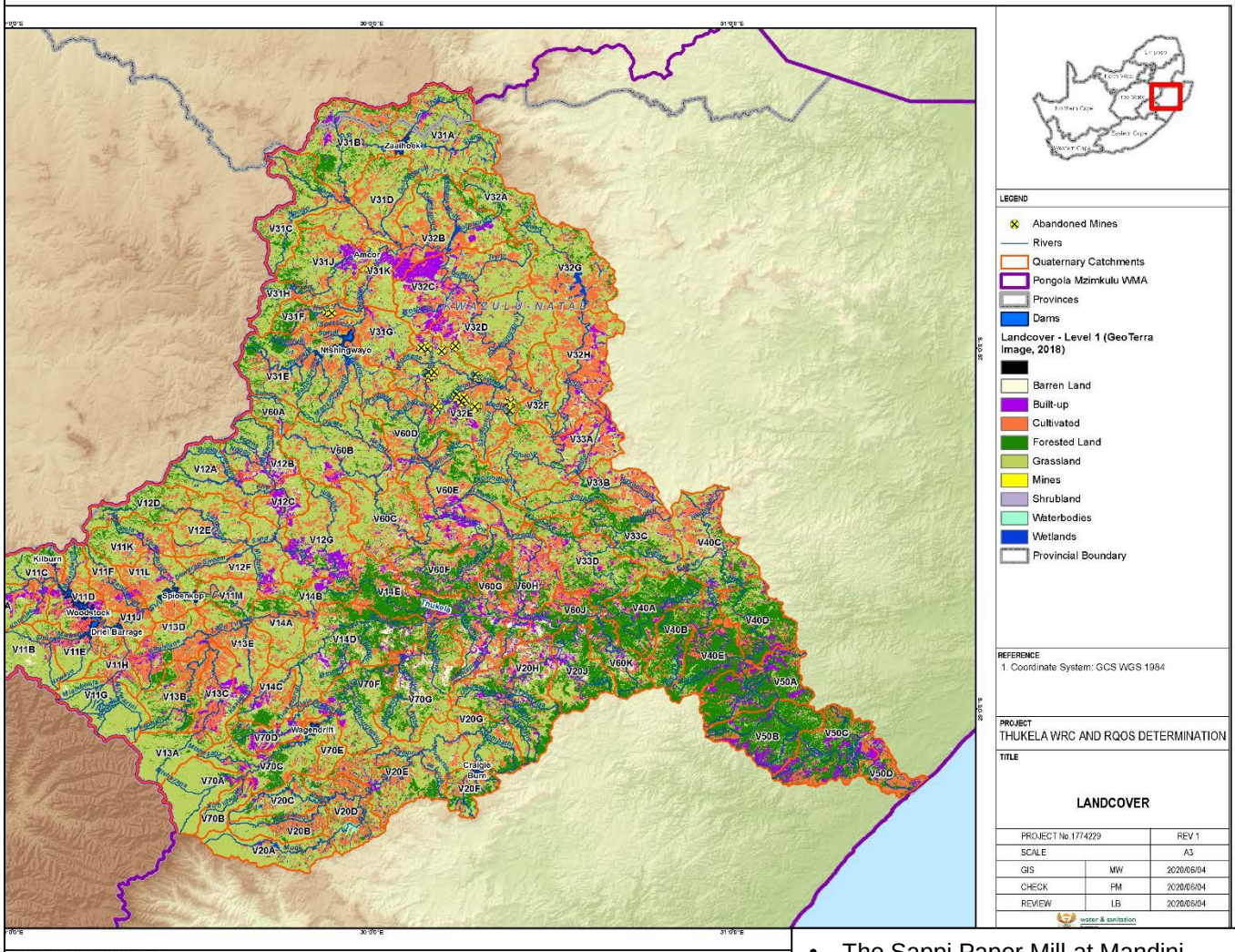
Land use – water quality impacts

- Coal Mining (coal) – 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

- Sand Mining –Buffalo River from the Ngagane River confluence to the lower reaches

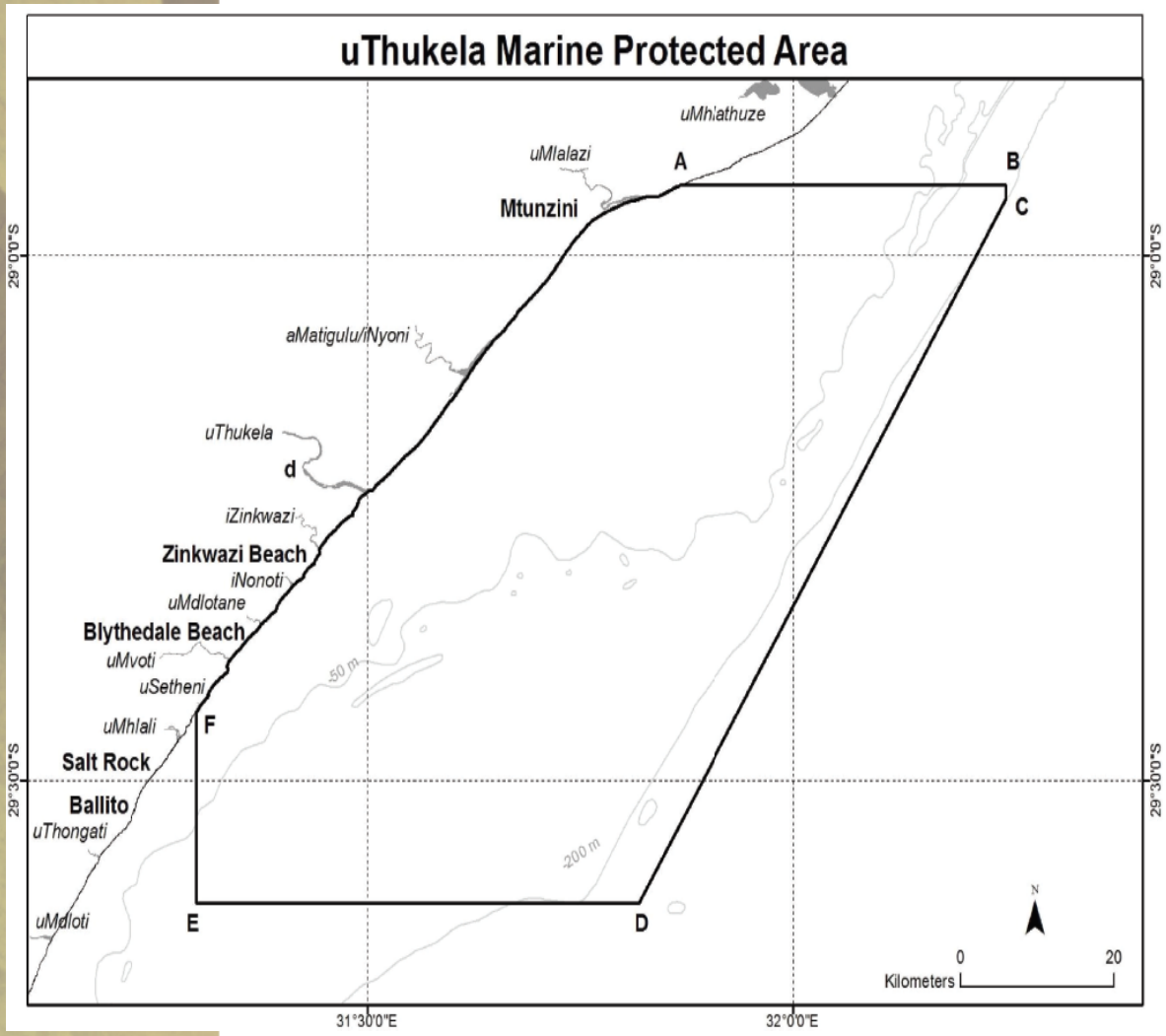
- Poor performing wastewater treatment works (WWTWs) are a major concern and a significant source of nutrient enrichment and high organic load: towns of Weenen, Wembezi and Escourt were rated as critical risk WWTPs (90-100% risk rating), and Ladysmith, Bergville, Colenso, Ekuvukeni, Winterton, Ezakheni, Utrecht and Tugela Ferry were rated as high risk WWTPs (70 - <90% risk rating) in the 2013 Green Drop evaluation

- Industrial activity: Ngagane, Lower Tugela, 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 Tugela River
- Agricultural activity occurs extensively throughout the Thukela Catchment

Thukela Estuary



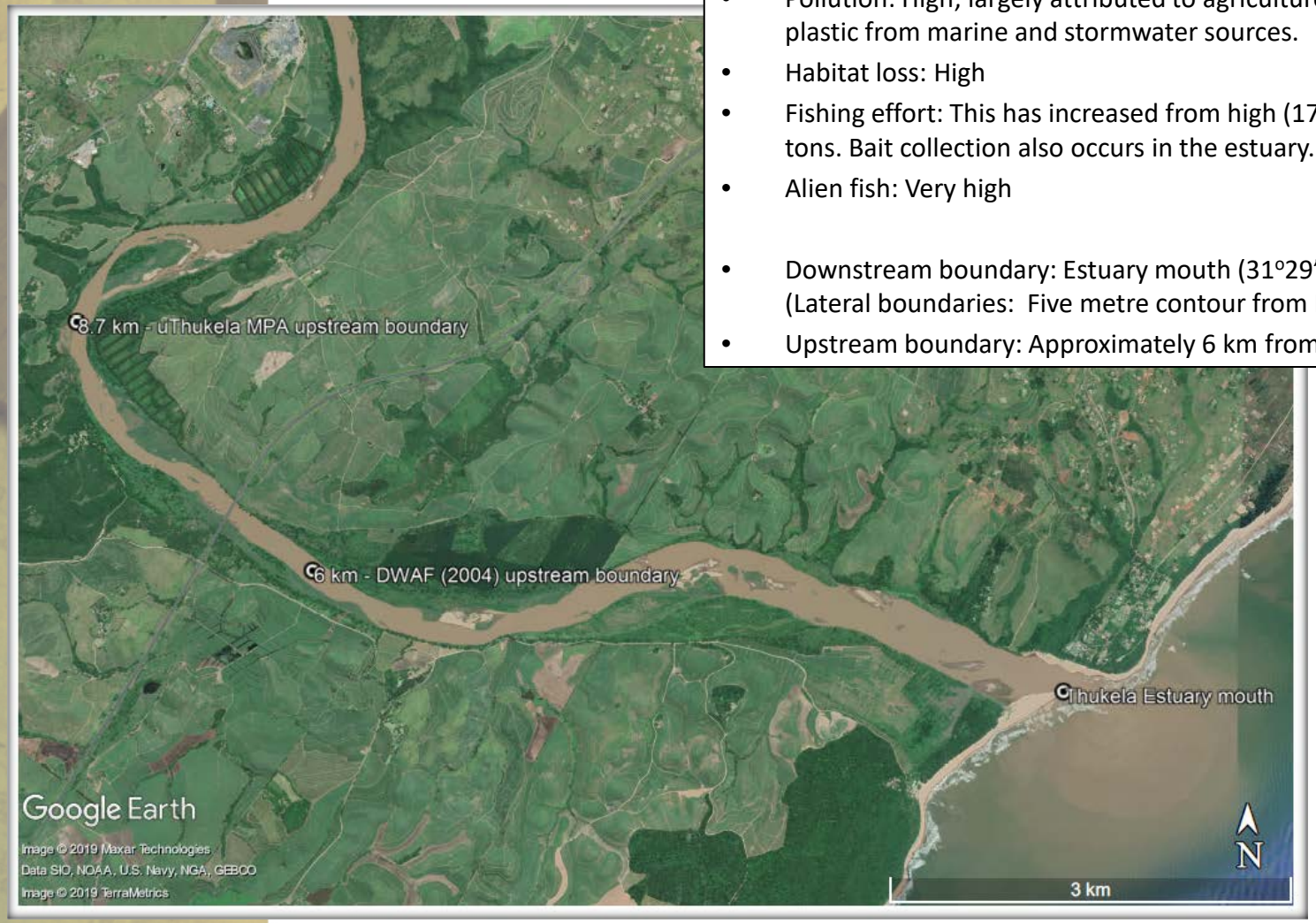
Boundaries of the uThukela Marine Protected Area; note that point d is located within the Thukela Estuary is approximately 8.5 km upstream of the estuary mouth (Government Gazette 42478 2019)

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)

Estuary: Description

- 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 to very high (30 tons. Bait collection also occurs in the estuary.
- Alien fish: Very high

- 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



Estuary : Biota and distribution

- 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
- Other aspects considered:
  - Microalgae
  - Macrphytes
  - Inverterbrates
  - Fish
  - Birds
- Impacts on the Estuary
  - Quality: modified state (elevated levels of chemical and biological oxygen demands (CODs and BODs), suspended solids, sodium and temperature)
  - Ecological integrity of the lower Thukela River reflected a moderately modified (Class C) state
  - Quantity of flows: Reduction in the quantity of river flow is a key driver of changes in biotic communities in the estuary
  - Could results in closing of the mouth more often for longer periods resulting in limited exchange with the marine environment
  - Land use changes
  - Invasives (Brazilian pepper trees and Spanish reeds)
  - Disturbance of the functional zone: agriculture has removed ~80% of natural floodplain vegetation (loss of 22 ha reeds, 1.5 ha swamp forest)

PROPOSED INTEGRATED UNITS OF ANALYSIS

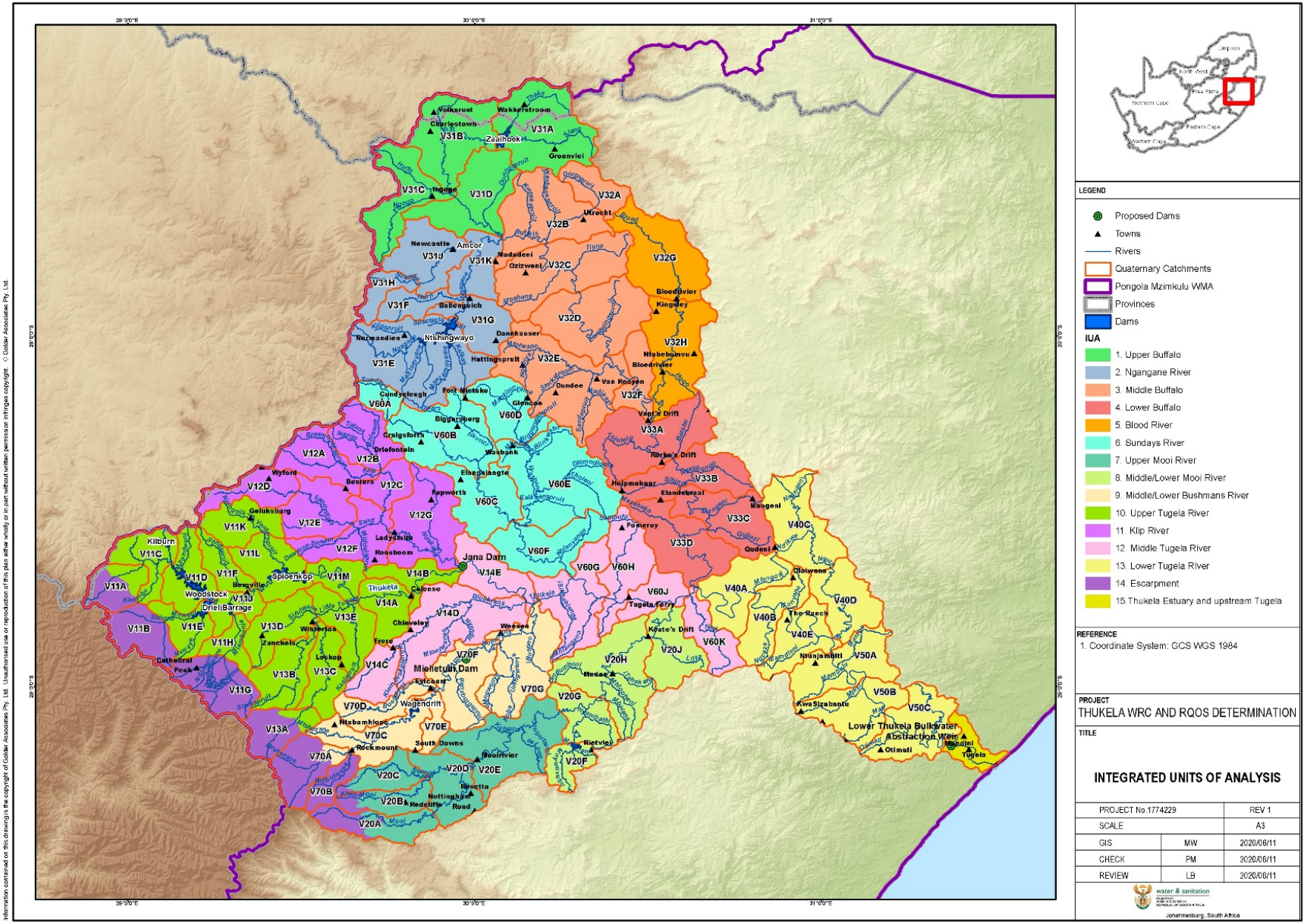
IUA Delineation

- 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 proposed IUA.
  - Present status of water resources.
  - Stakeholder input.

IUA Delineation

- Based on the SEZs determined and the assessment of the information and considerations outlined above,
- **15 IUAs** have been delineated.
- 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.

Integrated Units of Analysis



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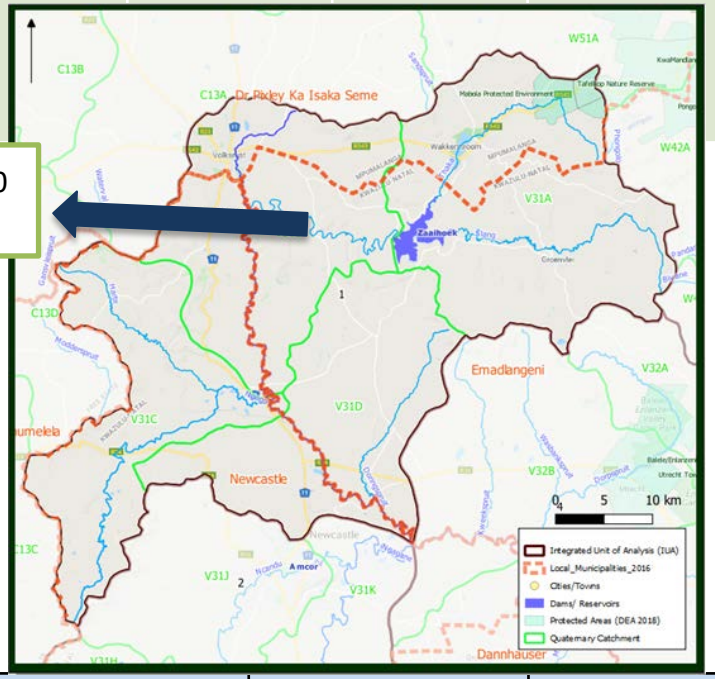
IUA 1: Upper Buffalo

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

Tributaries	Description	SEZ	EWR site	Dams	Quaternaries	Additional sites	PES
Ngogo River Harte River Thaka River Slang River Doringspruit	• Towns/ villages: Volksrust; Charlestown; Ingogo; Wakkerstroom; • Groenvlei • Agriculture; natural • Slang Transfer – Zaaihoek Dam • Potential irrigation (Eco-irrigation in Wakkerstroom area);	Mixed use	New site - Rapid to be done just before confluence with Ngagane River	Zaaihoek Dam	V31A; V31B; V31C and V31D	Upper Buffalo V31D	Rivers largely B and C category

Wetlands	RUs
• Important Wakkerstroom Wetland area (V31 A) • A number of priority channeled valley bottom wetlands (V31A)	• Wakkerstoom as RU31A Wetland RU • V31B Slang to confluence with Buffalo • V31C Ngogo to confluence with Buffalo • V31B, C, D – Buffalo to confluence with Ngagane

20 m^3/s (1 700 ML/d)



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
%	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

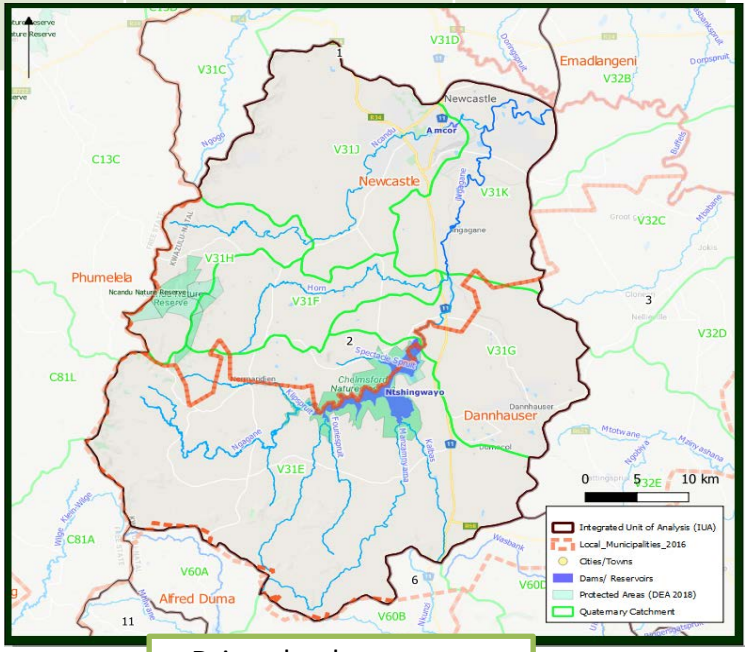
IUA 2: Ngagane /Buffels River

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

Tributaries	Description	SEZ	EWR site	Dams	Quaternaries
Ncandu River Horn River Klipspruit Mahlomyane River Fouriespruit Manzamnyama River Kalbas River	Nagagane River confluence with Buffalo River; quality from impacts from Newcastle urban; local communities; coal mining Towns/ villages: Newcastle; Normadien; Ballengeich Dannhauser;	Mixed use Zone	Rapid EWRs as part of PES/ EIS 2012	Ntshingwayo Dam (Chelmsford)	V31J; V31H; V31F; V31E; V31K; V31G

PES	Wetlands
Rivers largely B and C category Ncandu - D category Horn – E category – seriously modified	Priority wetland systems Groundwater is important in respect of maintaining the wetlands

WQ hotpots/Use /Groundwater	RUs
• NKandu/Tom Willerton • Ngagane • Water treatment plant upgrade – Ngagane – proposed 60ML/day • Ntshingwayo dam/River. confirm source • Horn River – WQ impacts • Flow nodes at Ntshingwayo Dam and downstream on the Ngagane River? • 988 boreholes – verify use • Land use and WWTW	• V31E Upper Ngagane to Chelmsford Dam • V31F Horn to confluence with Ngagane • V31H, J Ncandu to confluence with Ngagane • V31G, K Ngagane from Chelmsford Dam to confluence with Buffalo



Driven by the presence and operations of the Ntshingwayo Dam

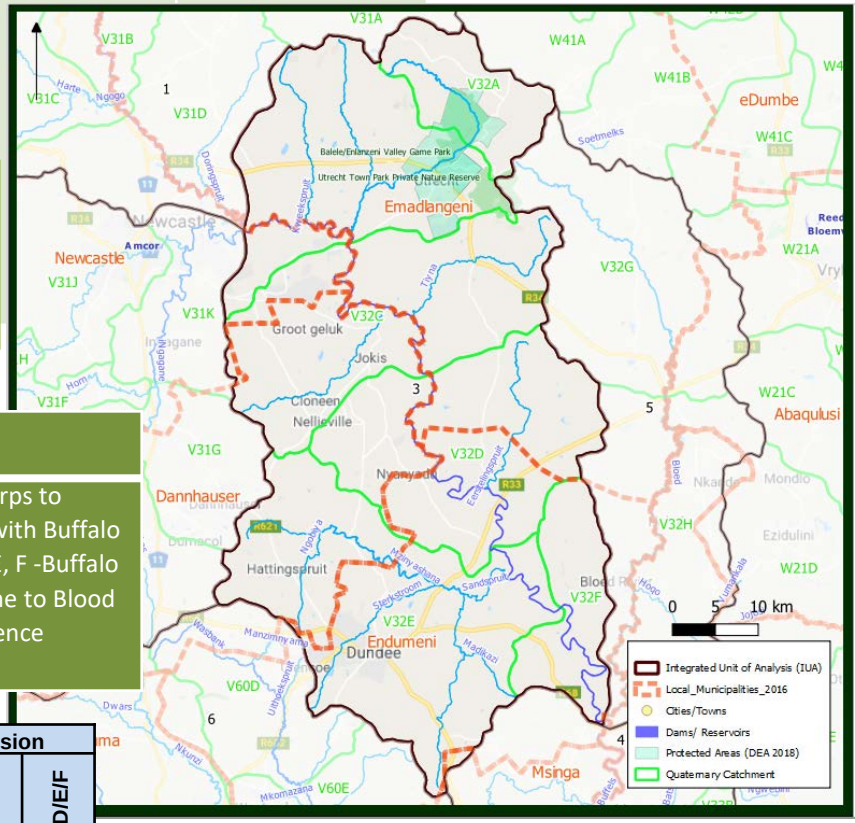
IUA 2	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
%	7.5	10.3	**82.2**	1.1	9.8	**89.1**	3.9	5.8	**90.3**	0.1	4.1	**95.8**	**54.3**	14.5	31.3

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.

Tributaries	Description	SEZ	EWR site	Quaternaries
Dorpspruit Wasbankspruit Kweekspruit Tiyne River Mbabane River Eerstelingsruit Mzinyashana River Motwane River Ngobiya River Sterkstroom Sandspruit Madikazi Ngagade River	Just below Nagagane River confluence to Blood River confluence; Towns/ villages: Madadeni; Hattingspruit; Utrecht; Ozizweni; Van Rooyen; Dundee; Glencoe	Mixed use	EWR 13	V32A; V32B; V32C; V32D; V32E; V32F;

Run of river system with limited to no support from the large dams upstream based on current operations



PES	Wetlands	WQ hotpots/Use / Groundwater	RUs
• Rivers B and C category • Mbabane- D category,	Priority wetland system in V32B; V32D	Madadeni V32B	• V32A, B - Dorps to confluence with Buffalo • V32B, C, D, E, F -Buffalo from Ngagane to Blood River confluence

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
%	14.8	17.6	**67.6**	0.0	1.3	**98.6**	6.7	13.4	**79.9**				**49.7**	14.8	35.6

IUA 4: Lower Buffalo

IUA 4 is delineated from the confluence of the Blood River confluence to the confluence of the Tugela River

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

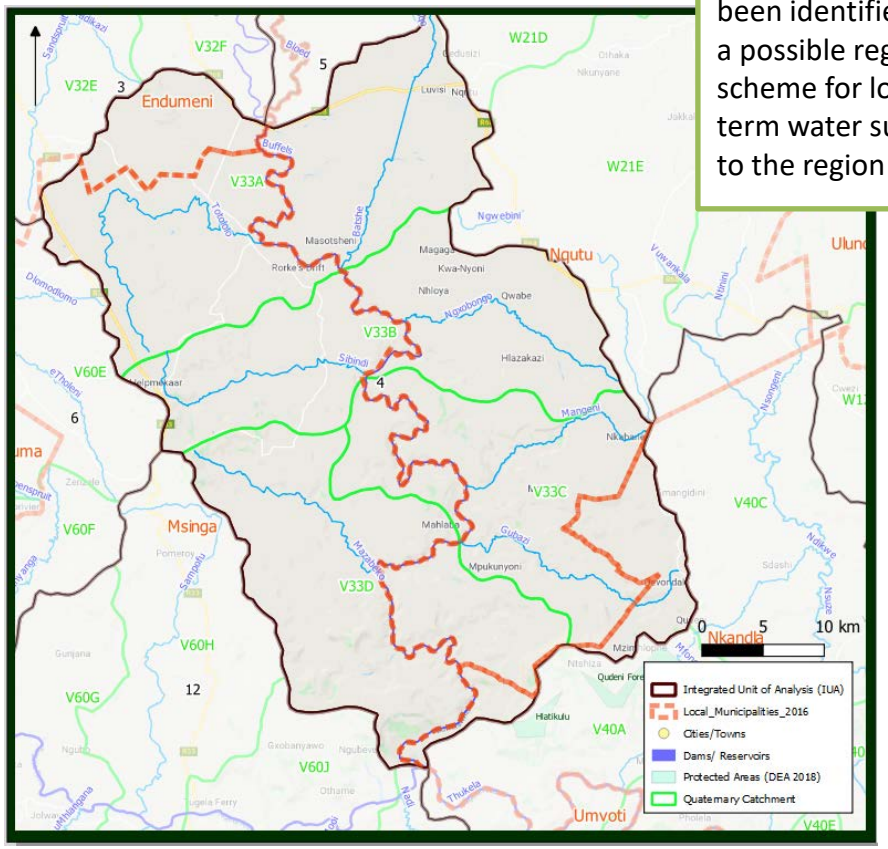
Tributaries	Description
Totololo River Batshe River Sibindi River Ngxobongo River Mangeni River Mazabeko River Gubazi River	Towns/ villages: Vant's Drift; Rorke's Drift; Elandskraal; Mangeni; Helpmekaar

SEZ	EWR site	Quaternaries
Rural Zone	EWR 14	V33A; V33B; V33C; V33D

PES	WQ hotpots/Use / Groundwater
• Rivers B and C category • Batshe, Ngxobongo, Buffalo in V33A - D category	Irrigation Defunct mines in V32E and V32D

RUs

- **V33A, B, C, D - Buffalo from Blood to Thukela confluence**



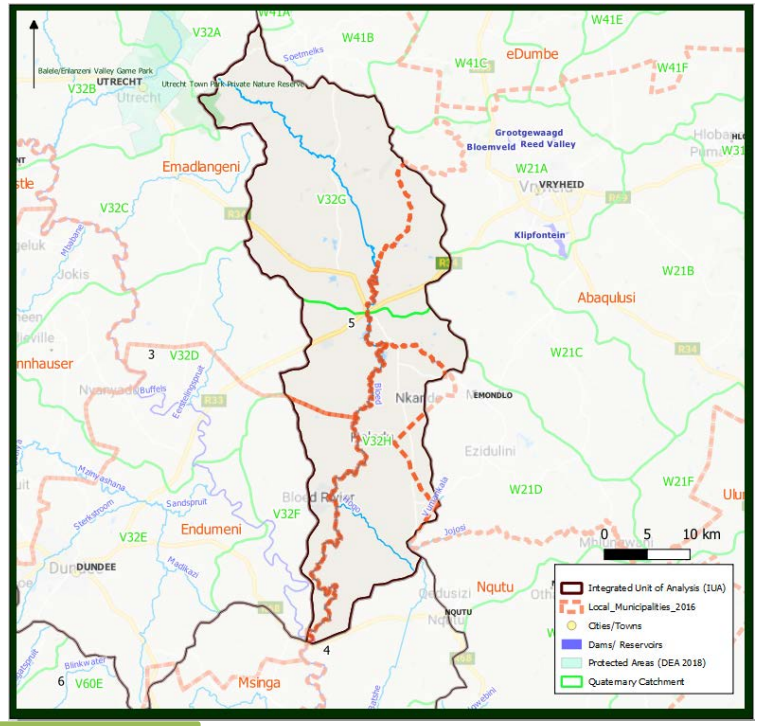
IUA 4	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
%	8.6	12.4	**79.0**		**85.5**	14.5	28.1	25.4	**46.5**				**60.8**	20.9	18.3

IUA 5: Blood River

The Blood River drainage region is delineated as IUA 5.

Tributaries	Description	SEZ	Quaternaries	Additional sites
Hoqo River	Very large vlei areas; wetland driven; Towns/ villages: Kingsley; Ntabebonvu; Bloedrivier;	Mixed use and rural zone	V32G; V32H	Wetland requirements rapid at Ncone on Blood

PES	Wetlands	WQ hotpots/Use / Groundwater	RUs	Key EWR site/ Nodes
Rivers B and C category	Priority systems	irrigation	V32G, H - Wetland RU	Rapid at Ncone



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

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
%	13.3	24.8	**61.9**		2.4	**97.6**	14.9	36.7	**48.4**		**100.0**		38.2	11.4	**50.4**

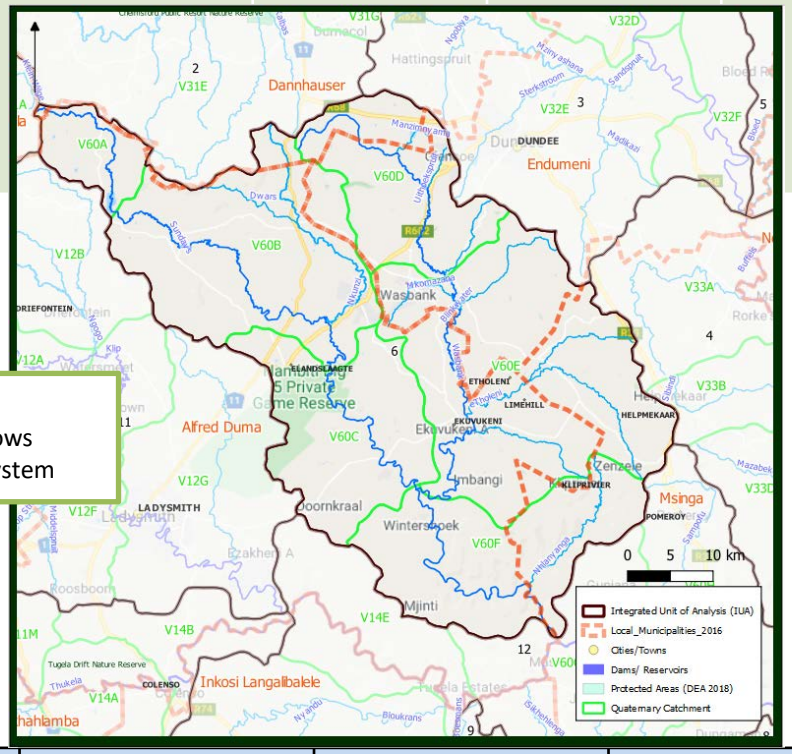
IUA 6: Sundays River

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

Tributaries	Description	SEZ	EWR site	Quaternaries	PES	Wetlands
Dwars River Nkunzi River Manamntana River Biggersgatspruit Mkomazana River Binkwater River Dlomodlomo River eTholeni River Kalkoenspruit Nhlanyanga River	Down to the confluence of the Sundays and the Nhlanyanga rivers; Towns/ villages: Cundycleugh; Craigsforth; Biggarsberg; Fort Mistake; Wasbank; Elandslaagte	Mixed use Zone; small portion Agricultural	EWR 7 and 8 (very close to the outlet); Comprehensive – biological surveys, discharge	V60A; V60B; V60D; V60C; V60E; V60F	Rivers C category Nhlanyanga (V60F) – B category eTholeni (V60E) - D category	Priority wetland system in V60A; V60B; V60C and V60D

WQ hotpots/ Use / Groundwater	RUs
Upper Wasbank – WQ (coal decants)	V60B, C - Nkunzi to confluence with Sundays V60D, E - Wasbank to confluence with Sundays V60A, B, C - From source to confluence with Wasbank V60F - From Wasbank to Thukela confluence

Driven by the incremental flows entering the system



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
%	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

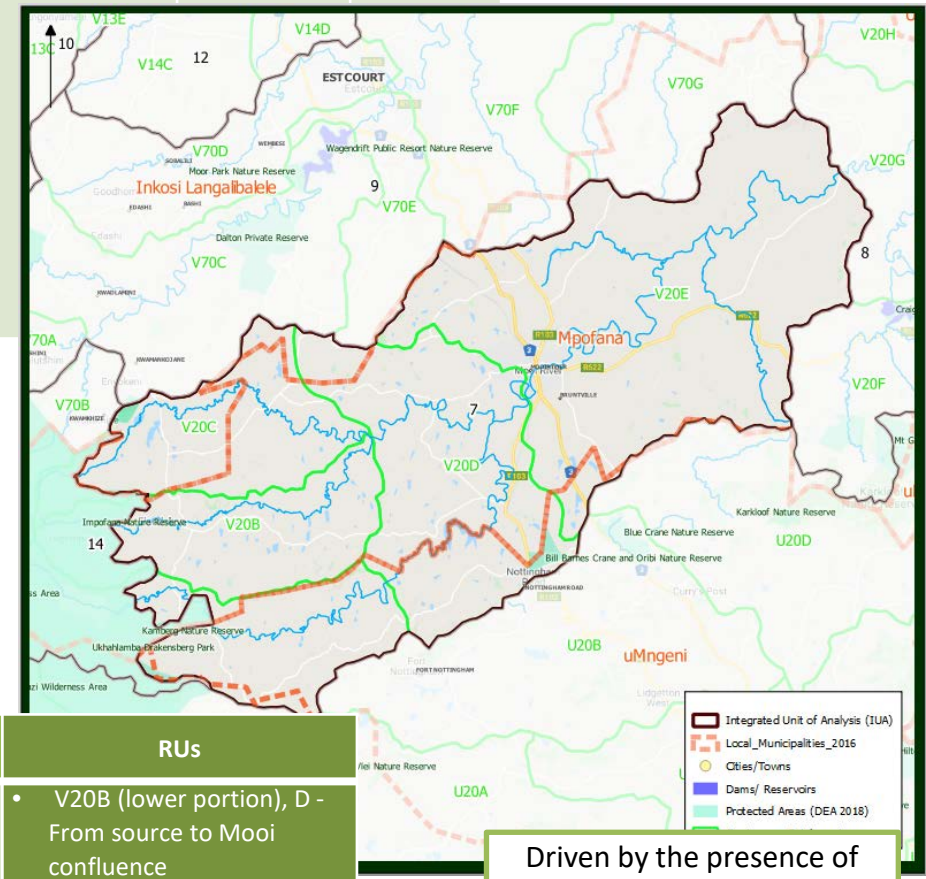
IUA 7: Upper Mooi River

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

Tributaries	Description	EWR site	SEZ	Dams	Quaternaries	Additional sites
Nsonge River Klein-Mooi River Katspruit Joubertsvlei se Loop	• Nsonge River to Mooi River at Doornkloof • Towns/ villages: Redcliffe; Rosetta; Nottingham Road • Mooi River; • Mooi Mgeni River Transfer Scheme: Phase 2 – Spring Grove Dam • Mooi Mgeni River Transfer Scheme: Phase 1 - Mearns Transfer Scheme	Existing rapid on N3; close to outlet of IUA; consider new rapid upstream Mooi River Town?	Agricultural Zone	Spring Grove Dam	V20C; V20D; V20E	Little Mooi V20D

IUA 7	Seep			Channelled VB			Unchannelled VB		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
%	14.2	29.9	55.8	2.1	6.4	91.5	5.0	15.1	80.0

Floodplain			Depression		
A/B	C	D/E/F	A/B	C	D/E/F
11.1	39.3	49.6	71.6	18.2	10.2



PES	Wetlands	WQ hotpots/Use / Groundwater	RUs
C ecological category Katspruit - D category Joubertsvlei se Loop - E category	• Present across IUA – Ramsar site protected areas • Wetland systems in V20E	Protected areas? Heavily irrigated area – V20E Agricultural – use of fertilizers Problems with fertiliser contaminants – water quality hotspots and irrigation return flows.	• V20B (lower portion), D - From source to Mooi confluence • V20E Joubertsvlei to confluence with Mooi • V20D Downstream Spring Grove Dam to outlet of V20E

Driven by the presence of the Spring Grove Dam and Mearns weir and associated Mgeni transfers

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 Tugela River (below) Keate's Drift.

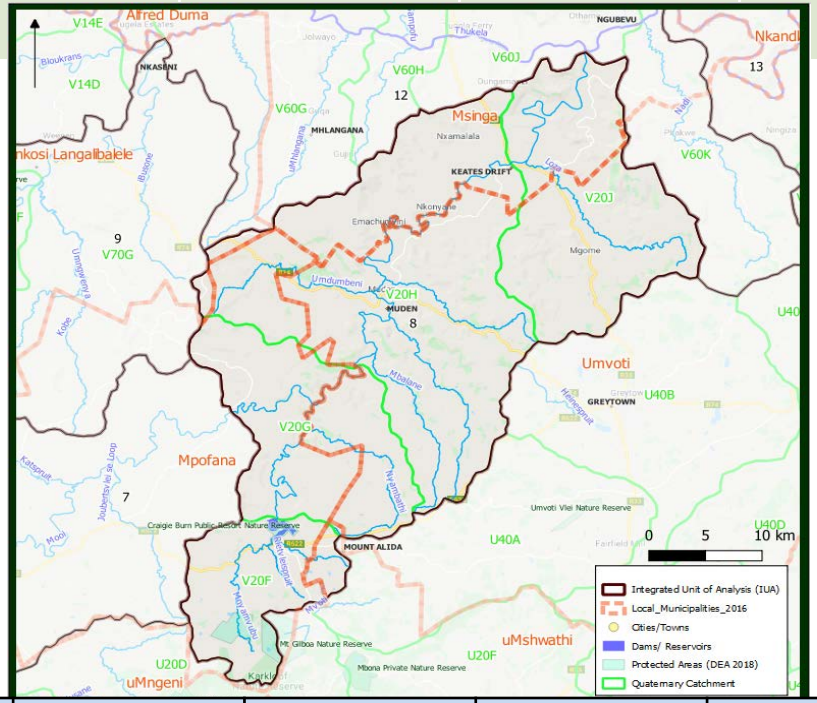
Tributaries	Description	SEZ	EWR site	Dams	Quaternaries	Additional sites
Mpatheni River Nyambathi River Mnyamvubu River Mbalane River Mhlopeni River Umdumbeni River iTshekana River Loza River	• From Mooi River at Doornkloof to Keate's Drift; includes irrigation • Towns/ villages: Rietvlei; Muden; Keate's Drift	Agricultural and Rural Zones	EWR 11; need new site on Mooi River below Keats Drift	Craigie Burn Dam	V20F; V20G; V20H; V20J	Mooi V20J need new site on Mooi River below Keats Drift

RUs

- V20F, G - Mnyamvubu downstream of Craigie Burn Dam to confluence with Mooi
- V20E, G Mooi to Mnyamvubu confluence
- V20H, J Mooi from Mnyamvubu to Thukela confluence

WQ hotpots/Use / Groundwater

- Proposed abstraction from Craigieburn Dam (bulk line) to supply Greytown – upgrade of water treatment plant (from 6Ml/d to 13 Ml/d and raw water main. Gravity lines to Enhlalakahle
- Connection of 2X boreholes to supply Kranskop



PES	Wetlands
• Rivers C ecological category • Mbalane River – B category • Mooi short reach below EWR 11 – B category	Wetland systems in V20F, V20G

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
%	9.7	32.8	57.5	21.1	21.3	57.6	1.5	11.3	87.2	100.0			20.4	79.6	

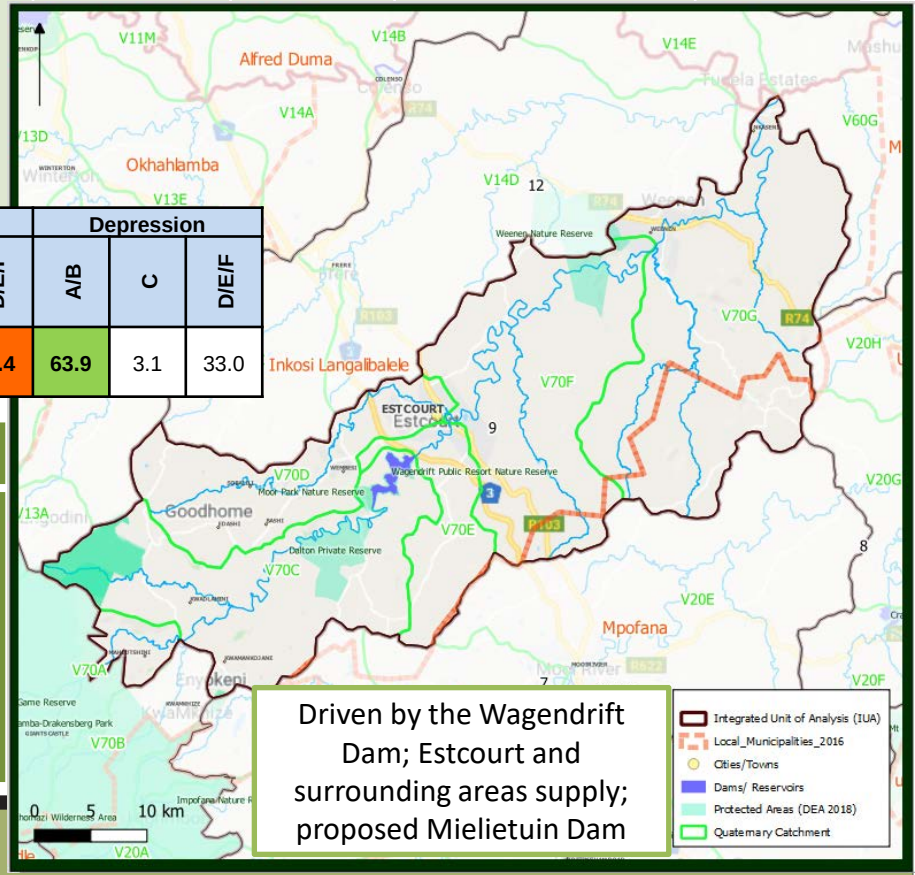
IUA 9: Middle/ Lower Bushmans River

IUA 9 is delineated from the outflow of the Bushmans River from the UKhahlamba Drakensberg National Park to its confluence with the Tugela River.

Tributaries	Description	SEZ	EWR site	Dams	Quaternaries	PES	Wetlands
Klein Boesmans River Rensburgspruit uMngwenya River Kobe River iBusone River	• Up to EWR 5 at outlet; Weenen irrigation and proposed Mielietuin Dam (RU – yes with EWR5?) • Towns/ Villages: Ntabamhlope; Rockmount; South Downs; Estcourt; Weenen	Agricultural Zone	EWR5 and EWR 6 at the outlet – Comprehensive sites	Wagendrift Dam Proposed Mielietuin Dam.	V70C; V70D; V70E; V70F; V70G	Umngwenya (V70G); iBusone (V70G) – B category C category – V70C; V70D; V70E, V70F, V70G	Priority wetland systems in V70C; V70D, V70E; V70F

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
%	8.2	21.1	**70.7**	0.2		**99.8**	19.7	27.4	**52.9**	37.5	13.2	**49.4**	**63.9**	3.1	33.0

WQ hotpots/Use / Groundwater	RUs
• WQ hotpots – Weneen, Escourt WWTWs – discharges - • impacting farmers. • Nzenwezi- sewage effluent to Bushmans River • New water treatment package plants 2.7Ml/day abstraction from Bushmans River	• V70D - Little Bushmans to confluence with Bushmans • V70E, F, G Bushmans from Wagendrift Dam to confluence with Thukela



Driven by the Wagendrift Dam; Estcourt and surrounding areas supply; proposed Mielietuin Dam

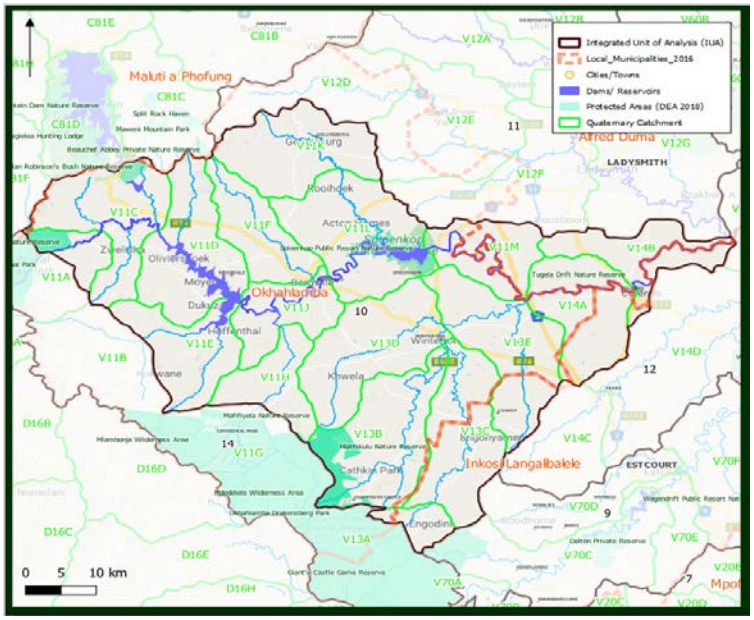
IUA 10: Upper Tugela River

IUA 10 delineation incorporates the upper Tugela River catchment from its headwaters at the outflow of the uKhahlamba Drakensberg National Park to the confluence of the Klip River.

Tributaries	Description	SEZ	EWR site	Dams
Khombe River Mpandweni River Nxwaye River Mnweni River (lower) Sandspruit Mlambonja River (lower) Njongola River Ventherspruit Situlwane River Sterkspruit Middle Little Tugela River Kaalspruit	• From Woodstock Dam to confluence with Klip River (proposed Jana Dam site) • Priority water source area; natural; agriculture; irrigation; villages; tourism • Towns/ Villages; Zunckels; Bergville; Winterton; Loskop; Geluksburg • Colenso • Thukela-Vaal Government Water Scheme	Agricultural Zone	• EWR 2; EWR 1; EWR 3 on Little Tugela; • Comprehensive – biological surveys, discharge	Woodstock Dam; Driel Barrage Spioenkop Dam; Kilburn

RUs
• V11J - Reach between Driel and Spioenkop Dam • V11M - Spioenkop Dam to Little Thukela confluence • V13A (lower portion), C, E - From IUA14 outlet to confluence with Thukela River • V14A, B - From Little Thukela confluence to proposed Jana Dam/ Klip confluence

Quaternaries
V11D; V11E; V11F; V11H; V11J; V11K; V11L; V11M; V13B; V13C; V13D; V13E; V14A; V14B



PES	Wetlands	WQ hotpots/Use / Groundwater
• Headwaters tributaries – A category and B category (mountainous areas) • Lower reaches – C category • Sterkspruit (V13B) – D category	Priority wetland systems in V11L, V13C; V14A; V13B	• Intensive irrigation • Sewage concerns around Colenso and Winterton area – water quality RUs

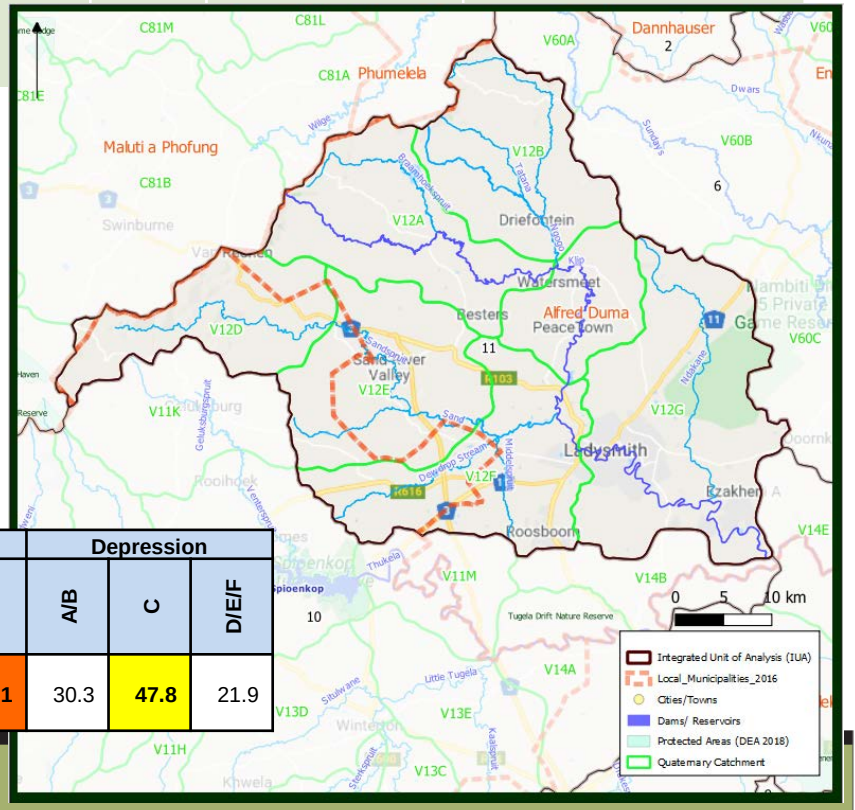
IUA 10	Seep			Channelled VB			Unchannelled VB			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
%	7.2	21.3	**71.4**	1.7	47.8	**50.5**	4.5	23.5	**72.0**		**100.0**		32.2	**48.7**	19.2

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 Tugela River.

Tributaries	Description	SEZ	EWR site	Dams	Quaternaries	Additional sites	PES
Mhlwane River Tatapa River Ngoga River Braamhoekspruit Sandspruit Dewdrop Stream Middelspruit Ndakane River	• Klip to confluence with Tugela to a location upstream of proposed Jana Dam; • Towns/ Villages: Driefontein; Besters; Ladysmith; Roosboom; Pepworth; Wyford • Ingula pump storage scheme	Agricultural and Rural Zones	New site on Klip River, downstream Ladysmith	Qedusizi Dam (flood control)	V12A; V12B; V12C; V12D; V12E; V12F; V12G;	• Klip River (one site either just downstream of the flood control dam in V12C or below Ladysmith, V12G)	• Headwaters V12A - A category and B category (mountainous areas) • Lower reaches – C category • A few tributaries - B category

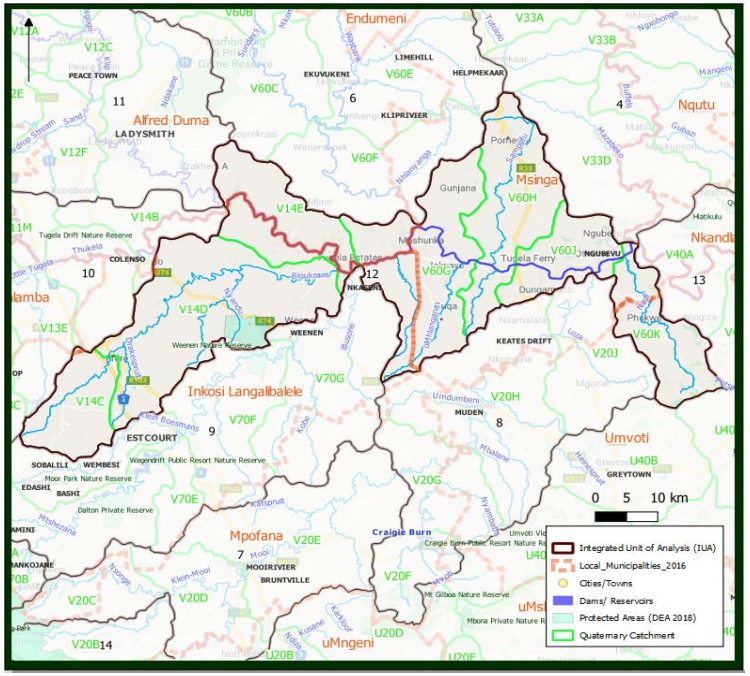
RUs	Kew EWR site/ Nodes	Wetlands
• V!"D – Upper reaches of the Sandspruit • V12G - Klip from Ladysmith to confluence with Thukela	• Flow - hydro node • New site • Rapid 3 on Klip– surveys for hydraulics (cross-section, discharge), fish, inverts, IHI • IWUI+IEI a rapid required	Priority wetland systems in V12A; V12E; V12D; V12G



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
%	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

IUA 12: Middle Tugela River

The IUA is delineated as the Tugela 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.



Tributaries		Description
Bloukrans River Drakespruit Mtontwanes River Nyandu River iSilwhehlenga River	uMhlangana River Sompofu Rver Nadi River Mfongosi River Manyane River Ngcaza River	• From confluence of Klip River (Jana Dam site) to Thukela at Middeldrift (The Ranch – EWR15 • Villages; • agriculture; Natural; steep slopes • Lower Thukela bulk water abstraction weir. • Towns/ Villages: Mbango, Blaaukrantz; Frere; Chieveley; Pomeroy; Tugela Ferry; Gxobanyawo; Ngubevu; Phakwe; Nhlonga • Djolwena

SEZ	EWR site	Dams	Quaternaries	Additional sites	PES	Wetlands	RUs
Agricultural and Rural Zones	EWR 9; EWR 4a or 4b; Comprehensive – biological surveys, discharge	Proposed Jana Dam	V14C V14D; V14E; V60G; V60H; V60J; V60K	Jana Dam as a RU	Tugela – C Category	Priority wetland systems identified in V14C; V14B; V14D	• V14E - from Klip confluence to Bushmansconfluence confluence • V60G, H, J, K - Thukela from Bushmans confluence to d/s Mooi confluence

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
%	5.9	11.1	**83.0**		20.2	**79.8**	7.5	28.2	**64.3**					**97.3**	2.7

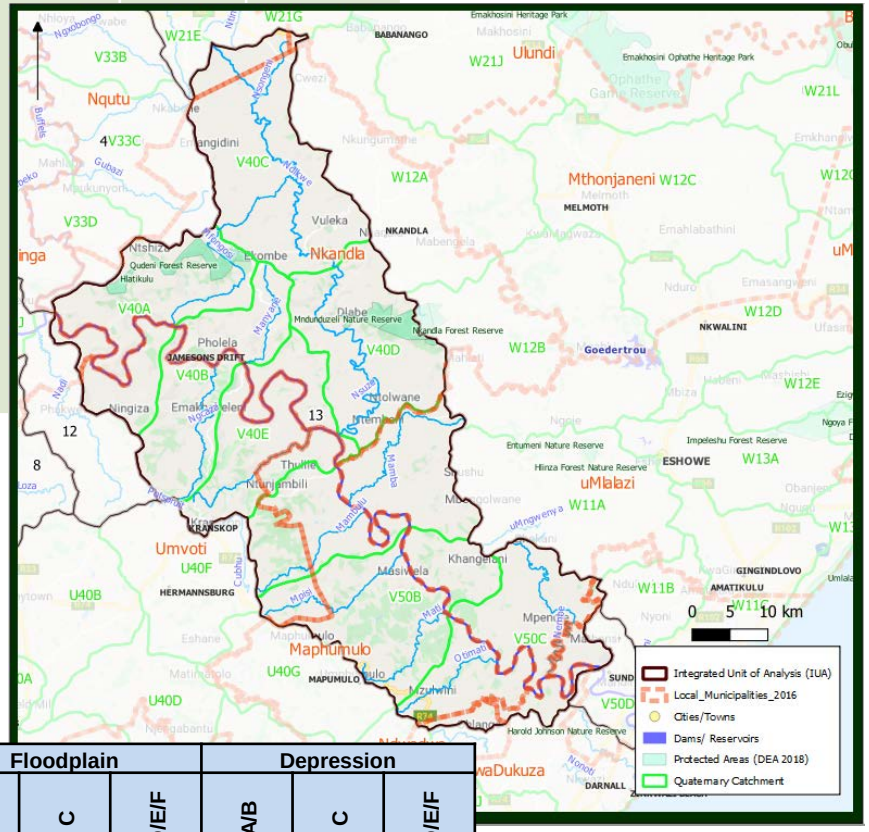
IUA 13: Lower Tugela

This IUA is delineated as the Lower Tugela River from confluence of the Buffalo River to the upper portion of quaternary catchment V50D.

Tributaries	Description	SEZ	EWR site	Dams	Quaternaries	Additional sites	PES
Nsuze River Nsongeni River Ndikwe River Mamdleni River Mamba River Mambulu River Mpisi River Mati River Otimati River Nembe River	The Ranch; Ntunjambiti; Fort Ntembeni; KwaSizabantu; Mapumulo; Otimati	Rural zone	• EWR 15 • EWR 16 • Comprehensive – biological surveys, discharge	Transfer at Middeldrift weir (EWR15), Transfer at Mandini weir (EWR16)	V40A; V40B; V40C; V40D; V40E; V50A; V50B; V50C;	Nzuse V40D	Lower Tugela – B Category Nsuze – A category

RUs

- V40A, B - Thukela from d/s Mooi confluence to Middeldrift transfer
- V40C, D - Nsuze from source to confluence with Thukela
- V40E, V50A, B, C, D (upper portion) - Thukela from Middeldrift to Mngeni transfer



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
%	7.6	6.3	86.1		99.3	0.7			100.0				94.4	2.0	3.7

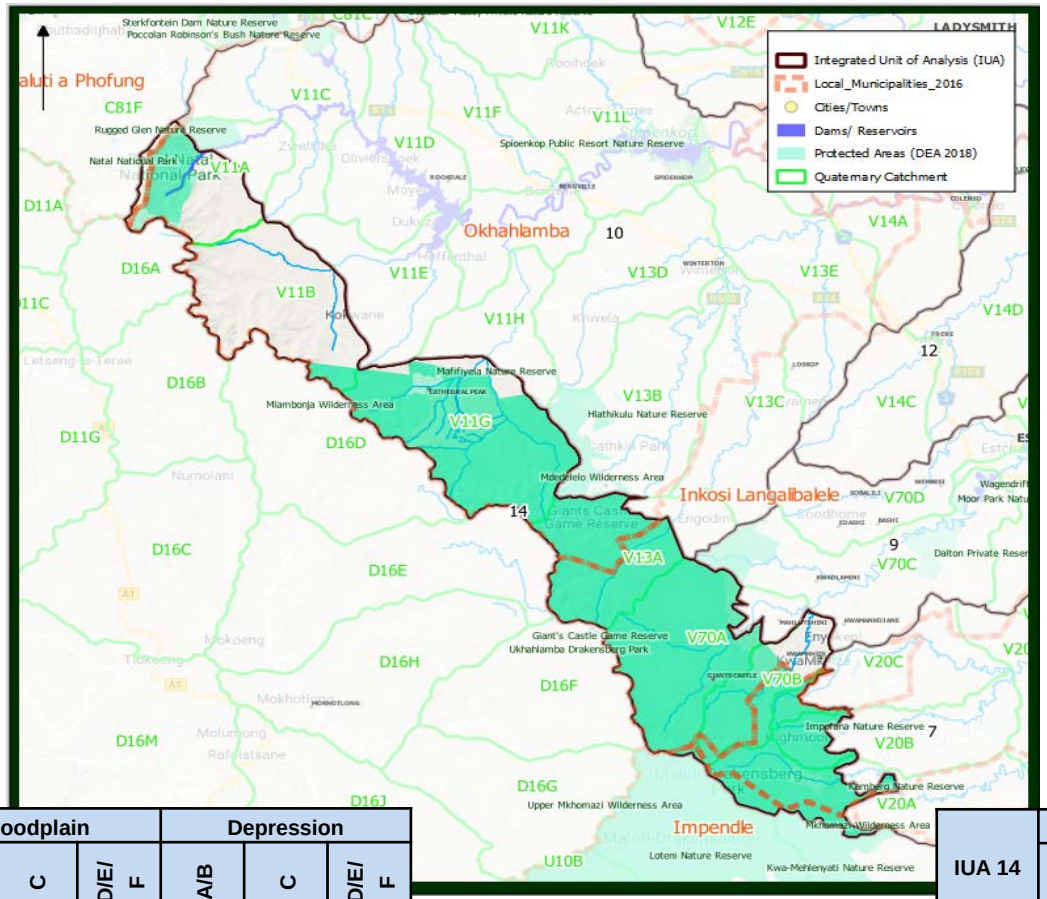
IUA 14: Escarpment

This IUA is delineated as the source of the upper Tugela River and its tributaries within the uKhahlamba Drakensberg National Park (park boundary as IUA boundary).

Description	SEZ	EWR site	Dams	Additional sites	PES	Wetlands	WQ hotpots/Use / Groundwater
Towns/ Villages: Cathedral Peak;	Agricultural Zone	No sites	None	None	A and B category	Scattered smaller systems in mountainous area	Trout farms – V70A

Tributaries

Thukela headwaters
Putterill River
Upper Little Tugela River
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)



RUs

- V11A - Upper reaches of Thukela River
- V11B - Source to confluence of Sithene and Thonyelana Rivers
- V11G - Source to confluence of Mlambonja and Mhlwazini Rivers
- V13A - Upper reaches of Little Thukela River
- V70A - Upper reaches of Boesmans River
- V70B - Source to outlet of V70B
- V20A - Upper reaches of Mooi River
- V20B - Upper reaches of Little Mooi River

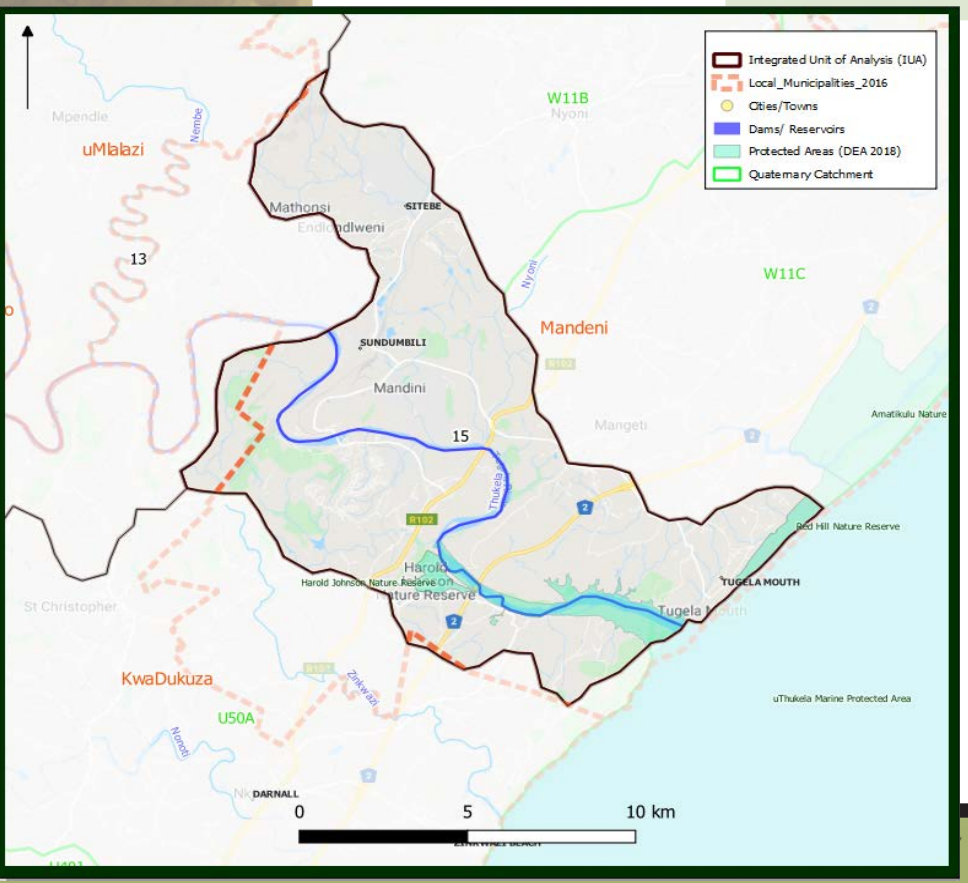
Unchannelled VB			Floodplain			Depression		
A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
10.6	34.9	**54.5**	4.0		**96.0**	**58.1**	15.3	26.6

IUA 14	Seep			Channelled VB		
	A/B	C	D/E/F	A/B	C	D/E/F
%	27.8	17.3	**54.9**	3.8	3.5	**92.7**

IUA 15: Thukela Estuary and upstream Tugela Reach

The lowest reach of the Tugela River in V50D and Thukela Estuary is delineated as the IUA.

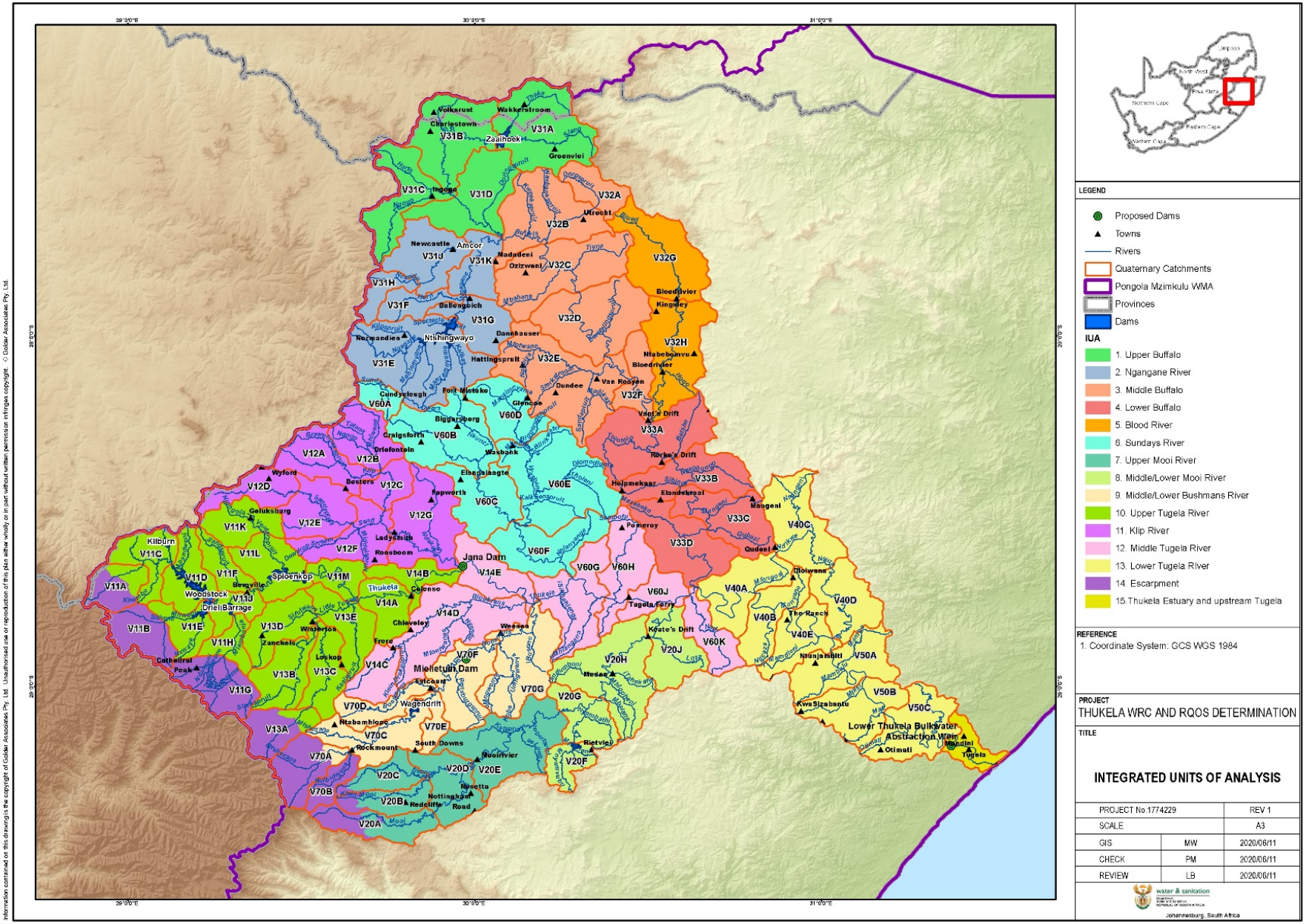
Description	SEZ	EWR site	Quaternaries	PES	Wetlands
Tugela Estuary Industrial area Towns/ Villages: Mandini; Tugela;	Commercial Development Zone	Estuarine requirements	V50D	Tugela – C Category Estuary PES – C category	No Priority wetland systems



WQ hotpots/Use / Groundwater	RUs	Kew EWR site/ Nodes
V50D (groundwater) Assess surface – groundwater interaction Mandini stream – WQ impact	Groundwater RU Estuary reach – from MPA boundary 8.7km	Estuary node: At Sappi monitoring point – John Ross bridge

IUA 15	Seep			Floodplain			Depression		
	A/B	C	D/E/F	A/B	C	D/E/F	A/B	C	D/E/F
%	38.0		62.0	8.8		91.2	100		

Integrated Units of Analysis



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UPCOMING ACTIVTIES

Upcoming Tasks/Activities

- Finalisation of IUAs (31 July)
- Quantification of EWRs (September 2020)
  - Field visits/Site surveys – August 2020
    - Rivers
    - Wetlands
    - Estuary
- Linking of the Socio-Economic and ecological value of the water resources (end August 2020)
- Resource Unit Delineation and Selection for setting of RQOs (September 2020)
- Water Resource Model Setup and Scenario analysis (Oct/Nov 2020)
- PSC Meeting 2 – November 2020

THANK YOU