Report no. RDM/WMA04/00/CLA/0119

DEPARTMENT: WATER AND SANITATION
CHIEF DIRECTORATE: WATER ECOSYSTEMS MANAGEMENT
DIRECTORATE: WATER RESOURCE CLASSIFICATION

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

REPORT TITLE: INCEPTION REPORT

FINAL

December 2019

DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems

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INCEPTION REPORT
WP 11255

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Department of Water and Sanitation
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Tel: (012) 336 7500/ +27 12 336 7500
Fax: (012) 336 6731/ +27 12 336 6731

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Prepared by:

Golder Associates Africa in association with AECOM, Prime Africa, Wetland Consulting Services, JMM Stassen, Zitholele Consulting, Dr Gavin Snow and Andre Joubert Communication Services

Title:	*Inception Report*
Authors:	*L Boyd, P Moodley, J Crafford, J Schroder, E van Wyk, R Stassen, G Snow, M Vosloo, A Joubert, G Marneweck*
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…………………………………………………. *…………………………………………*

Trevor Coleman *Date*

Project Director, Golder Associates

DEPARTMENT OF WATER AND SANITATION

Chief Directorate: Water Ecosystems Management

Approved for DWS by:

………………………………………………….

Mohlapa Sekoele

Project Manager: Water Resource Classification

………………………………………………….

Mkhevu Mnisi

Scientific Manager: Water Resource Classification

………………………………………………….

Lebogang Matlala

Director: Water Resource Classification

DOCUMENT INDEX

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1.0	RDM/WMA04/00/CON/CLA/0119	Inception Report

TERMINOLOGY AND ABBREVIATIONS

Acronym	Description
AOA	Annual Operating Analysis
BAS	Best Attainable State
BID	Background Information Document
BHN	Basic Human Needs
CD: WE	Chief Directorate: Water Ecosystems
CRA	Comparative Risk Assessment
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EcoSpecs	Ecological Specifications
EGSAs	Ecosystem Goods, Services and Attributes
ERC	Ecological Recommended Category
ESFs	Ecosystem Service Frameworks
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FEGS-CS	Final Ecosystem Goods and Services Classification System
FRAI	Fish Response Assessment Index
GDP	Gross Domestic Product
GGP	Gross Geographic Product
GIS	Geographic Information System
GRA	Groundwater Resources Assessment
HGM	Hydrogeomorphic
IFR	Instream Flow Requirements

Acronym	**Description**
IHI	Index of Habitat Integrity
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 System
MEA	Millennium Ecosystem Assessment
MIRAI	Macroinvertebrate Response Assessment Index
MPA	Marine Protected Area
NFEPA	National Freshwater Ecosystem Priority Areas
NGO	Non- Governmental Organisation
NWA	National Water Act
PES	Present Ecological Sate
PMC	Project Management Committee
PSC	Project Steering Committee
PSP	Professional Service Provider
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RDM	Resource Directed Measures
RUs	Resource Units
SANBI	South African National Biodiversity Institute
SEA	Socio-Economic Assessment
SeCT	Socio-Economic Classification Tool
SWS	Social Wellbeing Score

Acronym	Description
TEC	Target Ecological Category
TEEB	The Economics of Ecosystems and Biodiversity
TOR	Terms of Reference
TWP	Thukela Water Project
UNESCO	United Nations Educational, Scientific and Cultural Organization
WARMS	Water Use Authorisation and Registration System
WMA	Water Management Area
WRCS	Water Resource Classification System
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model

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1 INTRODUCTION

The Chief Directorate: Water Ecosystems has initiated a study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment.

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 classification system and the Reserve are intended to ensure comprehensive protection of all water resources. 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 established to give effect to determined water resources classes and the Reserve.

1.1. Study Objective

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

The key aims of this study are therefore to co-ordinate the implementation of the Water Resource Classification System (WRCS) published as Regulation 810 in September 2010 for determination of water resource classes and associated RQOs in the Thukela catchment. The study is linked to the previous Reserve determination Studies and other water resource management initiatives. Where the preliminary Reserve is available and relevant, the information will be adopted and where needed, within the ambit of this study, gaps will be filled.

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

It is recognised that the successful determination of the water resource classes and RQOs will depend on the integration of a number of disciplines in respect of water resources with the water uses and the needs of the water users present in the catchment area, through consultative processes. Specialist technical assessment and stakeholder engagement are key components to the process.

1.2. Purpose of this Report

The inception report has been produced to better define the scope of work for the study, document any changes to the scope of work from the proposal, and highlight related considerations that could influence the study, confirm the study programme and indicate any key challenges resulting from the initial assessments and reviews undertaken during the inception phase of the project.

2 STUDY AREA

The study area is the catchment of the Thukela River which is illustrated in Figure 1.

The Thukela catchment drains an area of 29 040km^2, rising on the escarpment of the Drakensberg and flowing approximately 512km through the eastern slopes, the midlands and discharges in the Indian Ocean. The Thukela catchment has two main drainage systems: The 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 Thukela River 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 main topographic feature in the water management area is the Drakensberg Mountain Range in the west, which also demarcates the continental divide between the rivers flowing eastward to the Indian Ocean, notably the Thukela River, and the Orange/Vaal River basin with its outflow to the Atlantic Ocean. The climate is strongly influenced by the topography and ranges from cool in the mountains to subtropical at the coast. Mean annual rainfall is in the range from 600 mm to approximately 1 500 mm. As a result of the rainfall distribution and topography, most of the runoff originates in the vicinity of the escarpment and in the upper reaches of tributaries, where waterfalls are a significant feature.

The Thukela River catchment is the largest river system within the Pongola to Mtamvuma Water Management Area (WMA 4) (and in KwaZulu-Natal) (Figure 2). The system includes small to large sub-catchment areas with the Thukela River flowing directly into the Indian Ocean via the Thukela estuary, situated some 95 km north of Durban.

The main 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 through Estcourt, and
- The Mooi River.

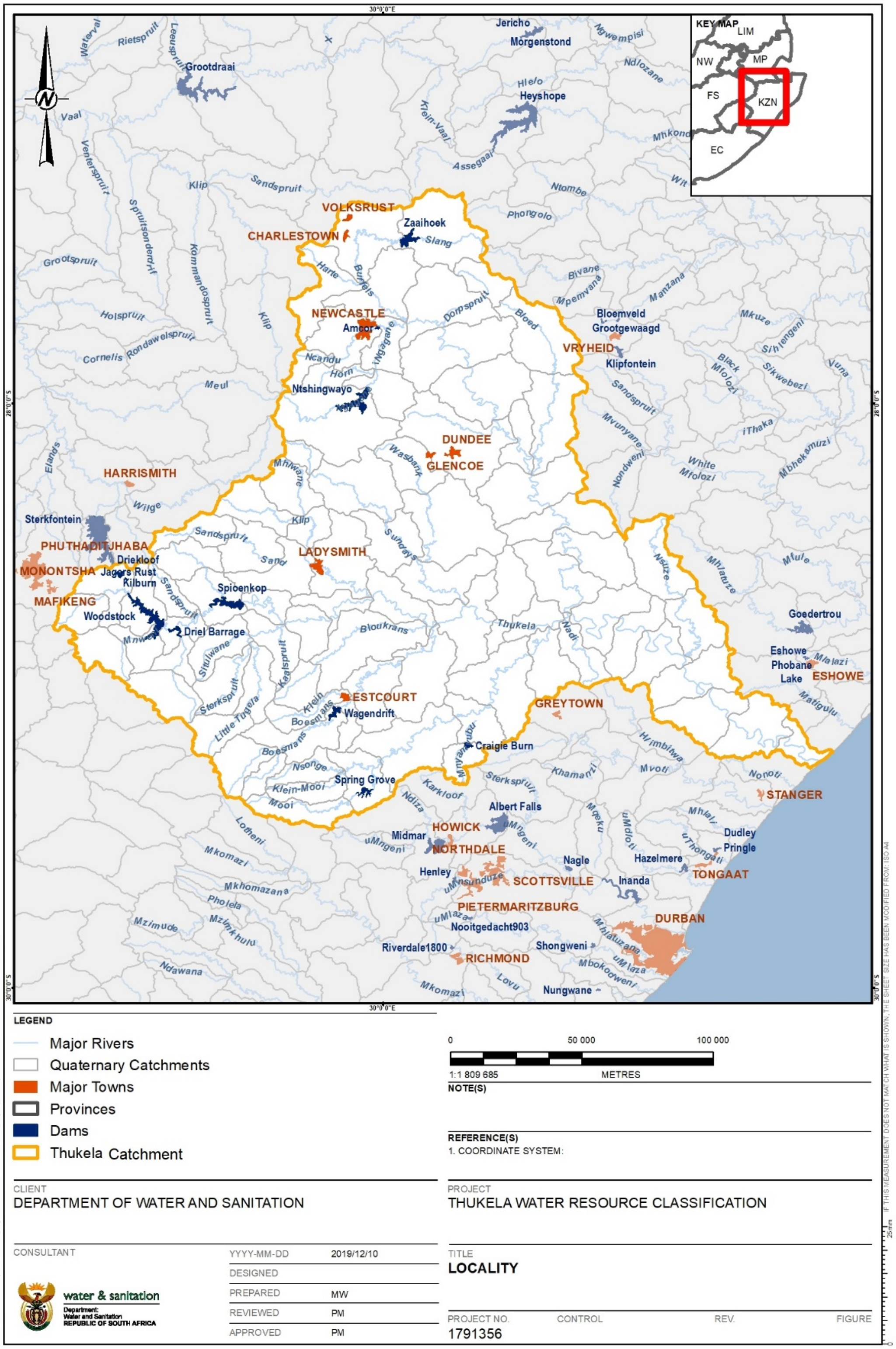

Figure 1: Thukela catchment – Study Area Locality

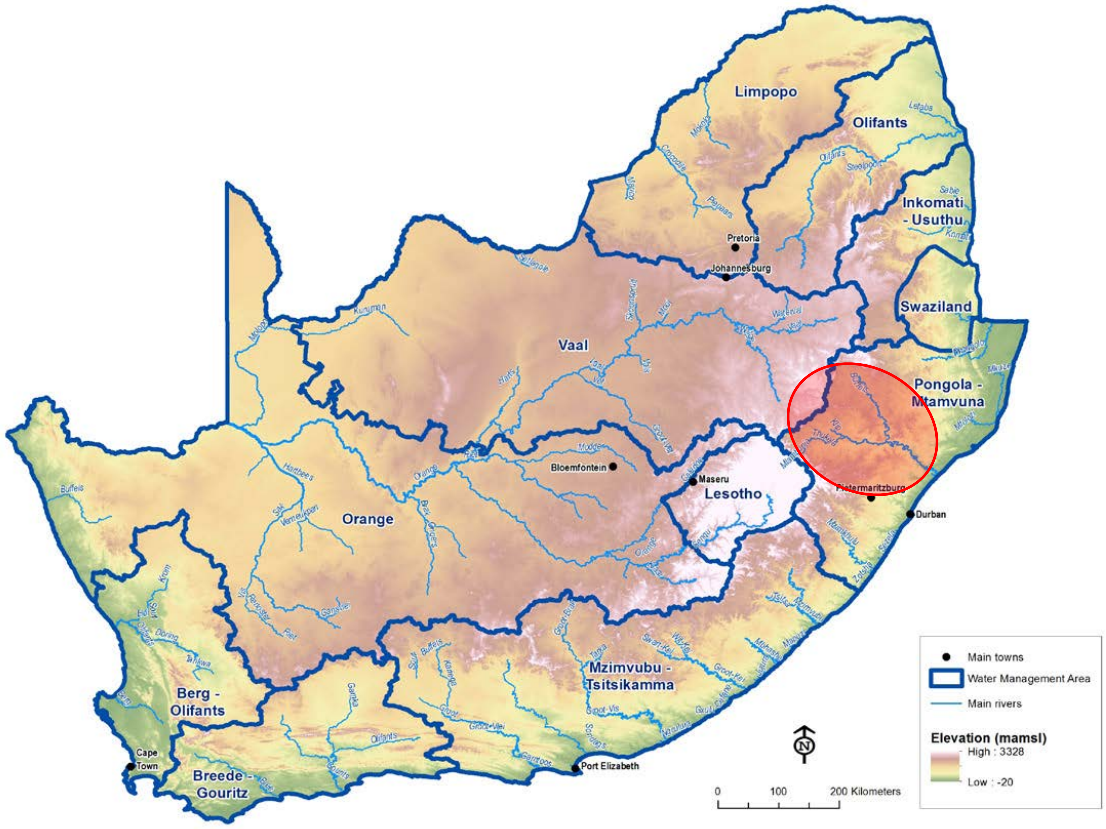

Figure 2: Thukela catchment within the Pongola to Mtamvuma WMA

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 (approximately 70% of yield) (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 area, and several options have been investigated in this respect. The largest and most notable of these is the Thukela Water Project which is to consist of the proposed Jana Dam on the main stem of the Thukela River, Mielietuin Dam on the Bushmans River and an extensive aqueduct system for transfer of water to the Vaal River.

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. A significant proportion of the base flow in surface streams is contributed from groundwater.

The uThukela, Amajuba, uMgungundlovu and uMzinyathi District municipalities, with various local municipalities and traditional authorities, provide the institutional backbone of the region. The total population of the catchment is approximately 1.56 million. This value was calculated from the 2011 Census data (Stats SA), extrapolated from ward data and aligned to catchment boundaries. As a result, it should be noted that 1.56 million is possibly an underestimate of the 2019 population numbers because of assumed growth since 2011. As the data are unpacked for the socio-economic study, more appropriate multipliers should be found so that a more accurate number is obtained. The catchment includes the major towns of Newscastle, Dundee, Ladysmith and Escourt. 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 area. 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, especially in the Ngagane River catchment a tributary of the Buffalo River. A number of other commodities such as sand and dolerite are also mined. Although many of the collieries in the catchment are inactive, they impact on the quality of the water resources in the area. The economy of the Newcastle area is heavily dependent on the mining activity. The natural drainage from geological formations, especially from coal mine workings also contains appreciable amounts of nitrates and phosphate.

Tourism and ecotourism are growing economic sectors primarily focussed on the beauty and splendour of the Drakensburg Mountains, game farming and water sport.

To enable improved representation of the water resources situation in the water management area, and to facilitate the applicability and better use of information for strategic management and planning purposes, the catchment area has been divided into sub-areas. Delineation of the sub-areas was based on practical considerations such as size and location of sub-catchments, homogeneity of natural characteristics, location of pertinent water infrastructure (e.g. such as dams), and economic development. Four sub-areas were identified, as indicated in Table 1 and shown in

Figure **3**. These areas will be further sub-divided when the Integrated Units of Assessment (IUA) are defined.

Table 1: Sub-catchment areas of the Thukela catchment (DWS, 2004)

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	V11, V12, V13 and V14	7645

Sub-catchment	Description	Tertiary drainage regions	Catchment area$^{(1)}$ (km^2)
	River		
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

Surface water has been highly developed in some parts of the catchment, where it is being fully utilised. The main storage dams (Table 2) are:

- Woodstock and Spioenkop Dams on the Thukela River,
- Windsor and Qedusizi Dams on the Klip River, in the Upper Thukela sub-area. Windsor Dam is expected to be decommissioned in the near future, whilst Qedusizi Dam expressly serves for flood control and has no active storage.
- Zaaihoek and Ntshingwayo (Chelmsford) dams in the upper tributaries of the Buffalo River.
- Wagendrift Dam on the Bushmans River, Craigieburn Dam on the Mnyamvubu, a tributary of the Mooi River, Spring Grove Dam on the Mooi River, Olifantskop Dam on the Sundays River, in the Mooi/Sundays sub-area.

No large dams have been constructed in the Lower Thukela sub-area.

Table 2: Major Dams in the Thukela

Dam name	Number	Quaternary catchment	River	Purpose	Full supply capacity (million/m^3)
Woodstock	V1R003	V11D, V11E	Thukela	Transfer to Vaal for domestic and industrial use	380.4
Driel Barrage	V1R002	V11J	Thukela	Transfer to Vaal for domestic and industrial use	8.7

Dam name	Number	Quaternary catchment	River	Purpose	Full supply capacity (million/m^3)
Spioenkop	V1R001	V11M	Thukela	Transfer to Vaal for domestic and industrial use	279.6
Qedusize	V1R005	V12F	Klip	Flood control	194
Zaaihoek	V3R003	V31A	Slang	Transfer to Vaal for domestic and industrial use	193.0
Ntshingwayo (Chelmsford)	V3R001	V31E	Ngagane	Municipal and industrial use	198.4
Wagendrift	V7R001	V70C	Bushmans	Irrigation	58.4
Spring Grove	V2R003	V20D	Mooi	Transfer to Mgeni for domestic and industrial use	139.5
Craigie Burn	V2R001	V20F	Mnyamvubu	Irrigation and future water supply to Greytown	23.4

The level of potable water supply in the catchment varies from household taps in developed areas, to standpipes in the townships, to none in remote areas. The main water resource infrastructure are the dams, which are located on the major rivers.

The majority of the towns in the catchment have their own potable water and sewage treatment works near the towns. The larger potable water treatment facilities are found at Newcastle, Esikawini township, Utrecht, Dundee, Ladysmith, Mandini, Bergville, Weenen, Estcourt, Emakwezini and Mooi River. The largest sewage plants are at Newcastle, Madadeni, Utrecht, Dundee, Ladysmith, Bergville, Estcourt, Mooi River, Colenso, Volksrust and at the prison near Volksrust and on the coast at Mandini.

The water quality of the water resources within the Thukela catchment indicates a generally good condition, with a number of sites within the ideal to acceptable range. The only exceptions to this occur in V30, V60 and V70 catchments (Bushmans and Mooi/Sundays, Lower Thukela area) which are in a poor water quality state due to localised activities (coal mining, agriculture and paper mill). Additional and more extensive water quality monitoring is required within the WMA to understand the water quality status.

The larger part of the catchment is in a good ecological condition, with the majority of river reaches in a largely natural to a moderately modified state (B and C present ecological state). A smaller portion of the river systems specifically in the vicinity of the urbanised developed areas are largely modified (D present ecological state), due to the impacts from land use and associated activities.

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

Inter-basin transfers

Woodstock and Driel Dams supply the existing Thukela-Vaal Project transferring water to the Vaal River System via Sterkfontein Dam in the Wilge River. Future transfers should the demand of the

Vaal River System materialise will include construction of the Jana Dam on Upper Thukela River and Mielietuin Dam on Bushmans River (The Thukela Water Project).

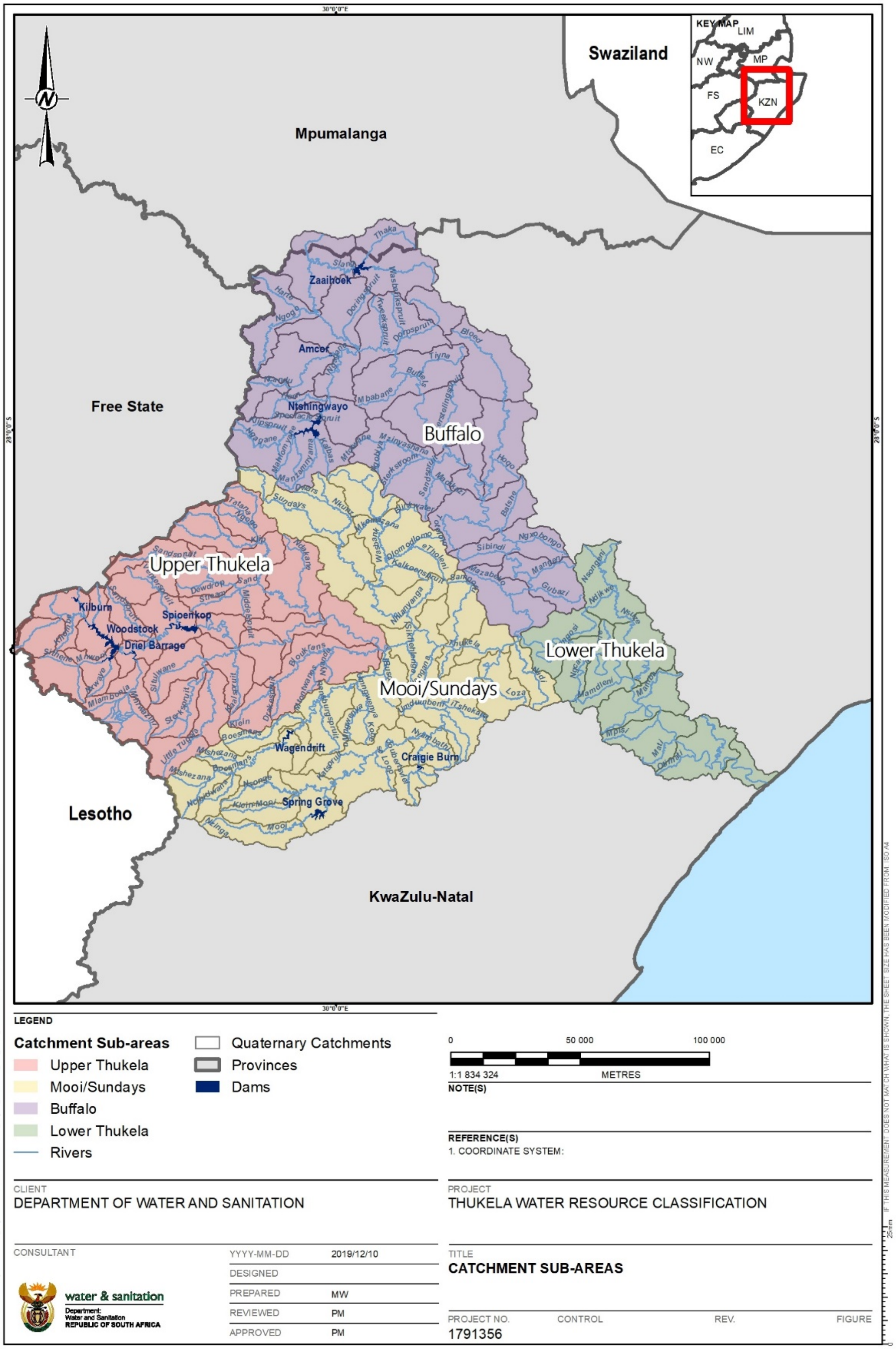

Figure 3: Thukela sub-catchment areas

Water is also exported to the upper reaches of the Vaal River Supply Area from Zaaihoek Dam for use at the Majuba Power Station and for transfer to Grootdraai Dam. Spioenkop Dam is the only dam on the main Thukela River which regulates flow for downstream users. The Thukela River System also supports inter-basin transfers to the Mgeni River System through the MooiMgeni Transfer Scheme, Spring Grove Dam on the Mooi River and the Middeldrift Scheme taking water from the lower Thukela River to the headwaters of the Mhlathuze River Catchment. The Lower Thukela Water Supply System and Thukela pipeline project further supports the Mooi-Mgeni system taking water from the lower Thukela at Mandini.

The water resources of the Thukela River system support significant economic activities both within the catchment as well as outside of the catchment. There is therefore a need to understand the implications of the preliminary Reserve in view of the socio-economic activities that are supported by abstracting water from the Thukela River for use in the catchment.

Groundwater

In terms of hydrogeology, sedimentary rocks of the Karoo Supergroup occur throughout the catchment and were deposited on basement rock formations represented by competent formations of the (i) the oldest rocks in South Africa, Barberton Sequence (mostly granites) and (ii) Namaqua-Natal (Metamorphic) Province Group (various degrees of shear-zoned meta-arenaceous rocks (quartzite, gneiss, migmatite and granulite).

The Karoo Supergroup is represented from the base by the basal diamictite/ tillite, through to the upper Karoo Formations – mainly argillaceous rocks (shales, claystones, mudstone and siltstone) and arenaceous rocks (sandstone, feldsphatic sandstone and arkose) to the younger overlying extrusive volcanic rocks (basalt and andesite) of the Drakensberg Group forming the southwestern boundary highlands of the catchment. On the coastal plains, for example at the Thukela Mouth area, undifferentiated (younger) coastal and inland deposits (consisting of unconsolidated to semi-consolidated sand, calcrete, aeolianite and conglomerate, etc.) occur.

Isolated occurrences of young (quaternary) fluvial deposits (*viz.* alluvial-primary aquifers) along major river channels are present throughout the catchment, but merely in the centre reaches of the Thukela, Sundays and Buffalo River and along the coastline in estuary aquifer systems.

Pre-Karoo formations have been altered significantly by shearing and associated metamorphism formed over various geological periods, thus representing isolated fractured aquifer zones. Following the Karoo Supergroup sedimentary deposits, they were significantly intruded by the Karoo Dolerite Suite in the initial stages of the Gondwana Land Break-Up in the form of massive dolerite sills/ oblique dyke intrusions. These features play a significant role in the physical characteristics of the hydrogeological occurrences/ regimes in the catchment.

Groundwater yields in the catchment vary significantly between the different aquifer classifications*, i.e.*

- Fractured Aquifer yield ranges: Moderate to high (0.1-0.5 to 2.0 ℓ/s); and
- Fractured and Intergranular yield ranges (0.1-0.5 to 2.0 ℓ/s).

It is, however, possible that dolerite contact-zone aquifers would have much higher yields, *i.e*. >5 ℓ/s. Due to the catchments highly variable climate signature and rainfall, groundwater recharge/potential varies significantly

The development potential in the area can be classified as moderate with resources mostly suitable for development of small reticulation schemes for local domestic use. Recharge calculations indicate the potential groundwater resources are underutilised: less than 25% of potentially available groundwater is presently used. There are, however, some quaternary catchments where the groundwater potential for allocations are low (*i.e*. <3 Mm^3/a) and should be considered for restrictions through stress index verifications.

Wetlands

The catchment includes a number of protected wetland systems and areas. A very well-known priority wetland is the Wakkerstroom Vlei, particularly for birding. The wetlands and sponges in the upper and middle Drakensberg are at present not under major threat of destruction, due to their remoteness and the fact that they are within a protected area. These resources need to be preserved as far as possible due to their critical role in supplying baseflows to all the rivers. Also included in the Thukela catchment is part of the Natal Drakensberg Park Ramsar Site (see www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa) which 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 area in South Africa due to its high yield and water quality, supplying rural, agricultural, urban and industrial users downstream. 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.

Estuary

The Thukela Estuary (29º13’24”E, 31º29’56”S) is located within the Thukela catchment approximately 100 km north of Durban in the KwaZulu-Natal Province. 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 (29º11’59.1”S, 31º25’27.1”E) approximately 8.5 km from the estuary mouth (Government Gazette No. 42478, 2019) (Figure 4).

The estuary is classified as an open river mouth (Large Fluvially Dominated) (Whitfield, 1992; van Niekerk *et al*. 2019a) and falls within the sub-tropical biogeographical coastal region of South Africa’s east coast. In terms of the National Biodiversity Assessment (NBA) 2018, 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*. 2019a). It was estimated that the Thukela River has the second highest mean annual runoff of 3754 x 106 m^3/a; 9.9% of South Africa’s total runoff after the Orange/ Gariep River (van Niekerk and Turpie, 2012).

The recently completed National Biodiversity Assessment 2018 highlighted that the Thukela estuary is functioning under a High Cumulative Pressure Level. Key pressures identified include very high fishing pressure and the presence of alien fish in the system. Pollution and habitat loss were also identified as exerting a high pressure on the Thukela estuary system (van Niekerk *et al*. 2019b).

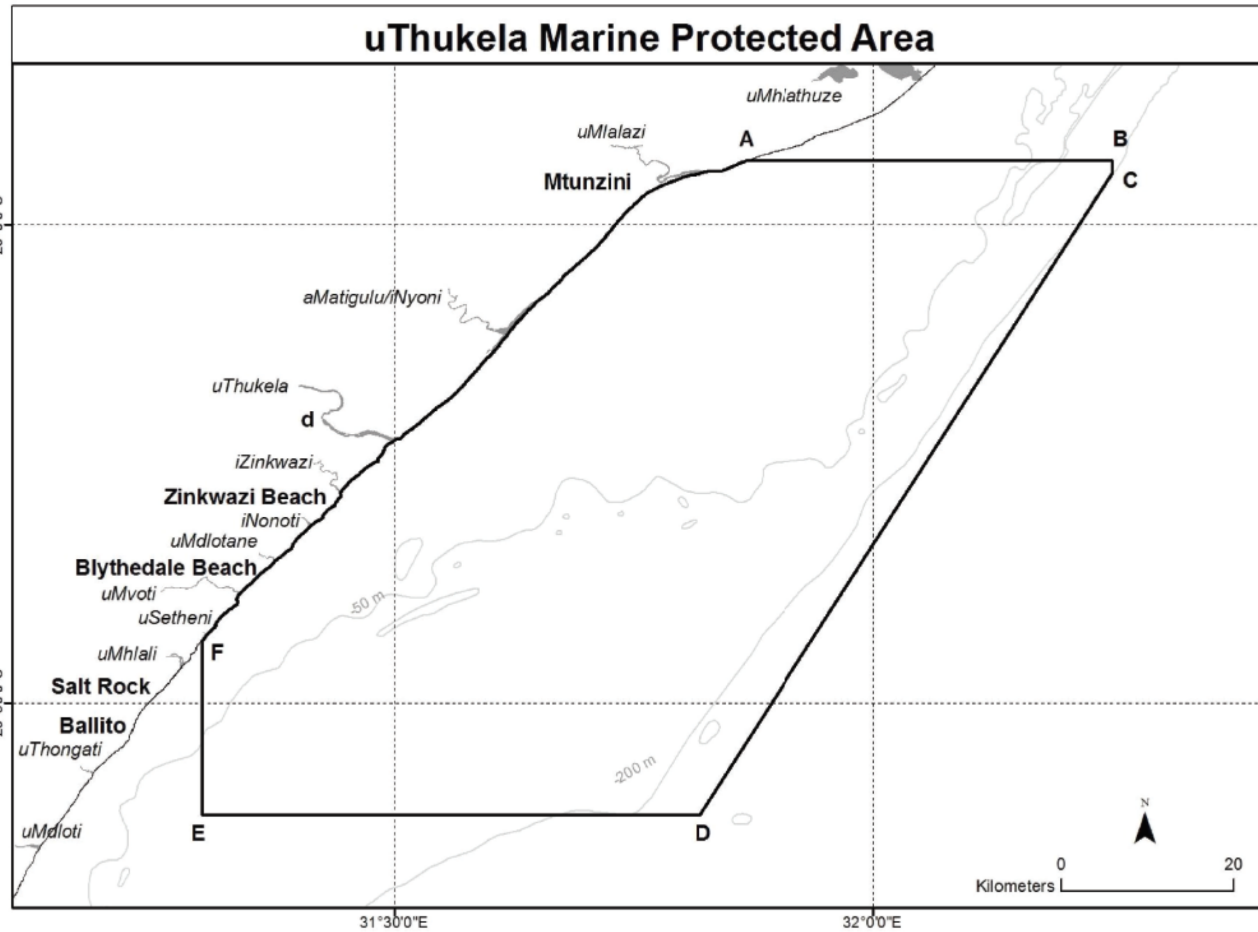

Figure 4: Boundaries of the uThukela Marine Protected Area; note that point d located within the Thukela Estuary is approximately 8.5 km upstream of the estuary mouth (Government Gazette 42478, 2019)

3 AVAILABLE INFORMATION

3.1. Previous Studies

The Thukela catchment was the subject of a number of large catchment studies up to 2005, with limited water resource studies over the past decade (since 2009). Table 3 lists available key sources of information available to the study.

Table 3: Previous studies conducted in the Thukela Catchment Area

Year	Study name
2003	Thukela Water Management Area: Water Resources Study
2004	Thukela Water Management Area: Internal Strategic Perspective
	Comprehensive Rivers Reserve Determination Study
	Thukela Estuarine Flow Requirement Report – Reserve Determination Study - Thukela River System.
	Thukela Estuarine Flow Requirement Report – Reserve Determination Study - Thukela River System: Appendices to Thukela estuarine flow requirements
1989 - 2005 *Thukela Water Project*	Thukela Vaal Transfer Scheme: Pre-feasibility Study
	Thukela Vaal Transfer Scheme: Interim Study
	Vaal River System Analysis Update Study
	Thukela Water Project: Feasibility Study
	Thukela Water Project Decision Support Phase
2005	Towards a Classification System of Significant Water Resources with a Case Study of the Thukela River (MSc Thesis – HH Pienaar)♦.
1997	Mkomazi-Mooi-Mgeni System Analysis Study
1999 and 2013	Desktop PES and EIS Study and rapid 3 assessments for selected rivers in V31
2011	Lower Thukela Feasibility study for Umgeni Water
2013	Drought operating rules for the Buffalo River system
2009	Groundwater Reserve Determination Study in the Thukela Catchment: High level Assessment

Year	Study name
2009	Water reconciliation strategy study for KZN coastal metropolitan areas
2011	All Towns Reconciliation Strategies for towns and water supply systems in the catchment.
2017	Holistic ecological risk and environmental water requirement assessment of the lower Thukela River and eMandeni Stream (intermediate Reserve at EWR16)
2017	Roy Point Mine Reserve study – Ngagane and Knockbrex Stream in V31
♦ Groundwater classification and resource quality objectives of the catchment was not addressed	

3.2. Reserve Studies

The Thukela Comprehensive Reserve Determination Study was undertaken in 2003, for the catchment area. Seventeen sites were selected, nine in the upper Thukela catchment and tributaries and eight sites in the Lower Thukela catchment (see Table 4 and

Figure 5).

Table 4: EWR sites as selected for comprehensive Reserve, 2003

Name/ Identification	River	Quaternary catchment	Lat	Long
Thukela_1, Bergville	Thukela	V11J	28.722	29.378
Thukela_2, Skietdrift	Thukela	V11M	28.717	29.621
Thukela_3, Klein Thukela	Little Thukela	V13E	28.383	29.616
Thukela_4A, Zingela	Thukela	V14E	28.705	30.059
Thukela_4B, Thukela Estates	Thukela	V14E	28.747	30.145
Thukela_10, Caravan Park	Mooi	V20E	29.200	30.029
Thukela_11, Mooi Falls	Mooi	V20E	29.116	30.135
Thukela_12, Gracelands	Mooi	V20H	28.902	30.419
Thukela_13, Upper Buffalo	Buffalo	V32F	28.153	30.476
Thukela_14, Lower Buffalo	Buffalo	V33C	28.437	30.595

Name/ Identification	River	Quaternary catchment	Lat	Long
Thukela_15, Jameson's Drift	Thukela	V40E	28.785	30.911
Thukela_16, Mandini	Thukela	V50C	29.159	31.336
Thukela_7, Upper Sundays	Sundays	V60C	28.458	30.053
Thukela_8, Lower Sundays	Sundays	V60F:	28.636	30.204
Thukela_9, Thukela Ferry	Thukela	V60J	28.769	30.515
Thukela_5, Weenen NR	Boesmans	V70F	28.897	30.035
Thukela_6, Darkest Africa	Boesmans	V70G	28.801	30.167

A number of flow scenarios were assessed as part of the Reserve study and the ecological and socio-economic consequences determined. These scenarios included the following:

- **Present Day** (2000 Development): Each scenario was analysed for the Present Day (2000 development) except scenario 7 and 8, which were analysed at 2015 development;

- **Scenario 1**: Sc 1 modelled the Present Day as described above and supplies the EWRs as a priority at the Upper REC level;

- **Scenario 2**: This scenario is the same as Sc 1; however, all EWRs are supplied at the Recommended REC level;

- **Scenario 3**: This scenario is the same as Sc 1; however, all EWRs are supplied at the REC lower than the recommended;

- **Scenario 4**: This scenario was modelled using the 2000 Present day. The scenario is in essence a modification of Sc 2, *i.e*. all EWRs are supplied for the Recommended REC with the following changes:
  - The lowest category (C/D) was used at EWR site 4;
  - Drought flows at EWR site 3 (Little Thukela River) and EWR sites 7 and 8 (Sundays River) were reduced by half;
  - Maintenance low flows in were reduced in June, July and August for all sites on the Mooi River (Sites 10, 11 and 12), and
  - For EWR sites 15 and 16 where scenario requirements exceeded Present Day Sc 7 flows, flows were reduced to present day flows.

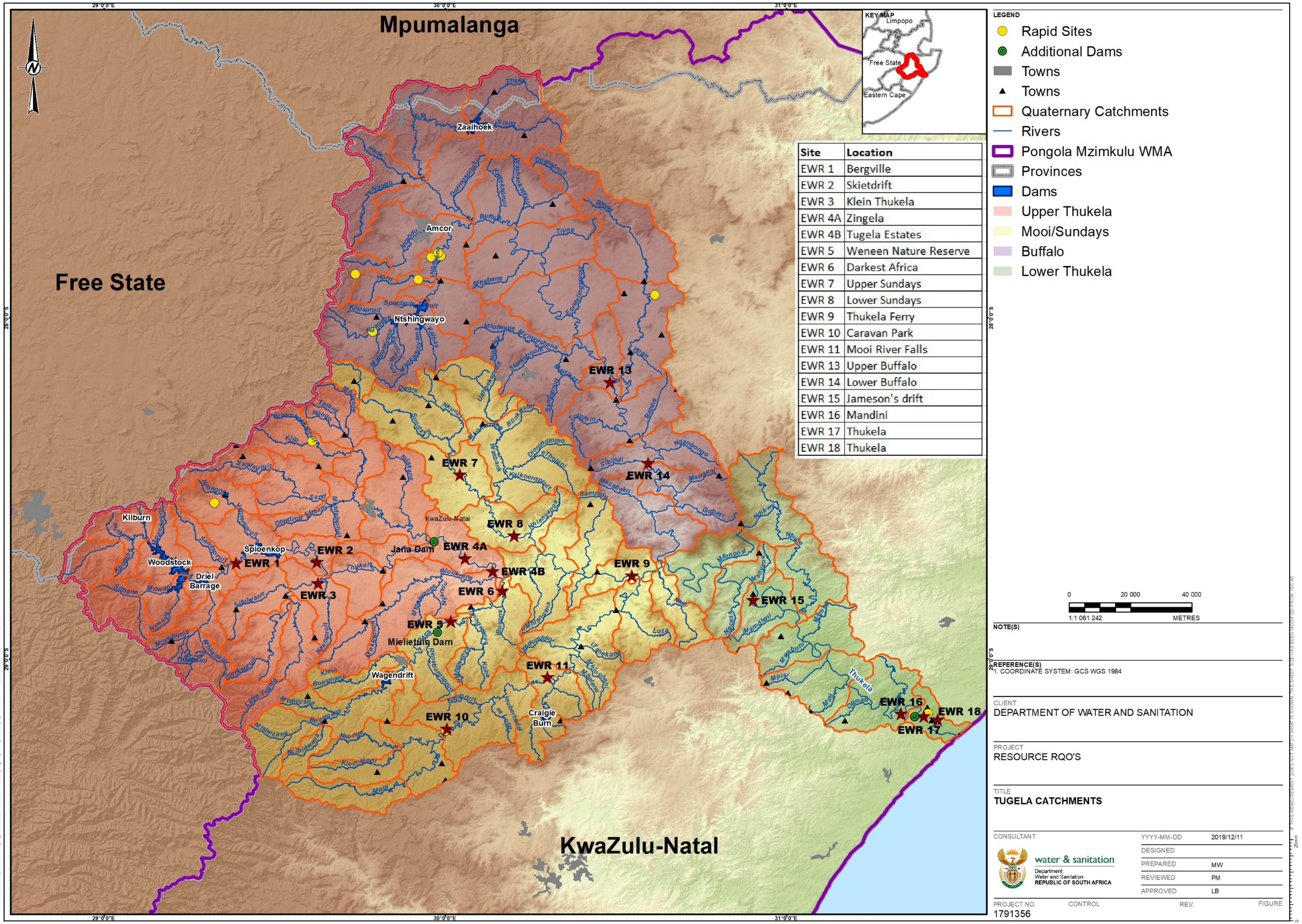

Figure 5: Thukela EWR sites (2003 Reserve study)

- **Scenario 5**: This scenario is essentially the same as Sc 4 with low assurance high flow (floods) removed from all sites;
- **Scenario 6**: This scenario is the same as for Sc 5 but all the Reserves (apart from EWR 4 which is still applied at a C/D category) are supplied at the lower ERC;
- **Scenario 7**: The Sc 7 description is similar to the 2000 Present Day; however, the operating releases are now incorporated, and operation of the dams will therefore not be demand driven, and
- **Scenario 8**: Sc 8 is a theoretical scenario to serve as a worst-case scenario. It represents 2015 development with no IFR releases.

A number of rapid Reserve determinations were undertaken between 2002 and 2005. However, there are no reports 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 for the Thukela River at Thukela_16 just upstream of the estuary was undertaken in 2017 with a rapid assessment of the eMandini Stream in V50D.

3.3. Modelling

A preliminary review of past and current studies has been conducted to confirm what existing water resources models, and associated study reports, have been completed for the Thukela catchment. In particular, an emphasis was placed on determining whether the DWS developed Water Resource Yield and Planning models (WRYM &WRPM) have been utilised. These mass balance models are used for determining water yields, system balances and assessing the impacts of development scenarios, and have also been used during the classification of water resources in other regions.

The Thukela catchment differs from most other large river systems, in that it has not been the focus of a single reconciliation strategy. The Thukela, or at least portions of the Thukela catchment, are linked to other systems through the various existing or proposed water transfers out of the Thukela, e.g. including the Integrated Vaal River System, Richards Bay, and KZN Coastal Metropolitan areas reconciliation strategies. As such, there is not a current consolidated stand-alone system model for the Thukela, which is typically developed and maintained for the reconciliation strategies.

The Thukela is modelled as part of the integrated Vaal River System, within the WRPM. In this model, the focus and greater detail is on the current transfers out of the Thukela to the Vaal. However, all sub-catchments within the Thukela are included, at varying levels of detail.

Similar to the integrated Vaal River System set up, WRYM models were configured for the Thukela Water Project in 2003. This WRYM has two separate configurations, one for the Thukela and one specifically for the Mooi sub-catchment. The unit catchments and level of detail for the WRYM setup are similar to the portion of the Thukela in the Vaal WRPM and thought to have been the building blocks for the latter Vaal WRPM configuration.

Additional to the above-mentioned system configurations, for the total Thukela catchment, models have been developed for portions of the Thukela catchment as part of other studies in recent years. These are summarised in Table 5.

Table 5: Summary of relevant water resources models and studies

No.	Study name	Date	Portion of Thukela	Model Configured	Hydrology period	Comment
Studies with System Models						
1	Vaal AOA	June 2011	Whole Thukela plus neighbouring Vaal, Usuthu, etc.	WRPM	1930 - 1993	Hydrology period limited by overlap of all catchments
2	TWP (Thukela Water Project)	April 2003	Whole Thukela	WRYM	1925 - 1994	
3	Mooi Mgeni Hydro Update	July 2019	Mooi River down to confluence	WRYM & WRPM	1925 - 2017	Recent study for Umgeni Water
4	Buffalo Annual Operating Analysis	May 2019	Buffalo down to V33C	WRYM & WRPM	1920 - 2004	WRPM more updated. WRYM at 2013 level
Studies without System models						
5	All-Towns Recon Strategies	2011 and 2013	uMzinyathi, Amajuba & uThukela DMs – main towns and schemes	Method of assessment TBC	Method of assessment TBC	Local water balances at towns were the focus.
6	Thukela ISP	2004	Whole Catchment	N/A	N/A	Study on main attributes & water balance of system.
7	Water Resources	2012	Whole Thukela	WRSM2000	1920 - 2009	National study with possible limitations in

	2012 (by WRC)					detail possible in Thukela.

3.4. Hydrological Data

The hydrology was developed for the period 1925 to 1994, for the whole Thukela catchment, as included in studies numbered 1 and 2 in Table 5. The Thukela was sub-divided into 46 sub-catchments as part of the development of this hydrology. These modelling catchments are included in Figure 6 as taken from DWAF (2003).

Additional hydrology is available for the Mooi River portion of the Thukela, at both the modelling catchment scale presented in Figure 6, as well as at a quaternary catchment level for the period 1925 to 2017.

Hydrology has also been developed at a quaternary scale for the Buffalo catchment up to V33C for the period 1920 to 2004.

As such, the longest overlapping period of all catchments within the Thukela is for the period 1925 to 1994. If the external catchments as part of the Integrated Vaal River System are also considered, should the WRPM be used, then the longest overlapping period of all associated catchments is from 1930 to 1993.

While not a catchment focused study, the Water Resources (WR2012) study by the Water Research Commission, updated all hydrology in the country to 2009 levels. There are however concerns about the level of detail possible at national scale, and it is thus recommended that hydrology generated from studies focused on the Thukela catchment are used. As the WR2012 data also does not cover the recent drought, the additional data (1994 to 2009) will not help factor in the drought between 2013 and 2016.

Along these lines, the Mooi-Mgeni Hydrology Update Study (Umgeni Water, 2019) covered this period and noted that while the drought in the 2013 to 2016 period was severe, it is not the critical period for the Mgeni or upper Mooi catchment. It is not certain if this is a reality for other parts of the Thukela catchment.

Based on the above observations, time series of between 64 and 70 years are anticipated to be used in the system modelling, and subsequently the length of outputs to be provided to specialist for further analyses for the Thukela. The decision will depend on the version of model selected and associated longest overlapping period chosen. The approach to making this decision is covered further in Section 6.1.

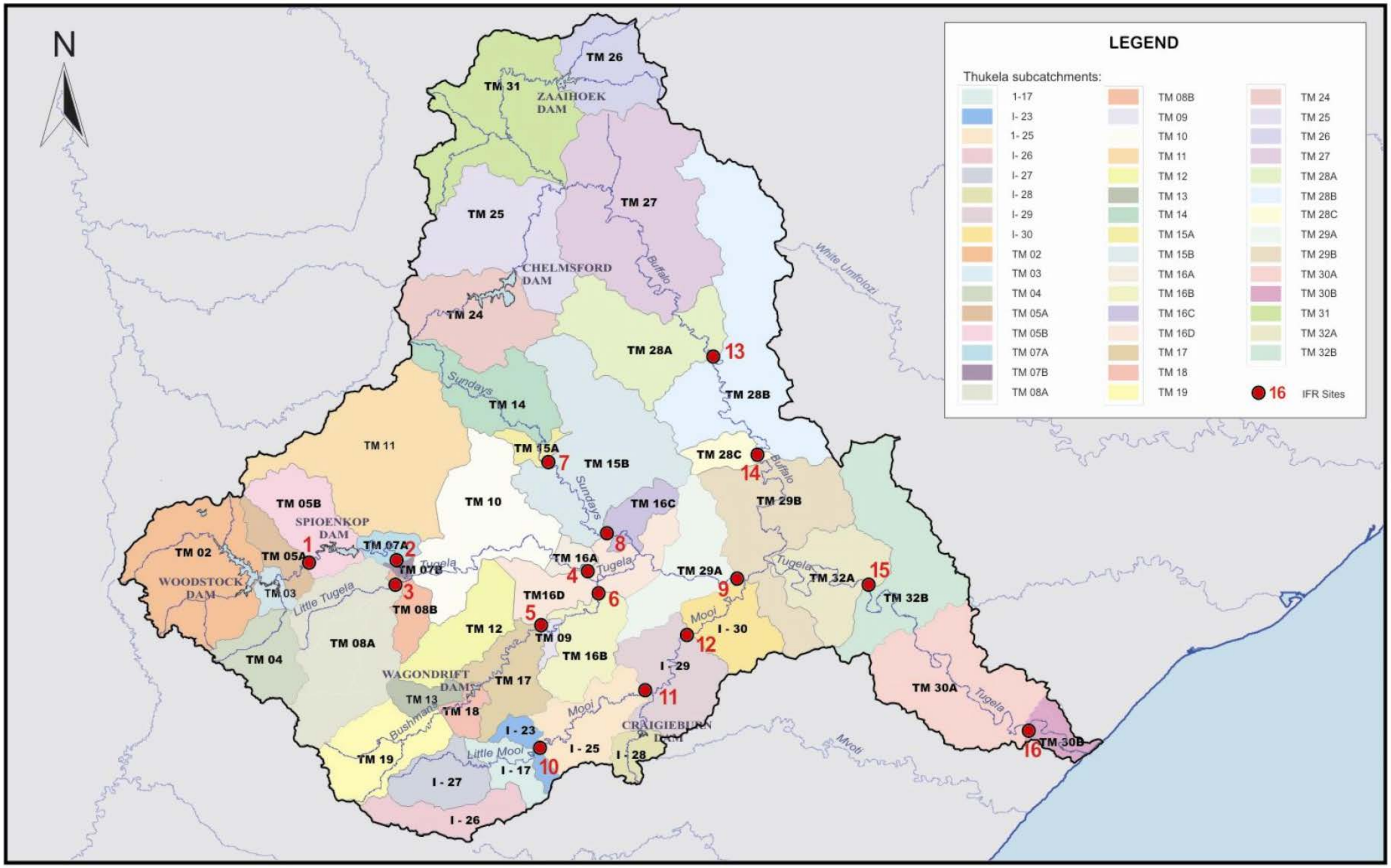

Figure 6: Hydrological modelling units of the Thukela Catchment (data from 1925 – 1994)

3.5. Groundwater Studies

The following groundwater related information is available:

- National Groundwater Archive: mainly borehole technical detail with water level depth;
- CHART: Only two long-term water quality time series with water levels in the V31E and V32B quaternary catchments are available, North western Middleveld, Thukela;
- There is a significant absence of long-term water level time series datasets;
- Assessment of groundwater contributions to river baseflows will have to be based on the availability of streamflow gauging where datasets are verified;
- Groundwater quality analyses for the Thukela catchment area: ~3,350 random analyses (spread/quaternary catchment not evaluated yet);
- GRAII Dataset (although some attributes are based on historic information);
- WARMS dataset from KZN Regional Office; and
- Groundwater Reserve Determination in the Thukela Catchment: High level Assessment (2009).

A limited search for local scale hydrogeological assessment will be conducted to augment the current data/ information base as far as possible. Many of the report/documents referenced in the 2009 Groundwater Reserve Determination Study maybe “out of date” in terms of the attributes required for this 2019 assessment.

The concern is, therefore, the lack of “recent” groundwater quality and use data (*viz.* abstraction figures). Local information on specific groundwater related activities would support the scientific value of the classification and resource quality objectives determination, significantly. This is specifically referring to local groundwater information from monitoring programmes that is required for water use license audits, for example.

3.6. Wetlands

Information on the inland wetlands of the Thukela catchment is largely limited to specific priority systems (see for example, Begg, 1989) and areas such as related to the Natal Drakensberg Ramsar Site. There are however resources that are available for assisting with identifying other important wetland resources in the catchment. These include but are not limited to, the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland layer (Nel *et al*., 2011).

Included in the priority wetlands indicated by Begg (1989) is Wakkerstroom Vlei, a very well-known wetland, particularly for birding. Also included in the Thukela catchment is part of the Natal Drakensberg Park Ramsar Site (see www.Ramsar.org – Annotated List of Wetlands of International Importance – South Africa) which 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 area in South Africa due to its high yield and pristine 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.

3.7. Estuary

An intermediate level Ecological Water Requirements (EWR) study was conducted during the period 2001-2004 and Thukela Estuarine Flow Requirements Report (Volume 1) published in 2004 (DWAF, 2004), which included specialist reports (Volume 2) in nine appendices. The study followed the methods described in *Resource directed measures for protection of water resource: Methodology for the Determination of the Ecological Water Requirements for Estuaries. Version 2* (DWAF, 2004) and included just one survey in August 2001 (winter).

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. 2019d). However, now that the estuary falls within the boundaries of an MPA the area is classified as protected and should be restored and maintained in either an A category or the Best Attainable State (BAS).

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. 2019c). The Estuary Importance Index determines an estuary importance score based on estuary size, zonal rarity type, habitat diversity, biodiversity importance and functional importance. In the case of the Thukela, a river mouth with a large influence on offshore processes, the functional importance scored 100. This score recognised that the estuary plays a significant role in the delivery of sediments and nutrients/detritus to the marine and coastal environment.

According to the rules, the Ecological Reserve Category (ERC) for the Thukela Estuary should be a *Present State Category (i.e. C) + 1*, based on the estuarine importance score of 76, which is a category B (DWAF, 2004). If it is not possible to improve conditions in the catchment to achieve this state, then the BAS would be a C. Non-flow related anthropogenic activities, which included human disturbance of birds, overfishing, and removal of wetlands for agriculture, were recognised as having a significant influence on the present state of the estuary. The specialist team agreed that it would be difficult to reverse the impacts caused by these activities so it was decided that the PES score of a C be selected as the ERC. It should be noted that the PES score of a C corresponded to a high C, where the score of 70 fell within the 61 to 75 range, and so the estuary should be managed as a high C.

More recently, the NBA 2018 concluded in its assessment that based on the estuary's current condition and existing pressures the estuary be assigned a Recommended Ecological Category of D. The NBA 2018 further recommended that the following restoration measures be implemented to improve the health and productivity of the Thukela estuary (van Niekerk *et al*. 2019d):

- Restore / protect base flows;
- Improve mouth management;
- Rehabilitate riparian areas / wetlands;
- Remove alien vegetation;
- Remove or reduce fishing and bait collection pressures; and
- Investigate eradication of alien fish.

The 2004 study inform this Classification and RQOs study.

3.8. Socio-Economics

Although no socio-economic classification has been conducted for the Thukela catchment there are various resources that will provide inputs into the classification process (Table 6).

Table 6: Data sources that will provide inputs to the socio-economic classification of the Thukela catchment

Year	Study Name
2017	Review of Socio-Economic Guidelines for Water Resource Classification and Development of an Improved Decision Tool. WRC Project No K5/2465.
2012	Census 2011 Statistical Release.
2018	National Water Accounts for South Africa Systems, Methods and Initial Results
2005	Millennium Ecosystem Assessment: Ecosystems and Human Well-Being
2013	The Economics of Ecosystems and Biodiversity for Water and Wetlands
2016	Administrative boundaries Spatial Datasets
2016	Catchment boundaries Spatial Datasets
2000 and 2013/ 14	Land Cover Datasets
2011	NFEPA Rivers
2011	NFEPA Wetlands
2006	Municipal Financial Census
Latest	Municipal Integrated Development Plans

4 INFORMATION AND REQUIREMENTS

4.1. Overarching Reconciliation Strategy for the Thukela

No Reconciliation Strategy has been completed for the Thukela catchment in its entirety, thus a gap exists in terms of the planning scenario analysis with respect to future development and reconciling water resource availability and requirements in the catchment. While the Thukela sub-catchment areas have been subject to a number of reconciliation analysis for adjacent catchments (e.g. Vaal, Mvoti-Umzimkulu, Usutu-Mhlatuze) with respect to inter-basin transfers out of the catchment, the absence of reconciliation options for the Thukela itself presents a challenge for the classification scenario evaluation task.

The Internal Strategic Perspective undertaken in 2004 in support of the National Water Resource Strategy (2004), provides a reconciliation perspective in terms of requirements and availability for a 2025 base scenario, but longer planning horizon up to 2050 is required for the classification process to be of any relevance. The All Towns Strategies (DWS 2013) developed for key water supply areas in the Thukela catchment will provide some guidance, however this is limited to the municipal jurisdiction and supply and does not provide the water balance, scenario analysis and options identification for the reconciliation of water availability and requirements in the catchment.

The absence of the overarching reconciliation strategy is considered a shortcoming in terms of the process to be undertaken and will influence the scenario analysis and evaluation component of the classification process in terms of the long-term planning for the catchment.

4.2. Water Resource Modelling

In support of the water resource modelling task of the Classification process, DWS Water Resource Classification (WRC) would have to facilitate the following in terms of the modelling system information required from within the Department:

- A copy of the WRYM model for the Thukela catchment (data and hydrology text files) as developed for the Thukela Water Project Decision Support Phase (2003); and
- The latest version of the Integrated Vaal WRPM model (data and hydrology text files). The study team has a version from 2013 (used further for the Vioolsdrift Feasibility Study), but this is possibly outdated and if a newer version has been used for a study approved by the DWS, is requested that this version be provided.

Attainment of the following data also requires facilitation by the DWS Water Resource Classification:

- Actual recorded transfer volumes from the Thukela to the following catchments (as managed and monitored by the DWS):
    - Thukela to Vaal (Sterkfontein Dam);
    - Buffalo to Vaal (Zaaihoek Dam); and
    - Thukela to Mhlathuze.

For data that is related to Umgeni Water, the study team has actual transfer volumes from the Mooi to the Mgeni. Actual abstractions from the Lower Thukela for the Lower Thukela Bulk Water Supply Scheme (LTBWSS) are requested from the DWS via Umgeni Water.

Since there is no consolidated reconciliation strategy or system operating forum for the Thukela, it is recommended that a meeting is scheduled between the DWS National Water Resource Planning, to confirm the long-term plans related to the transfers and development within the Thukela catchment.

Along these lines, key matters to discuss at this meeting will be if the DWS either provides:

- A time series of transfer volumes required from the Thukela for each of the main transfers, or
- Provides the model with future water requirements in the neighbouring catchments included, and the study team simulates the transfers required.

The latest, or most suitable version of the annual operating analysis report for the Vaal River System is also requested to confirm operating rules built into the model(s).

Should the DWS be aware of any other studies related to actual water use, or planned developments in the Thukela that have not been covered in this review, these are requested to be shared with the study team.

4.3. Reserve

The results from the existing Reserve determination studies will be evaluated and adjusted in terms of the final base hydrology that will be chosen for this study, as a number of different hydrological sets were used for the 2004 comprehensive, 2013 rapid and 2017 intermediate assessments.

The availability of the hydraulics from the cross-sections at the existing EWR sites are required for the assessment and interpretation of the ecological consequences for various water resource development scenarios.

As the comprehensive Reserve study was undertaken during 2003, the EWR sites might have changed completely due to floods, water resource developments or other anthropogenic impacts. This might result in re-surveying and sampling of the key sites to provide up to date hydraulic and biological information for use during the classification process.

Additional EWR sites might be required where little or no biological information is available, especially in highly impacted river reaches or where the present state is near natural or with a very high EIS. The results from the 2013/14 Desktop PES/EI/ES study will provide the initial information to guide the selection of Priority River reaches where additional information is required. The delineation of the IUAs and selection of the hydronodes will also inform the selection of additional EWR sites.

The various models prescribed by the Department, including MIRAI, FRAI, IHI and EcoStatus, will be used during the assessment of the existing and new EWR sites.

4.4. Estuary

The geographical boundaries of the Thukela Estuary will need to be finalised. The boundaries used during the Estuarine Flow Requirements study (DWAF, 2004) were defined as follows (Gauss Projection, Clarke 1880 Spheroid) (Figure 7);

Downstream boundary: Estuary mouth (31º29'56"E; 29º13'24"S);

Lateral boundaries: Five metre contour from MSL along banks; and

Upstream boundary: Approximately 6 km from the mouth.

However, given the recent notice that the estuary has been incorporated into the uThukela MPA in terms of Section 22A of the National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003), the upstream boundary should rather be regarded as being approximately 8.7 km upstream of the mouth (Figure 8) at GPS point 29º11'59.1"S, 31º25'27.1"E (which corresponds with -29.199736, 31.424198 as defined in the Government Gazette No. 42478, 2019).

Figure 7: Google Earth image of Thukela Estuary with locations of estuary mouth (downstream boundary) and the two upstream boundaries; DWAF (2004) and uThukela MPA (2019).

Figure 8: 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)

The estuary, classified as a fluvially dominated (Whitfield 1992; van Niekerk *et al*. 2019a), 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; this is an aspect that needs to be expanded. 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. Bosman *et al*. (2007) provides an excellent synthesis of the research conducted on the sediments of the Thukela River mouth. 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 linefish fisheries.

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. This is an aspect that needs to be investigated further. 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.

4.5. Groundwater

The following information backlog on the groundwater component is highlighted as a challenge to the current Classification study:

- Groundwater use: updated WARMS dataset (open up for verification per quaternary catchments);
- Demarcation of potential groundwater pollution sources such as, redundant mines/industries;
- Recent groundwater quality characteristics to indicate long-term changes due to climate variation and anthropogenic development/impacts (WMS at DWS will be screened for updated water quality data);
- Demarcation of surface water-groundwater interaction – especially the primary aquifer systems present in the middle river channel reaches. Hydraulic attributes to assess this interdependence may hamper quantification of such interactions; and
- Areas (*viz*. quaternary catchments) where groundwater yield and/or quality may be stressed generating a concerned status, or hotspot condition – GIS dataset on land use activities would be required.

Data/information to verify the current, *i.e.* 2019 status of the groundwater Reserve presents a key constraint. Only one RDM related assessment was undertaken in 2009.

4.6. Wetlands

Apart from the National Wetland Map 5 (Van Deventer *et al*., 2018) and the NFEPA wetland layer (Nel *et al*., 2011), there does not appear to be an integrated GIS layer indicating priority wetlands in the catchment. There also does not appear to be an integrated layer indicating the delineation, typing and ecological categorisation of such systems. These layers will need to be developed as part of this study.

4.7. Socio-Economic Analysis

The purpose of the socio-economic component of the WRCS is to assess the economic prosperity and social well-being implications of different catchment configuration scenarios while utilising the 7-step WRCS procedure. The component assesses and demonstrates the value of ecosystem services (referred to as Ecosystem Goods, Services and Attributes (EGSA)) and the economic consequences of water planning scenarios and in particular, how they relate to social well-being. EGSAs are broadly defined as the services that ecological systems provide, directly and indirectly, to human welfare that are often ignored in economic analyses. Understanding the contribution these natural benefits make to socio-economic wellbeing, requires resource-economic valuation techniques of which a variety are available.

The process requires the definition of the ecological value chain arising from ecological infrastructure and linking to beneficiaries in the catchment. This definition is a precursor to valuation as ecosystem service valuation requires firstly, the identification of these linkages and secondly, the quantification of the flow of services. The identification of linkages requires the use of Ecosystem Service Frameworks (ESFs) of which numerous frameworks have been developed over recent years.

The development ESFs has arisen from the realisation that natural biodiversity and its associated ecosystem services can no longer be treated as inexhaustible and free ‘goods’ and their true value to society as well as the costs of their loss and degradation, need to be properly described and extent understood (TEEB 2010, de Groot *et al.* 2012). Key ESF’s utilised in the socio-economic analysis include, but are not limited to, The Millennium Ecosystem Assessment (MEA), The Economics of Ecosystems and Biodiversity (TEEB) and Final Ecosystem Goods and Services Classification System (FEGS-CS).

4.7.1. The Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MEA) (2005) defines ecosystem services as the benefits that people receive from ecosystems and makes the link between ecosystem services and human well-being (2005). The MEA classifies ecosystem services into supporting (basic ecosystem functions and processes that underpin all other services), regulating (covering the absorption of pollutants, storm buffering, erosion control and the like), provisioning services (covering the production of foods, fuels, fibre etc.), and cultural services (covering non-consumptive uses of the environment for recreation, amenity, spiritual renewal etc.).

4.7.2. The Economics of Ecosystems and Biodiversity

The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative to draw attention to the benefits of biodiversity. It focuses on the values of biodiversity and ecosystem services, the growing costs of biodiversity loss and ecosystem degradation, and the benefits of addressing these pressures. The TEEB initiative has brought together over five hundred authors and reviewers from across the continents in the fields of science, economics and policy (TEEB 2013).

The TEEB initiative can be viewed as the next step in ecosystem service understanding and builds on the MA by providing a focussed approach for dealing with the costs of biodiversity loss and how this impacts society.

4.7.3. Final Ecosystem Goods and Services Classification System (FEGS-CS)

The Final Ecosystem Goods and Services Classification System (FEGS-CS) is developed by the US Environmental Protection Agency (US EPA) towards providing a comprehensive framework for the evaluation of ecosystem services (Landers and Nahlik 2013). The FEGS-CS builds on the MEA and similarly defines Final Ecosystem Goods and Services FEGS as "components of nature that are directly enjoyed, consumed, or used to yield human well-being." The goal of FEGS-CS is to "Identify, measure, and quantify FEGS in a scientific, rigorous, and systematic way that can be aggregated from local to regional and national scales" (Landers and Nahlik 2013). In other words, it attempts to accurately identify and value contributions of ecosystem services toward economic well-being.

4.7.4. Socio-Economic Glossary

Terminology used when conducting a socio-economic analysis are provided in Table 7.

Table 7: Glossary of terms utilised in Socio-Economic Analysis

Cultural Services	Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, e.g. cultural diversity, knowledge systems, educational values, social relations, sense of place, cultural heritage and ecotourism (MEA 2005).
Ecological Infrastructure	A functioning ecosystem that delivers valuable services to people such as fresh water, climate regulation, storm protection and soil formation (SANBI 2012).
Ecosystem Services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious, and other non-material benefits (MEA 2005).
Provisioning Services	Products obtained from ecosystems, e.g. fresh water, food, fibre, fuel, genetic resources, biochemical, natural medicines and pharmaceuticals (MEA 2005).
Regulating Services	Benefits obtained from the regulation of ecosystem processes, e.g. water regulation, erosion regulation, water purification, waste regulation, climate regulation and natural hazard regulation (e.g. droughts, floods, storms) (MEA 2005).
Supporting Services	Services necessary for the production of all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some services, like erosion regulation, can be categorised as both a supporting and a regulating service, depending on

	the time scale and immediacy of their impact on people. Supporting services include primary production, nutrient cycling and water cycling (MEA 2005).

4.7.5. Potential Data Gaps

No water resource classification has been done for the Thukela catchment and as a result no baseline has been defined. Although this does not prevent a valuable classification from being conducted it has resulted in a lack of existing studies relating to key inputs required for the process. Potential gaps in data that are required for the socio-economic component may include the following:

- Current Population Data Extrapolated from 2011 Census Data;
- Health Data by municipality for the catchment;
- Current Spatial Land Use Data;
- Economic data may not be available at municipal or catchment level;
- Water Quality Data for the Catchment;
- Physical water account for the sub-catchment (Water use data *i.e.* Volume of water used by sectors, municipal water use, transfers data, groundwater extractions, waste-water volumes); and
- Economic Status, EGSA Status, Macro-Economic Classification Data for the Thukela catchment.

4.8. Risk Assessment

The potential identified risks that could have an influence of the execution and completion of the tasks in respect the classification of water resources in the Thukela catchment are listed in Table 8. As the process will be undertaken with the best available current information, the project team will attempt as far as possible to mitigate the risks within the current scope, time and budget of the project. Should a key constraint be encountered the project team will inform the DWS Water Resource Classification Directorate timeously.

Table 8: Possible identified risks and uncertainties

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
Evaluation of scenarios within IWRM	Scenario analysis of entire catchment may not be possible.	No current combined model available of the entire catchment. Currently available complete WRPM or WRYM	Certain sub-catchments are well studied with updated hydrology and models. An updated	The modelling of the scenarios of proposed classes and EWR requirements may be limited from an	Study team/DWS March 2020.

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
		configurations are outdated, or not focused on the whole catchment.	complete single model will be built by the PSP based on the available information.	integrated catchment point of view. A perspective of the full upstream to downstream cascading water requirements may not be assessed.	
	No planning scenarios for the Thukela catchment.	A reconciliation strategy with reconciliation options is not available for the Thukela catchment in its entirety. Development long term planning options/scenarios will have to be generated to determine possible changes in water resources supply and demands. National scale inputs – detail at local scale is lacking. Inclusion of accurate agricultural water use is problematic.	The following are required: • Future water requirements with transfer volumes out of the catchment; and • Time series of transfer volumes from Thukela for each of the main transfers Meeting with relevant DWS directorates and bulk users in the catchment will be undertaken to define future development.	No development scenarios will be assessed as part of the scenario analysis. An underestimate of the future demands will occur which will present inaccurate analysis of the proposed water resource classes.	DWS May 2020
	No interactive linkages in the WRYM model with	Loss in flexibility if WRYM is used.	Necessary gaps will be addressed as far as possible.	Underestimate of the water transfers volumes which	DWS May 2020

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
	respect to transfer (fixed value).			will influence water demand projections.	
	Present day demands are unconfirmed	The most recent development levels (demands) for the entire catchment is required.	The DWS Directorate NWRP will be approached to obtain the information.	An underestimate of the development will result in an inaccurate water balance, which will influence the results of the scenario analysis	DWS May 2020
	Transfer volumes out of catchment are unconfirmed	Recorded volumes are required for: • Thukela to Vaal (Sterkfontein Dam) • Buffalo to Vaal (Zaaihoek Dam) • Thukela to Mhlathuze	The relevant DWS Directorate will be approached to obtain the information.	Incorrect water balance for the catchment which will influence the results of the scenario analysis (over or underestimate)	DWS May 2020
Setting up system model and provision of natural and present-day hydrology data	Uncertainty in terms of the hydrology dataset to be used	Various sets of hydrology are available for the different catchments in the Thukela system. The most recent set of data available for the entire catchment is the WR2012 data (1920-2009) – No drought information for the last few years is included.	Comparisons will be run and the best available dataset used.	Inaccurate calibration of the model, which will influence the results of the scenario analysis.	Study team March 2020

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
		Comparisons will be run and the best available dataset used.			
Socio-economic assessment	Economic Status, EGSA Status, Macro-Economic Classification, Physical water account Data for the Thukela catchment is lacking.	No assessments previously undertaken in this regard (catchment—wide).	The assessment will rely on the ESFS as described in Section 4.7 and available census and municipal data	Inaccurate quantification of economic and social value of water resources with respect to the analysis.	Study team/DWS June 2020
	Water transfers out of catchment – Absence of the economic data quantifying the value of availability of water to receiving catchments	Lack of available data and suitability to assess impacts and benefits of transfers out of Thukela in the management scenarios.	Proposed approach is to only assess the economic benefit of the transfer volumes and not the benefits derived by use of the water in the receiving catchments.	Underestimation of the economic value of the water resources in terms of the benefit to the receiving catchment which impact on the results scenario analysis – macro economic impact to the country	Study team/DWS June 2020
EWR Quantification	Hydraulics – Unavailability of data and modelling results from previous 2003 Reserve Study.	Hydraulics data from EWR sites are vital for the evaluation of the scenarios. Absence of the survey data implies re-surveying of sites.	Selecting key sites based on priorities in terms of IUA and hydronode selection can reduce the number of sites required.	Additional Budget required. Re-surveying was not catered for in terms of the scope of work 2 weeks in field and additional modelling to re-	Study team/DWS February 2020

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
			Existing 2003 data is being sourced from previous study team. Should the data not be usable, the department will be engaged on a way forward.	survey the existing sites will be required.	
Wetlands Assessment	No GIS priority wetland later available	No integrated GIS layer of priority wetlands is available for the Thukela catchment	Priority Wetland layer with selected priority wetlands will have to be developed.	Selection of priority wetland systems is limited. Difficulty to classify resources.	Study team May 2020
	Ecological status of systems is unknown	Present Ecological State (PES) and Importance and Sensitivity (IS) information is not available for most systems.	Surrogate databases and information sources will be used where appropriate to derive general state and importance and sensitivity indicators where possible.	Inaccurate classification or limitation on the systems that can be classified.	Study team July 2020
Groundwater Assessment	Inability to assess present day water use figures (WARMS)	Integrity of the WARMS dataset in terms of water use locations cannot be confirmed.	Best available data will be used.	Inaccurate groundwater use figures will be used in the assessment (underestimation)	DWS March 2020
	No verification of current	Identification of water quality deterioration and demarcation of stressed areas is	Best available data will be used.		

Task description	Risk	Risk description	Risk mitigation	Risk Implication	Risk Owner & Timelines
	groundwater quality status.	limited and outdated.			
	No verification of modern aquifer saturation status	Total lack of long-term water level data for the catchment – only a few sites available.	Best available data will be used.	This is a significant challenge for recharge estimations.	Study team/DWS May 2020
	Interaction between surface water and groundwater is unknown.	Limited data/ information is available on the interaction between surface water and groundwater in the Thukela catchment.	Mapping of inland primary aquifer systems based on National Geohydrological Maps will be done; and Assessment of Streamflow Reduction Status will be undertaken where necessary.	Estimation of contribution to surface water baseflows (at EWR sites at the estuary) will be inaccurate.	Study team/DWS May 2020
	Absence of groundwater contribution to baseflow and baseflow reduction data.	Limited/no data on groundwater contribution at EWR sites. Urgency to have a good representative cover of the groundwater conditions around EWR sites.	This will be undertaken to the best extent possible considering the existing data. Updated baseflow values and mapping/ calculation of baseflow reduction (where expected) will be done.	Inaccurate determination of EWRs.	Study team September 2020

5 SCOPE OF WORK

5.1. Overview

According to the Terms of Reference (TOR) the main aim of this study is two-fold:

- To co-ordinate the implementation of the Water Resource Classification System (WRCS) in order to classify all significant water resources in the Thukela Catchment.
- To determine Resource Quality Objectives (RQOs) using the DWA procedure.

This study is of technical nature being supported by extensive stakeholder engagement and consultation.

The project approach and methodology that will be applied is in accordance with the 7-step process of the WRCS as outlined Regulation 810, the DWS manual 'Procedures to Develop and Implement RQOs' (DWA, 2011), and the integrated process as outlined in the recently completed study, 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017). As the Reserve determination has been undertaken, integration also has to consider the preliminary Reserve as through the processes. The standard methodologies for Reserve determinations will be applied to address gaps identified. The integrated framework developed for the resource directed measures (see Figure 9) will be applied as the basis to this study.

There are 8 main aspects that need to be addressed through the study. These are:

- Filling in of information gaps related to the preliminary Reserve determination studies and EWRs in the Thukela catchment;
- Status quo assessment of the catchment areas (water resource quality, water resource issues, existing monitoring programmes, infrastructure, institutional environment, socio-economics, sectoral water uses & users) etc.
- Delineation of the Integrated Units of Analysis, priority resource units and identification of the hydronodes;
- The application of the WRCS, *i.e.* establishing the water resource class by integration of the economic, social and ecological goals through a suitable analytical decision-making system (trade-offs) specifically the modelling of identified scenarios to determine practicality.
- The application of the RQO procedure to determine the RQOs (resource unit delineation; sub-component and indicator prioritisation; numerical limits)
- Stakeholder engagement, co-operative governance and consultation processes to be followed.
- Preparation of the gazette templates.
- Study management

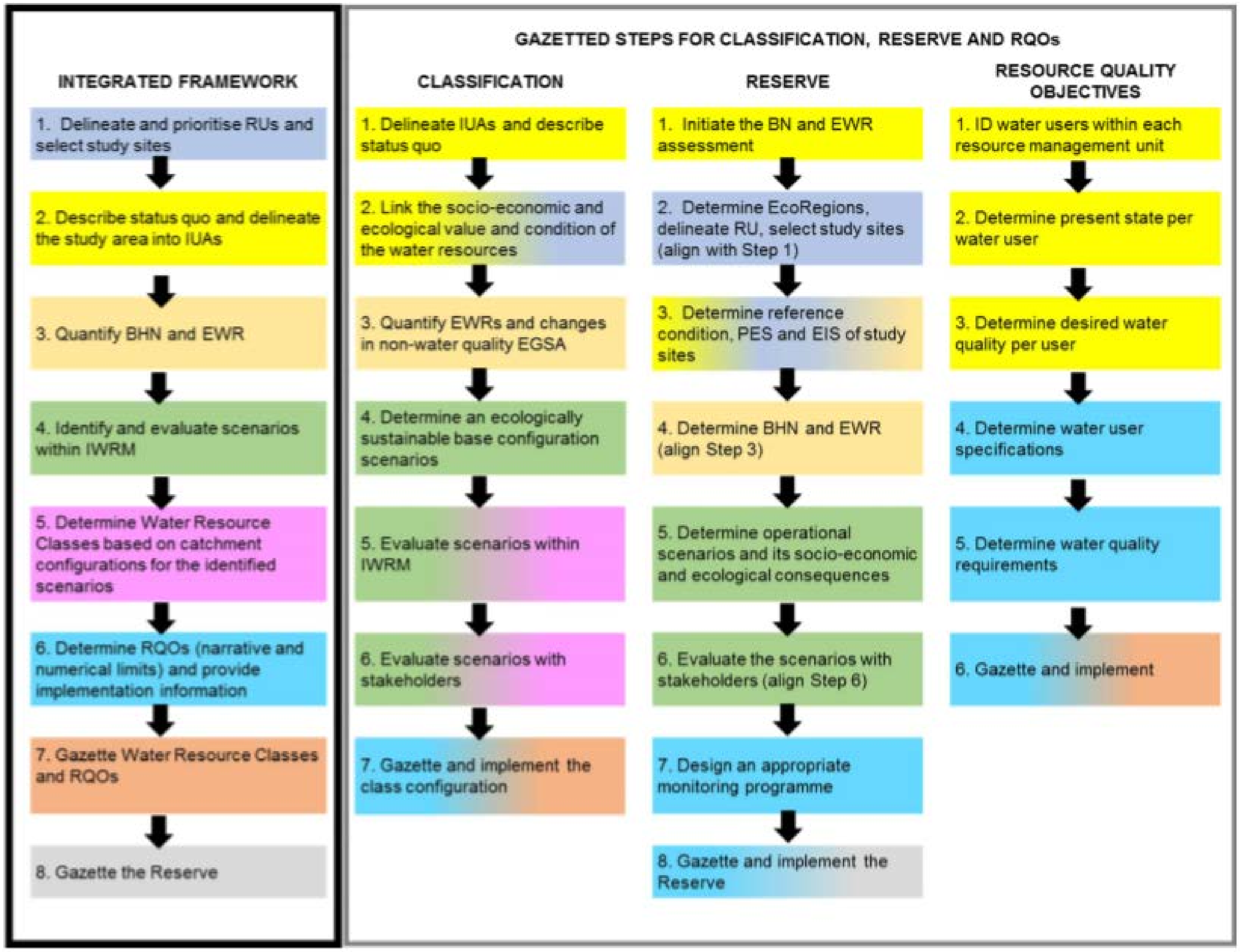

Figure 9: Integrated Framework of the Gazetted steps for Classification, Reserve and RQO Determination (DWS, 2017)

The Study management, stakeholder engagement and capacity building task will continue throughout the study period (Figure 10). Study tasks are for the most part not linear and will run concurrently over project timeframe.

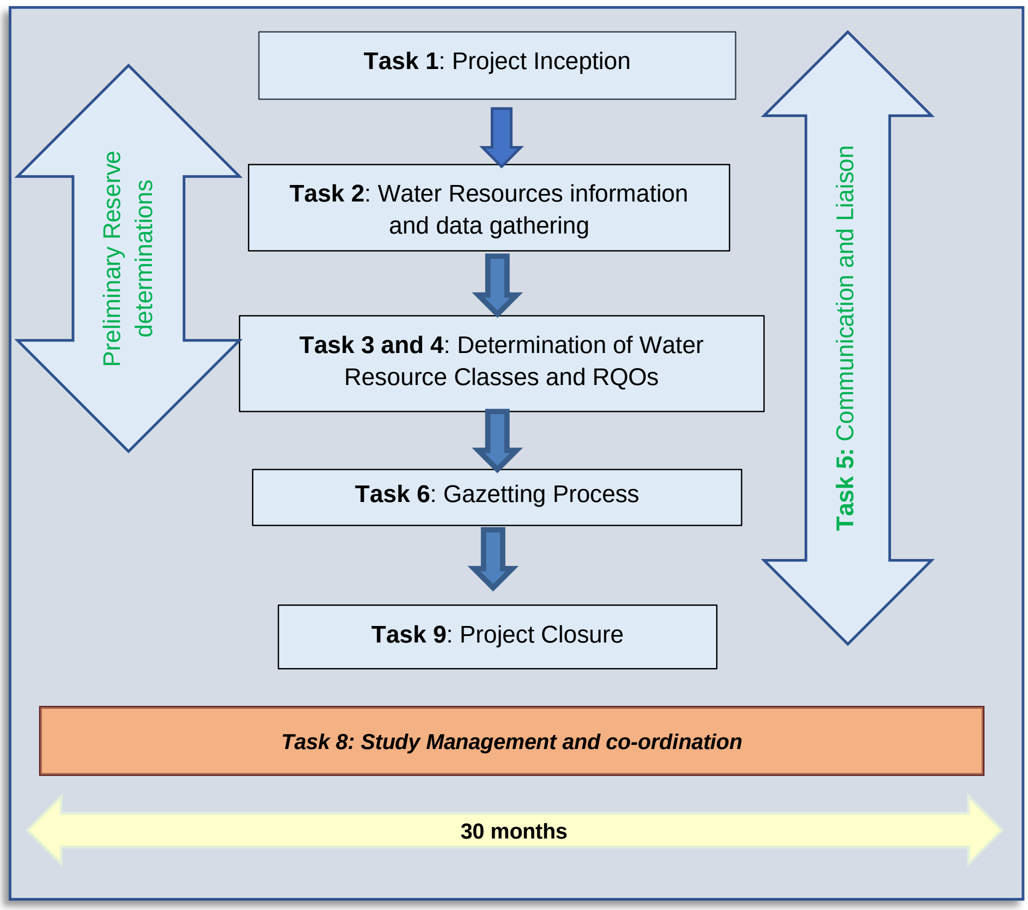

Figure 10: Study Tasks

5.2. Water Resource Components

This study focuses on the classification of significant water resources in the Thukela. This will include an identified network of significant resources comprising rivers, dams, wetlands, groundwater and the Thukela estuary through the catchment area. The available information will be used to prioritise their significance in the catchment and importance to associated water resource systems. For the purpose of this study significant is defined as per the WRCS definition (Volume 2: February 2007, Appendix A).

- **Rivers**: The significant rivers to be classified within defined integrated unit of analysis (IUA) will be identified and confirmed during the status quo phase. This will, as a first step, comprise the main stem rivers with associated tributaries in each catchment, within the Thukela catchment area including:

- Thukela River (upper –V10, lower – V40, V50);
- Buffalo River (V30);
- Mooi River (V20);
- Sundays River (V60), and
- Bushmans River (V70).

Additional considerations, e.g. existing dams or priority river reaches for future water resource developments or protection purposes will refine these IUAs. Large wetland systems and groundwater areas contributing significantly to the base flows of the rivers will be included as part of the consideration of IUA delineation.

- **Wetlands**: Priority systems as identified through the National Wetland Map and NFEPA wetland layer

  Wetlands in the study area will be assessed and a priority list of the most important wetlands/wetland systems will be compiled which will be taken through to RQO development.

- **Groundwater**:

  An assessment of the groundwater attributes required for this study will be conducted to establish the level of data and information gaps that need to be addressed. Various datasets are available, however, most of the datasets are older than 10 years and may not represent the current situation in the catchment. The focus on gap analyses will be on identifying recent datasets wherever available. Interaction with the KZN Regional Office is therefore important. Mapping of the groundwater resources in the Thukela Catchment has been done through various studies and are already demarcated in rigid groundwater resource units as per their hydraulic nature that remains semi-static over time. This demarcation is based on the 2003 geohydrological mapping series. It is, however, recommended that the groundwater resource units remain as demarcated in previous studies, i.e. the 2009 Reserve Determination Study, however, water level and quality are time dependant attributes depending on climate (aquifer sustainability) and secondary impacts on the groundwater quality as a result of various land use/ anthropogenic activities, i.e. industries, active/redundant mines, agricultural practices and wastewater treatment works. Integrated units of analyses would be considered where ecological water requirements need to be assessed and qualification of streamflow depletion could be considered given appropriate aquifer hydraulic data.

  Five (5) main hydrogeological (time dependant) attributes will be addressed for this assessment.:

  - Groundwater recharge (impacted over time by climate variations/trends);
  - Groundwater interaction with surface water resources to support EWR requirements, *i.e.* baseflow contribution;
  - Long-term water level trends providing a measure of aquifer saturation levels – impacted by climate variation(s);

- Groundwater quality time series status and trends will be studied to establish long-term trends and short-term;
- Status of groundwater use and Basic Humans Needs (BHN) Reserve.

- **Estuary**: Thukela estuary

5.3. Project Inception

Project inception (this phase) provides the opportunity for assessing and understanding the nature of the scope of the project to ensure alignment between DWS's expectations for the study and that to be delivered by the study team.

The purpose of this component is to clearly define the project scope, proposed approach, envisaged gaps and risks, to ensure the DWS and the study team are clear on the deliverables, timing, study programme and the budget. Project inception has included:

- Initiation meeting with the client to confirm the study terms of reference and client's specification in terms of study management, communication and liaison, stakeholder engagement and contractual aspects.
- Team liaison and co-ordination to mobilise team members and initiate study.
- Preliminary review of available information and data availability and basis on which study will be based.
- To identify the key challenges that are envisaged;
- Outline of approaches to the key components to be undertaken through the study process.

Deliverables forming part of the inception phase include:

Task 1 Deliverables:

- Study Inception Report,
- Integrated Work Programme,
- Capacity Building programme, and
- Stakeholder engagement plan including a working database.

5.4. Information and Data Collation

The purpose of this task will be to review previous studies, existing literature, reports, available data and any other relevant information on the study area that is required for the determination of water resource classes and associated RQOs in the Thukela catchment.

The classification process will be reliant on the hydrology and modelling undertaken through previous studies. The available base hydrology, model setup, development data (demands) and appropriate level of confidence is to be confirmed with DWS and relevant specialists. As there are a number of studies and system models developed by the DWS over the years, focus will be given to the latest studies and model set-ups. A summary will be made of the various studies and their purposes, as well as the hydrology used before selecting the preferred system configuration, or combination thereof, to be used for this study.

There is no catchment wide water quality model available for the study area and therefore detail simulations of water quality will not be possible as part of the classification process. However, existing water quality data from the DWS Water Management System will be used, and any other data from external studies that may be available will be sourced.

Reserve information will be obtained from existing reports of the preliminary Reserve determination undertaken in 2003 and the data available from the DWS Reserve database. Rapid assessments are proposed to be undertaken at additional sites to address potential EWR gaps and biological surveys at key existing EWR sites to provide information for the confirmation of the present state of the water resources.

In understanding the status quo and delineation of the IUAs, a description of the water resource components, operating rules and relevant development planning considerations will be compiled.

Best available resources, literature, databases and reasonable evidence will be assessed to understand the data availability to support economic valuation and the input parameters to socio-economic decision-analysis framework.

A key component of the information collation will be the understanding and incorporation of the outputs of the above as well as the identification of the data required to be collected, where data gaps exist and where data and information is outdated. The gap analysis will determine the extent of additional work required. Specific recommendations will be made as to the collection of additional data and/or the extrapolation of existing data.

Task 2 Deliverables:

- Report on water resources information gap analysis and recommendations to address outstanding data requirements
- Water resource models and their applicability.

5.5. Study Management

The objective of this task is to ensure effective, efficient and pro-active management of the study. Mr Trevor Coleman serve as the study technical director, with Ms Lee Boyd overseeing the daily management and coordination of the study. In order to ensure effective management of this study with the appropriate guidance from various levels of DWS the following management structures will be used for both guidance and review:

5.5.1. Client liaison

Liaison with the DWS Study Manager will include the following activities:

- Attend the PMC over the course of the Study as required. Approximately 10 PMC meetings will be held over the course of the study.
- Establishing interim communication (between meetings) to advise the Study Manager of, inter alia, important events or problem situations, possible changes to the scope of work, co-ordination with DWS Regions, Directorates, requests for information, etc.
- Direction and support on study related matters that require DWS involvement/intervention;
- Motivating the appointment of proposed new members of the study team to the Study Manager, as and when required.
- Correspondence on daily study management tasks and activities as required.

Task 5: Deliverables:

- Stakeholder database;
- Meeting documentation; and
- Record of stakeholder comment/issues and responses

5.5.2. Coordination of Study Team

The Study Manager will be responsible for overall coordination of the Study Team and activities will include:

- Serving as link between DWS Study Manager and Study Team;
- Ensuring that the task leaders and specialists are properly briefed prior to commencing with work; and
- Monitoring and control of performance, programming and cost of study, including revision of the Study Programme, if and when necessary.

5.5.3. Study administration

Study administration duties to be performed will include:

- Compiling, certifying and submitting monthly invoices and progress reports to the Client. The Client will be presented with an invoice with a supporting progress report from the Study Team. The Study Leader will arrange payment to the other members of the Study Team after receiving the same from the Client; and
- The Study Leader will provide a secretariat to perform the required duties for the identified meetings as required.

5.5.4. Reporting

Reporting will be undertaken in accordance with the milestone tasks and deliverables as per the study contract and specified timelines.

Task 8 Deliverables:

- Meetings and minutes;
- Milestone progress reports;
- Record of Decisions;
- Invoices with supporting progress reports.

6 DETERMINATION OF THE WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES

The project approach will be in accordance with the 7-step process of the WRCS as outlined in Regulation 810, the DWS manual 'Procedures to Develop and Implement RQOs' (DWA, 2011), which has been integrated into the process as outlined in the recently completed study, 'Development of Procedures to operationalise Resource Directed Measures (Feb 2017). Activities common to the Water Resource Classification process and RQO determination will be synchronized and outcomes aligned. The steps to be undertaken as required in terms of the scope of work are indicated in Figure 11 and the approach to be undertaken in respect of the various components is described in the sections that follow.

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

The respective approaches/tools will apply for the respective water resource components in terms of the steps outlined above.

6.1. Water Resource Modelling

As mentioned in Sections 3.3 and 3.4, the starting point following on from the review of available information, is to gather any outstanding information and versions of the model, as highlighted in Section 4.2.

For the Thukela system modelling, a single system configuration needs to be utilised to model the flow of water through the catchment, in particular the contribution of upstream sub-catchments to the downstream EWRs. The proposed point of departure will be to select the existing complete system configuration as the base system. This system configuration will be updated with newer information, where available.

Currently, there two possible base system configurations for the Thukela system modelling, *i.e.* the Vaal Annual Operating Analysis (Integrated Vaal System) and the Thukela Water Project (TWP) models (Table 5). The main differences between these two existing complete configurations of the Thukela are:

- WRYM vs WRPM; and
- Connected to (a part of) or disconnected to the Integrated Vaal system.

Each system configuration has its benefits and disadvantages such as:

- The length of run times to complete the simulations;
- The length of record simulated and output when considering the overlapping hydrological records within the total catchment for historic runs;
- The ability to formally simulate the transfers out of the catchment through the linkages with the other systems.

While this decision is important, both existing models can be used for this classification study. As such, it is recommended that this decision be concluded once the two model set-ups are obtained to enable a comparison. At that point, the details contained in the model can be confirmed and a more informed decision can be made, with a focus on generating results that are most suitable and defendable. A focus on ease of communication of the results with the stakeholders will also be considered, if relevant.

Once the base system configuration has been finalised, the Buffalo and Mooi sub-catchments will be updated with more detailed information contained in the newer model configurations for these two catchments, where appropriate.

When updating the system model, the system network (nodes and channels that are used to construct the model) will be refined to allow flows at key points to be simulated. This entails the possible sub-division of catchment modelling units to get greater resolution. This may be required to align the model with:

- The defined outlets of the integrated units of analysis (IUA);
- The location of EWR sites; and
- The correct contributions of incremental catchments upstream of EWR sites.
- The location of water users relative to EWR sites.

Once the model network is correctly defined, the model will need to be populated with water demands and catchment land-use developments for the following main scenarios:

- Natural scenario (which will exclude all anthropogenic impacts);
- The present-day scenario; and
- Future development scenario(s).

Key interventions to be considered towards the definition of future development scenarios are:

- The proposed Jana and Mielietuin dams;
- The 2nd phase of the Lower Thukela Bulk Water Supply Scheme (LTBWSS);
- The 2nd phase of the transfer to the Mhlathuze River;
- Possible dams on the Little Mooi River for agricultural and water supply.

The simulation of flows at key locations, as well as the extent of supply of the users within the catchment and within each IUA, will allow the following to be achieved:

- The confirmation of natural flows in the Thukela System;
- The establishment of the status quo in the catchment with regard to the supply of water and volumes of flow at key sites; and
- The determination of available flows at key sites in the catchment, and the extent of supply to future identified water users with associated water resource development scenarios included.

These flows and water supply volumes will be inputs for the specialists to assess the impacts and benefits of the various scenarios. In particular, the level of supply of these current and future water demands (both in the catchment and volumes of water transferred out of the catchment), will provide an indication of the socio-economic benefit of the different scenarios. The flows at the selected IUA outlets and key EWR sites will be provided to assess the ecological benefits.

Along these lines, the Thukela is somewhat complicated from a socio-economic benefit perspective, as these benefits are realised inside, and outside, the Thukela Catchment. The significant volumes of water transferred result in large socio-economic benefits in neighbouring catchments, and large economies are supported with water from the Thukela. It is not practical to assess the extent of supply or lack of supply to each individual user in the greater Vaal and Orange River systems. As such, it is recommended that the impact of the scenarios on benefits generated outside of the catchment, be established through assessing the benefits of the changing volumes of water transferred to neighbouring catchments.

It is also recommended that the status quo, from a water availability and water balance perspective, be assessed early in the study. This will assist to confirm the extent of system utilisation and degree of challenges likely to be experienced in finding a balance. This is important, considering the lack of current updated system water balance and reconciliation strategy. The likely water availability associated with key future planned developments should also be established as early as is practical in the study, as it may require further discussions with the DWS on what realistic combinations of future developments are, to include.

6.2. Ecological Water Requirements Quantification

Step 1: Confirm, quantify and finalise EWRs

The results from the existing EWR sites will be evaluated to identify key gaps in terms of data availability (e.g. hydraulics, biological data relevance and present state confirmation) and to use the results for extrapolation to identified hydronodes.

Ecological water requirements will be determined at each of the selected EWR sites per IUA, priority hydronodes and at the outlet of the IUAs (if EWR site is not in the vicinity of the outlet) for the PES, REC and TEC. The EWR determination will be based on a combination of (i) use existing results from previous studies, (ii) update the EWR (PES, REC) based on surveys to be undertaken as part of this study and (iii) extrapolate to other sites using the exiting EWR sites characteristics.

The approaches and tools as prescribed by DWS will be used, including MIRAI, FRAI, IHI EcoStatus model and the DRM to determine the EWRs.

The output will be a set of EWRs per EWR site, hydronode and outlet of IUA for the PES, REC and TEC. Drought, maintenance flows and freshets/ floods will be specified separately to provide flexibility of ecological consequences determination during the evaluation of scenarios. EWR summary and rule tables, monthly time series and flow duration curves will be derived at each site.

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

The catchments and IUAs will be described in terms of present state taking into account the water use developments. The results from the The results from the existing EWR sites will be evaluated to identify key gaps in terms of data availability (e.g. hydraulics, biological data relevance and present state confirmation) and to use the results for extrapolation to identified hydronodes.

The IUA delineation will consider the broader catchment boundaries (major tributaries), large scale water resource developments, including major dams, transfer of water into or out of the catchment, land use activities (protected areas, irrigation), ecological information (ecoregion level II, present status, EIS). This will be integrated with the socio-economic zones and stakeholder input to determine the final IUAs.

Priority resource units (RUs) and associated hydronodes will be identified within the IUAs. These priority RUs will be based mainly on ecological considerations (A, A/B and B category reaches with very high EI and ES). Reaches with high and serious water use impacts (quantity and quality) will also be included as priority reaches. The results from the Desktop PES/EI/ES study will be used for this task. Reaches with major wetland systems and ground water areas contributing to the base flows in the rivers will be included as part of the priority RUs.

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

A number of operational scenarios will be defined, including water use developments as well as scenarios for the protection of the water resources. These scenarios will be modelled with the final selected WRYM/ WRPM for the Thukela River. Each scenario will be evaluated to determine the ecological state and ecological consequences at each of the selected EWR sites and priority hydronodes.

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

The ecological consequences as determined in the previous step will be integrated to provide the resulting classes of each scenario per IUA and at the hydronodes. Thus, a balance between protection and water use for each IUA is established (the TEC). The implications of meeting the TEC will be described.

Step 5: Determine resource quality objectives (narrative and numerical limits) (priority resource units, sub-components and indicators). The various tools as developed to prioritise (step 2), identification of sub-components and numerical indicators and limits will be used to determine the water quantity objectives. The EWR results for the TEC (quantity, habitat and biota requirements) will be used for those RUs that are selected where RQOs need to be set.

The final results after the stakeholder meetings will be prepared for inclusion in the gazette template. These will include the final EWRs for the TECs and the RQOs for quantity, habitat and biota requirements.

6.3. Estuary

In the 2004 EWR study (DWAF, 2004), there were six initial and eight yield flow scenarios used in the quantification of the ecological reserve. The final decision from the specialist workshops was to select initial scenario River Category B (associated with a 39.8% reduction in % MAR) as the recommended reserve as this would maintain a REC of a high C, although a number of alternative flow scenarios were considered suitable too. The results of the 2004 EWR study (DWAF, 2004), which include the likely consequences of selected future scenarios, will be used to inform this Classification study. The NBA study outcomes will also be considered.

It is important to assess whether there have been any changes to the pressures exerted onto the estuary within the period since the 2004 EWR study. To maintain the Thukela Estuary in a high Category C – the Ecological Reserve Category (ERC) – 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 EWR 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 9 below.

Table 9: 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
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

Where necessary, a sampling trip to the estuary by the team will be conducted to survey for changes in abiotic drivers and biotic responses where data are limited or changes in anthropogenic pressures are perceived. The additional information gained from this and from more recent available information will be used to:

- Identify flow and non-flow pressures;
- Confirm ecological baseline and health;
- Reassess the Present Ecological Status (PES) of the estuary during a specialist workshop;
- Re-evaluate ecological water requirements; and
- Prepare the RQOs for the PES and Recommended Ecological Category (REC) for all estuary components as follows:
    - flow
    - hydrodynamics,
    - water quality,
    - sediment processes,
    - microalgae,
    - macrophytes, invertebrates, and
    - fish and birds.

The approaches and tools as prescribed by DWS will be used in conjunction with the 'Estuary Health Index Manual' by Turpie, 2013.

6.4. Groundwater

Groundwater Resource Units (GRUs) will be based on the quaternary catchment demarcations.

There is no need to go for a finer demarcation of resource units (RUs) as the data is simply not available. However, where specific hotspot/stressed areas are present, these will be high-lighted in terms of the specific stress/hotspot condition(s) (Steps 1 and 2 of Integrated Framework for RDM – see Figure 9).

RUs were adopted for the catchment in the 2009 groundwater Reserve determination, and it is proposed that Classification stay within these demarcations. Specific characteristics (as per Step 2.1 of the Integrated Framework) and additional information requirements will be based on the availability of geohydrological data as in the National Groundwater Archive (which unfortunately is outdated), but the basic attributes should remain the same due to the aquifer's hydraulic characteristics (Table 4.2 as in Step 2.2 of the Integrated Framework for groundwater resources).

An update of the BHN Reserve, in terms of the most recent population (census) information and a 2019 BHN evaluation will be conducted (based on a 25ℓ/p/d allocation). The groundwater Classification and associated RQOs will be addressed specifically at the EWR sites to address surface water – groundwater interaction. If possible (*i.e*. depending on actual hydraulic information), stream (flow) depletion impacts (or factors) will be quantified/qualified (Step 3 - 3.1/3.4 of Integrated Framework for groundwater resources).

Classification of the mapped aquifers in the Thukela catchment as assessed through a "national" groundwater classification system, based on the geohydrological mapping exercise was done historically. The attributes demarcating this classification on the groundwater potential side do obviously not change over time due to the aquifer matrix uniformity, however, the groundwater quality and quantity can change and therefore impact on the groundwater classification – Step 4 of Integrated Framework for groundwater resources). Information based on the different aquifer configurations and characteristics will be applied as per geohydrological mapping and groundwater resources assessments, and wherever updated information is available, this will be used to augment the original baseline characteristics.

Groundwater quality tends to change over relatively long periods due to extraordinary conditions such as direct pollution, over-usage and/or drastic climate variations. Therefore, groundwater (quality) classification will be addressed using all water quality datasets available and only those units (*viz.* quaternary catchments) where significant changes have been spotted will be re-assessed in terms of the water quality classification. Associated resource quality objectives per IUAs will be addressed and formulated (as per narratives and numerical limits), and to account for such cases where deterioration of the water quality is noted, priority resource units/subcomponents/indicators will be proposed (towards Step 6 of Integrated Framework for groundwater resources).

Groundwater quantity has been mapped in terms of borehole yields, *i.e*. as indicated on the 2005 national geohydrological maps. This is actually a serious backlog in terms of the aquifer sustainability as significant changes in terms of rainfall recharge and water use have probably developed since 2005. Based on the information generated in the Groundwater Reserve Determination Study for the Thukela WMA (DWS, 2009), certain quaternary catchments have relatively small residual allocation values which puts them into a stressed classification status (Step 5 of Integrated Framework for groundwater resources).

Classification in terms of the current aquifer saturation status (time series water level trends) is expected to be problematic for a 2019 assessment slot, however, where possible recent water level data will be sourced from the KZN Regional Office groundwater monitoring programmes. Based on this information, and the water level status generated in the 2009 Reserve determination study, some indication of water level recession/replenishment could be drafted. RQOs for aquifer saturation levels would be possible to generate. As a support, long-term rainfall trends, using cumulative rainfall departure analysis could be applied to support classification and associated resource quality objectives for groundwater quantity – this attribute is however, highly impacted by climate variability and long-term objectives might be difficult to specify. Protection of the resource rather than over-utilization should be proposed/practiced (Step 6 of Integrated Framework for groundwater resources).

Based on the available groundwater datasets/information, assessment of quaternary catchments where over-utilisation/hotspots areas of groundwater resources in terms of water quality and quantity will be undertaken. Furthermore, where there is significant contribution of groundwater to base flows, these quaternary catchments will be high-lighted and base flow rates defined where flow data is available. Depending on the availability of local groundwater data/information, "hotspots" in terms of water level and water quality trends will be evaluated and used to specify the resource classification and quality objectives.

The most important scope of work will be to ensure that the historic groundwater information platform/datasets are updated to recent information. Several attributes additional to the above-mentioned attributes, *i.e*. baseflow estimations and the effect of climate variation somehow "disqualifies" the application of groundwater datasets older than the 1990's. This aspect is important when setting numerical limits for groundwater resource quality objectives, as recurrence rates of groundwater recharge that normally replenishes aquifer saturation levels and potentially changes the chemical composition of aquifer water quality during extraordinary recharge events has dropped significantly. The aquifer saturation levels and quality can't be measured against historic values.

Preliminary observations and the geological characteristics of the catchment favour a significant interaction between interflows and groundwater contributions to the surface component – thus baseflow is probably highly dependent on groundwater releases over time. Groundwater quality/quantity at EWR sites need to be considered as a high priority. EWR sites will therefore be regarded as important nodes in the groundwater GRU/IUA's.

Once the groundwater resource classes and quality objectives have been established, GRUs/IUAs will be prioritized in terms of resource residual allocations and water quality "hotspots" – specific indicators will be identified, and implementation measures proposed.

6.5. Wetlands

Preliminary identification of significant wetland resources

Use will be made of existing GIS resources such as the National Wetland Map 5 (Van Deventer *et al*., 2018), the NFEPA wetland layer (Nel *et al*., 2011) and other literature on wetlands of the area to identify significant wetland resources in the Thukela catchment. Depending on the resolution of available imagery, this will be complimented with desktop mapping where appropriate in areas where the wetland coverage is poor. Information from available reports related to key wetlands in the catchment will also be used to support this. The expected outcome is the development of a preliminary Priority Wetland layer for the catchment.

Workshop to determine which wetlands are likely to be providing key ecosystem services (ecosystem services assessment)

A specialist wetland workshop will be held by the team to understand the catchment stresses and to provide input into the determination of the IUA's. This will assist in identifying those wetland resources likely to be providing key ecosystem services within the catchment.

Refinement of Priority Wetland layer and desktop delineation of Priority Wetlands

Based on the workshop outcome, the Priority Wetland layer will be refined and a desktop delineation of selected Priority Wetlands will be undertaken. The refinement will include consideration of the following criteria:

- Whether or not the system is, or occurs within, a Ramsar Site;
- Whether or not the system occurs within a conservation area;
- Whether or not the system is recognised as having cultural significance;
- Whether or not the system occurs in a database, regional, local or other, that indicates it as being an important wetland;
- Whether or not based on expert opinion, the system can be considered an important wetland;
- Whether or not the system is known to support rare or endangered species;
- Whether or not the system can be considered representative of a specific type representative of an eco-region;
- Systems known to contain peat (peatlands);
- Systems known or thought to be important in terms of supporting livelihoods or providing key ecosystem services;
- Systems thought to be important in terms of the hydrology, geohydrology and/or the biogeochemistry of a particular area or sub-catchment;
- Systems thought to be unique or representative of a type unique to a particular area or region;
- Whether or not the system forms part of a particular complex of wetlands that may be linked by certain attributes or a key driver; and
- Whether or not the system forms part of a river, biodiversity or landscape corridor that is considered important for a particular area or region or a particular species.

The above will further be considered in the context of the health or state of the wetland systems selected and the likely trajectory of change given the current land-uses in the area or whether or not it is considered to be at risk from proposed new water uses in the area. The intention is to produce a refined Priority Wetland layer for the catchment, also taking into account aspects related to land and water use issues in the catchment.

Desktop typing and categorisation of Priority Wetlands (PES and IS)

Where possible, the selected Priority Wetlands will be typed in accordance with the HydroGeoMorphic (HGM) classification system first described by Brinson (1993) and modified for application in South Africa by Kotze *et al.* (2007), and SANBI (2009). Key drivers, which are essentially automatically derived as part of the HGM classification, will also be determined for the Priority Wetlands. This is the strength of the HGM system as each HGM wetland type has conceptually distinct hydrological drivers based on the input, throughput and output of flows or water (see Kotze *et. al*., 2007). This process will further be strengthened by considering aspects related to the catchments of the wetlands and considering possible groundwater links.

Given the extent of the study area, and based on experience of the wetland databases available, it is expected that Present Ecological State (PES) and Importance and Sensitivity (IS) information will not be available for most systems. As such, surrogate databases and information sources will be used where appropriate to derive general state and importance and sensitivity indicators where possible. It is envisaged that regional and national land cover databases as well as provincial conservation plans, river health programme and NFEPA information will be used as the baseline data for this purpose. If appropriate, it is proposed that a desktop PES assessment is undertaken using a combination of the desktop PES model (Kotze, 2016) and image-based rapid assessment technique.

Verification of the Priority Wetland layer

It is proposed that this involve a field visit to selected Priority Wetlands. Rapid field assessments of the systems visited will be undertaken where possible and access allows, and the land categorisation used in the desktop PES assessment will be checked and verified as applicable. The objective of the field visit will be to verify, where possible, the desktop categorisations and typing of the wetlands visited.

Update the categorisation (PES and IS) and determine the REC and TEC of the Priority Wetlands

Based on the findings of the field visit, the categorisation of the Priority Wetlands will be updated as necessary. It is envisaged that additional workshops may be held with the study team during this phase of the study in order to align and integrate the findings of the wetland study with the overall Classification. During this task, the Recommended Ecological Category (REC) will be derived for the Priority Wetlands based on a modification of the standard rules indicated in Rountree *et al*. (2013). Based on known threats or pressures for development within the related catchment areas, the relationship between the threats/pressures and the expected change in condition of the Priority Wetlands identified will be determined. Wetland baseline condition or current PES will serve as the starting point. Expert judgement will be used to derive how the priority systems are likely to either stay the same or change depending on the pressures they are currently experiencing or based on additional threats or pressures going forward.

Determine sub-components and indicators as applicable

It is envisaged that this will involve a wetland team workshop to determine sub-components and indicators for each Priority Wetlands RQO's as applicable.

Set preliminary RQO's

Generic and specific preliminary RQO's for each of the Priority Wetlands will be developed as applicable.

6.6. Socio-Economic Assessment

The socio-economic assessment (SEA) for Thukela catchment water resource classification requires the definition, understanding and classification of social, economic and ecological components. The approach classifies the primary characteristics of each component towards assessing impacts against various scenarios. The classification will be conducted in line with DWA 2007c: Socio-economic guidelines for the 7-step classification procedure and will draw directly from the updated guidelines as presented in WRC, 2018 project entitled: Review of Socio-Economic Guidelines for Water Resource Classification and Development of an Improved Decision Support Tool. A schematic representation of approach and tasks to be followed as per WRC, 2018 are presented in Figure 12.

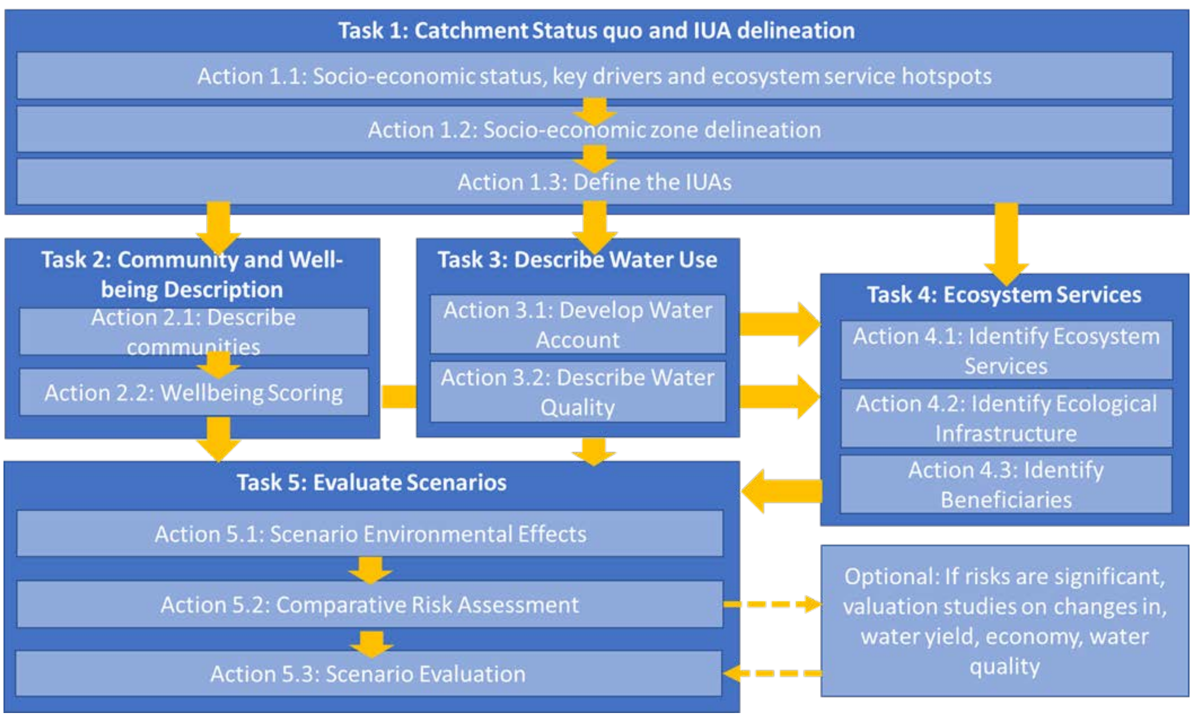

Figure 12: Socio-economic assessment approach with stepwise tasks and intermediate actions to be followed in the Thukela socio-economic analysis

It should be noted that the proposed approach corresponds with the gazetted DWA. 2007c: Socio-economic guidelines for the 7-step classification procedure as per Figure 13.

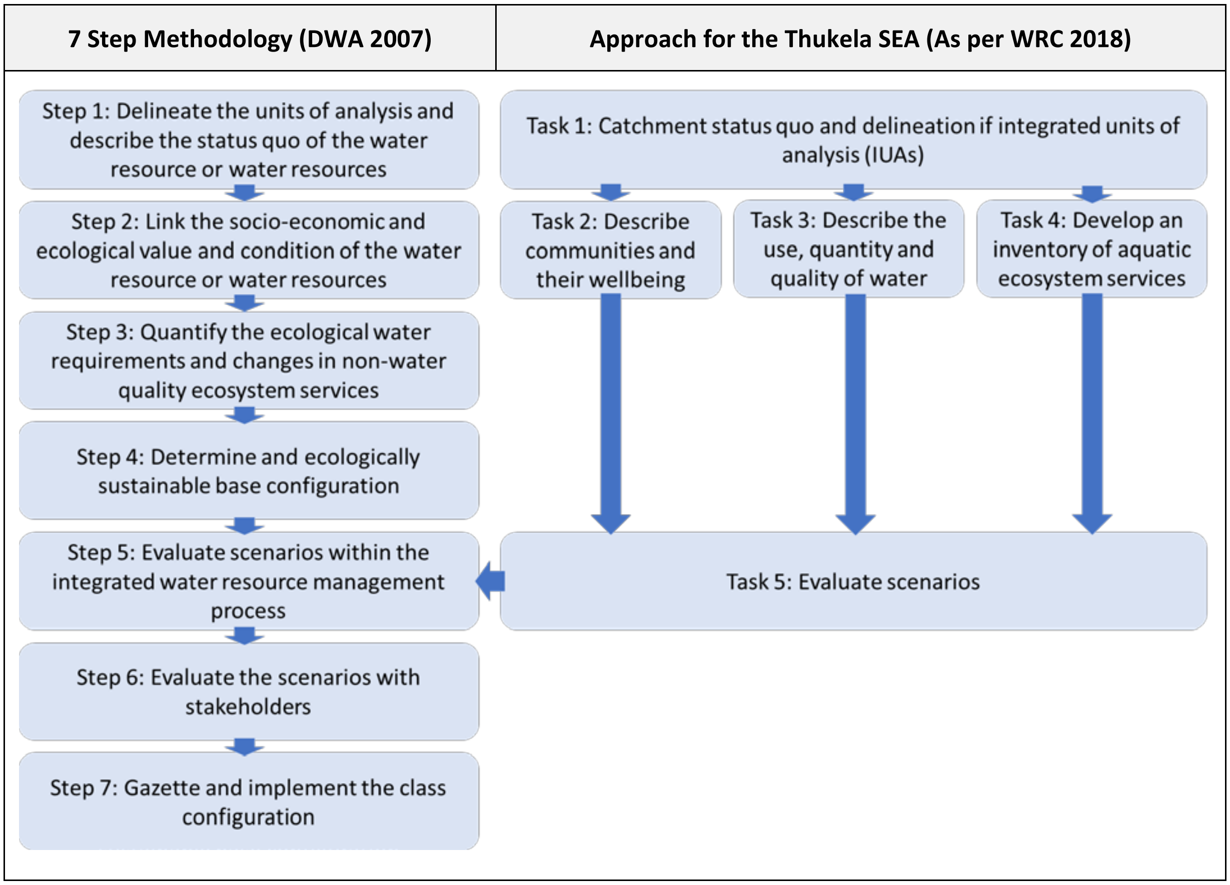

Figure 13: Alignment of the Socio-economic guidelines with the 7-Step process for determining water resource classes

6.6.1. Task 1: Determination of Catchment Status-quo and Determination of IUAs

The three actions required for determining the IUA's are as follows:

- **Action 1.1**: Describing the present socio-economic status and key drivers and ecosystem service hotspots within Thukela catchment through identifying of ecosystem services across the catchment guided by MEA 2005 and TEEB 2013. This action requires an understanding of spatial patterns in population densities, land use and the economic drivers across the catchment.
- **Action 1.2**: Delineating the socio-economic zones through having homogenous socio-economic characteristics and dependencies to the services provided by associated aquatic ecosystems.
- **Action 1.3**: Defining the IUAs in workshop environment with all relevant specialists contributing their findings and agreeing on the proposed IUA delineations.

6.6.2. Task 2: Describe Communities and Their Wellbeing

The aim of this task will be to describe the wellbeing of communities within each IUA identified in the previous step.

The well-being of the communities in the Thukela catchment will be described using various indicators of financial, physical, human, social and natural capital assets available to those communities. The process includes the construct of an index of wellbeing which are used together to determine a Social Wellbeing Score (SWS).

Three actions required to complete this task:

- **Action 2.1**: Describe the social context. This will largely be based on the latest census data.
- **Action 2.2:** Wellbeing Index Scoring which will be approached through multiple indicators of well-being being integrated, resulting in an overall Social Wellbeing Score (SWS).
- **Action 2.3:** Describing the relationship with water sources which will illustrates the reliance of households and individuals on specific water sources for daily use**.**

6.6.3. Task 3: Describe the Use and Value of Water

The objective of this task will be to describe the way in which water is used on an IUA level, and to estimate the value generated by that use.

- **Action 3.1:** Water accounts will be developed and that includes physical and monetary flow accounts. Water flow accounts are useful for analysis on how economic changes impact the environment and how changes in water availability impact the economy.
- **Action 3.2:** A high level water quality account will be defined that will assist in reporting consequences of economic development that result in ecological degradation. This action will rely heavily on inputs from the other classification components.

Integration of water quality account and water flow account will assist in quantifying available water that is suitable for use.

6.6.4. Task 4: Develop an Inventory of Aquatic Ecosystem Services

Following on from task 1, the purpose of this step will be to identify the ecosystem services (ES) within the catchment at an IUA level and determine a broad idea of the demand of these services by communities and the economic sectors that utilize them.

Three actions required to complete this task:

- **Action 4.1:** The TEEB (2013) classification system provides a typology of ecosystem services. This typology will be used as a guideline to identify the relevant ecosystem services within each IUA.

- **Action 4.2:** Identifying the ecological infrastructure, which in turn supplies the flow of ecosystem services identified in Task 1.
- Action 4.3: Determining beneficiaries and demand for ecosystem services on a desktop level in conjunction with relevant experts and using tools such as Google Earth and aerial photography.

6.6.5. Task 5: Evaluate Scenarios

The objective of this task will be to evaluate the selected scenarios within the socio-economic framework. The scenarios, in the context of water resource management and planning, are plausible definitions (settings) of all the factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Three actions required to complete this task:

- **Action 5.1**: Develop environmental effect statements which will provide context on the broad effects that scenario changes have at the IUA level. This allows participants of the analysis to form a causality chain of the effects of changes in the environment to beneficiaries.

- **Action 5.2**: Conduct a Comparative Risk Assessment (CRA) process.

  The aim of the CRA is to determine the risk the selected scenarios pose to ecosystem services. This process will be informed by outputs of Tasks 2, 3 and 4.

  CRA methodology takes a rigorous approach to determining the risk posed to ecosystem services resulting from various management scenarios. The CRA is typically conducted by a team of multi-disciplinary experts in a workshop setting whereby the list of ecosystem services are prioritised based on risk. The prioritised list will contain a descriptive chain of causality for each ecosystem service/scenario interaction. Prioritised ecosystem services would then move on to the valuation step.

- **Action 5.3**: Ecosystem Services Economic Valuation

  In the event that ecosystem services are at risk, economic valuation techniques will be utilised to assist in the evaluation of the trade-offs between the various scenarios. It is important to note that the valuation step can be resource intensive, especially where no previous valuation has been done for the region. As a result of this the methodology used in the valuation step will be driven by available resources. As a point of departure however, the framework to support decisions when choosing valuation techniques as developed by Blignaut and Lumby (2004) will be utilised. Techniques to be explored are included below:

  - If market values are available, then changes in productivity techniques will be employed,
  - If non-distorted (efficient) market prices are not available, then surrogate market approaches such as the travel cost and hedonic pricing methods can be used;

- If market prices are not available, but direct (efficient) proxies are, a variety of assumed preference techniques such as damage cost, replacement cost, cost of illness or other benefit transfer methods (BTM) can be used;
- When indirect proxies are available, observed behaviour techniques such as the travel cost and hedonic pricing methods can be used; and
- If no market prices or proxies exist, hypothetical behaviour methods such as contingent valuation methods or conjoint analysis methods can be used.

It is often necessary to use a combination of valuation techniques rather than a single technique to value ecosystem services. The team will explore techniques which will be practical and relevant for Thukela catchment.

The approach described above relies heavily on data inputs from the greater classification process and transdisciplinary collaboration. As a tool to standardise and simplify the process the Socio-Economic Classification Tool (SeCT) as developed in WRC, 2018 will be utilised.

6.6.6. The Socio-economic Classification Tool (SeCT)

The Socio-economic Classification Tool (SeCT) is 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 incorporates all the tasks from the socio-economic assessment, by ensuring standardised inputs and outputs. This tool aims to simplify the process and ensure that classifications are transparent and comparable. The tool also provides a platform from where realistic socio-economic information is presented when determining trade-offs resulting from various water use scenarios.

6.6.7. Additional Considerations: Transfers

The classification of a catchment in terms of contribution of available water and ecosystem services to socio-economic wellbeing is a valuable method to inform appropriate resource management approaches. Although the quantification of components within catchment boundaries provides for an effective management unit in theory, the reality is that there is movement of water resources across boundaries therefore spreading benefits at a larger national scale. In the case of the Thukela catchment, the movement of water resources through transfers out of the catchment is significant meaning the value of water availability is not limited to the catchment but also to receiving catchments.

To ensure the risks of management scenarios in the Thukela catchment are fully considered it is vital that transfers form a key consideration into the classification approach.

The approach to inclusion of transfers into the classification will rely heavily on availability of resources and suitability to assess impacts of management scenarios. As a result, the likely approach would be the quantification of total water transfer volumes and relating this, as a percentage, back to the results for the Thukela catchment.

The specific approach will be explored further in subsequent deliverables as management scenarios become clearer.

Tasks 3, 4 and 6 Deliverables

- Status Quo Report and delineation of RUs and IUAs
- Socio-economic evaluation report
- Ecological Water Requirements Report
- Scenarios Report
- Water resource classes gazette
- Preliminary Resource Units Report (Selection and Prioritisation)
- Resource Units Prioritization, Sub-component prioritisation and indicator selection Report
- Draft RQOs and Numerical limits;
- Stakeholder consultation on agreed RQOs
- Gazette template of RQOs per RU
- Plan for implementation/operationalisation of water resource classes and RQOs

7 STAKEHOLER ENGAGEMENT

It is recognised that the process of determining water resources classes and associated RQOs requires a strongly driven stakeholder engagement and communication component supported and guided by the necessary technical and institutional components. Stakeholder engagement is a key consideration, however, the outcome in terms of this process is essentially technically driven and supported by the appropriate engagement structures.

Given the context of the classification process, stakeholder engagement, seeks to:

- Inform the broader public of the project and what water protection measures means to them and the catchment;

- Engage key stakeholders (directly affected parties, influencers, decision-makers and thought leaders representing various sectors of society) involved in concurrent activities to intelligently apply the collective wisdom to the successful determination of water classes and RQOs; and

- Through sound relationships with key stakeholders and satisfactory communication, build trust and create an understanding as well as, collaboration to ensure that all role players work towards sustainable water resource protection and use.

Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and / or the ability to influence its outcome, either positively or negatively.

Previous stakeholder databases generated through the Reserve Determination Study, Coastal Areas Water Reconciliation Maintenance Strategy Study, Sappi Reserve Determination Study, Thukela Water Project Study of the DWS, etc., were used as a basis to identify stakeholders.

The stakeholder communication and liaison process involves a number of steps described below.

7.1. Development of a stakeholder database

A stakeholder database will be compiled, updated and maintained throughout the study. The identification of stakeholders is important and will be done in collaboration with the DWS and stakeholders in the study area.

Stakeholders may include locally affected communities or individuals and their formal and informal representatives, national or local government authorities, politicians, religious leaders, civil society organisations and groups with special interests, the academic community, or other businesses.

A copy of the stakeholder database, complete with stakeholder’s names, organisations and contact details has been compiled and submitted to the DWS.

The stakeholder database is dynamic and will be updated during the course of the project. The study team will keep track of interactions with stakeholders, e.g. correspondence and meeting attendance. The study team will provide the DWS with a copy of the stakeholder database upon completion of the project.

A stakeholder engagement plan has been submitted as supporting deliverables this inception report.

7.2. Announcement of the study

Following finalisation of version 1 of the stakeholder database at the end of this inception phase, the study will be officially announced in a short letter on a DWS letterhead and signed by the Chief Director: Water Ecosystems. A Background Information Document (BID) explaining the whole study in detail will be included in the announcement email. There will also be a registration and comment sheet.

7.3. Project Management Committee meetings

- Attend 10 project management committee meetings (PMC) over the course of the Study as required;
- Provision of secretariat services; and
- The committee will focus on assessing and monitoring progress of the study, providing guidance and support.

7.4. Project Steering Committee meetings

Up to six Project Steering Committee (PSC) meetings will be held over 30 months and will take place after specific milestones have been reached. It is envisaged that the PSC will comprise approximately 50 stakeholders. It is suggested that the PSC meetings be shared between Escourt and Newcastle.

Tasks will include booking of the venues, preparation of the invitations, agendas, attendance registers, presentations and a BID for each meeting. Take minutes in the form of questions / comments / issues and responses.

7.5. Specialist Workshops

Specialist workshops will be arranged when the need arises for in-depth discussion with scientists / specialists / non-governmental organisations. Three proposed workshops are catered for. Task will include booking of the venues.

- Clear objectives for the meeting/workshop will be defined and communicated;
- Specialists will receive notification of the meeting date and its objectives at least three weeks in advance;
- A formal advance registration process will be followed if necessary;
- Attendees will receive documentation for the meeting at least five working days before the meeting, with a formal information letter of their attendance; and
- Minutes in the form of questions / comments / issues and responses will be taken.

7.6. Technical Task Group meetings

Technical Task Group meetings will be arranged as needed. Task will include booking of the venues.

- The stakeholders will be identified and invited to participate on the PSC/task group. The group will form the representatives of identified organisations, users, constituencies and other government departments. A database will be maintained and updated.
- Clear objectives for the meeting/workshop will be defined and communicated;
- Stakeholders will receive notification of the meeting date and its objectives at least three weeks in advance;
- A formal advance registration process will be followed if necessary;
- Attendees will receive documentation for the meeting at least five working days before the meeting, with a formal information letter of their attendance; and
- Minutes in the form of questions / comments / issues and responses will be taken.

7.7. Public Meetings

Two rounds of public meetings (4 meetings) will be arranged at suitable centres in the catchment area. Meetings will be held at on study initiation (IUA delineation task 3) and towards the conclusion of the study to inform stakeholders of the recommended water resource classes and RQOs. Tasks will include booking of the venue.

- The objectives for the meeting will be communicated;
- Stakeholders will receive notification of the meeting date and its objectives at least three weeks in advance;
- A formal advance registration process will be followed if necessary;
- Attendees will receive documentation, including a BID for the meeting at least five working days before the meeting, with a formal information letter of their attendance; and
- Minutes in the form of questions / comments / issues and responses will be taken.

7.8. Consolidated Issues and Responses Report

An Issues and Responses Register will be compiled and updated throughout the project. This report will list all the comments from stakeholders (to be received from comment sheets, at meetings, via emails and telephone calls) and responses from the project team. This report will be used as a monitoring tool and will also be attached to the final report going to the Minister.

7.9. Feedback to Stakeholders

Feedback to stakeholders will be done by means of:

- Direct answers to any questions or requests for additional information by emails.
- Meetings (PSC and public) throughout the project;
- Issues and Response Register will available on the website (http://www.dwa.gov.za/rdm/WRCS /default.aspx); and
- Regular BIDs during the project.

Task 5 Deliverables:

- Stakeholder database;
- Meeting documentation; and
- Record of stakeholder comment/issues and responses.

The stakeholder engagement plan has been submitted as a supporting deliverable to this inception report.

8 CAPACITY BUILDING

The main objective of the study is to determine appropriate water resource classes and RQOs for all significant water resources in the Thukela River catchment area. A key requirement of the Terms of References for the study is capacity building of relevant departmental officials.

Capacity building will be realised through the following mechanisms in this study, namely:

- **Mentorship**: *Mentoring of the Thukela study DWS project manager and DWS Water Resource Classification team* - which will involve dedicated, one-on-one guided sessions with the identified specialists on the team addressing wetlands and IUA delineation as the subject matter.
- **Stakeholder Engagement** - *Stakeholder involvement over the course of the projec*t, *through their participation*. Stakeholder groups will develop an understanding of water resource protection through the Classification/RQO Process and its relevance. This will also assist in the enhancement of their understanding of the concepts of integrated water resource management and sustainable development.
- **Training Workshops** - *Participation of identified DWS officials* - in dedicated day workshops on water resource components and classification aspects which will build their capacity and broaden their skills base with respect to the WRCS and RQO process as well in terms of specific technical content.

Three capacity building activities will be addressed through the study:

8.1. Mentorship:

- The study team will mentor the DWS Water Resource Classification Team on delineation of IUAs. Golder will provide a workshop on delineation of IUAs and also review the Usutu Delineation Report that would be produced by the DWS Classification Team.
- The DWS Study Project Manager, Ms Mohlapa Sekoele will be mentored on the wetland component of classification and RQOs determination.

8.2. Workshops:

- Workshops will be given to identified DWS trainees. 8 Training workshops are envisaged to meet the training needs of the trainees. These are as follows:

  - **Overview of the Classification and RQOs Determination**

  A one- day workshop will be held for trainees to provide an overview of the Classification and RQO Determination process – all components, the process, the tools and the application to surface water and groundwater resources. The workshop will be the form of presentations and include insight to the use of the tools as well as databases, relevant maps, resources, etc.

  The aim of this exercise is to adequately equip the DWS officials with the relevant study information on the Classification process, RQO process, the outcomes, how to apply the information, what does it require and its implications.

- **Socio-economic analysis:**

The purpose of the workshop will be to provide DWS officials with an understanding of the socio-economic analyses and how trade-offs are analysed when comparing the different catchment configurations. Officials will be taken through the underlying data sources and general analyses that determine the Socio-economic Comparison Tool (SeCT) and how this tool can be practically used. The workshop is expected to take no longer than one day, but if necessary further time can be added.

- **Surface Water Hydrology and Water Resource Modelling**

A workshop shall be held with the DWS and other nominated persons, to cover the selection of the models and how they are updated and used to perform the analyses of water availability. The intention will not be for this to be a technical training workshop on how to use the models as a modeller, but rather focus on the following that is more relevant to the DWS, as custodians of this information:

- What past studies have been conducted on this system, and what versions of the model are available (in general and for this catchment in particular);
- What are the main differences between the various available models;
- How the data should be stored and labelled for future reference;
- How to combine different studies' data into a new model that meets the study purposes; and
- Different kinds of simulations and associated outputs possible.

The workshop will be held over one day, and fairly early in the study program, as this is when the associated work and decisions are being taken by the study team.

- **Water Quality**

An introduction to water quality will be provided to trainees. Training on the use and application of water quality component in terms of the process will be conducted.

- **Groundwater resources:**

A flow sheet explanation of how the groundwater component of the study developed will be compiled for capacity building applications. Specific evaluations/calculations as per the Seven Step Guideline will form the framework of the approach and specific variables required in the assessment process will be high-lighted. These specific variables required for the GRDM evaluation, for example, are:

- Groundwater Resource Units (GRUs) and Integrated Units of Analyses (IUAs):
    - o Six (6) specific attributes to be addressed (Table 4.2 as in Step 2.2 of the Integrated Framework for groundwater resources).

- Procedure how to prioritise GRUs using the following characteristics:
    - Stream flow reduction (where EWR's are available – addressing groundwater-surface water interaction;
    - The evaluation/ranking of groundwater Stress Factor; and
    - Other attributes: (i) groundwater level/elevations, and (ii) groundwater conductivity.
- Application of Groundwater contribution to river/stream Baseflow:
    - Principles of (present day) Baseflow, groundwater contribution to baseflow and baseflow reduction;
    - Alignment to EWR; and
    - Application of the Streamflow Depletion Principle (factor).
- Principles of groundwater resource classes based on aquifer and land use conditions in specified GRU/IUA:
    - Groundwater quantity and quality expressed in terms of PES, REC and TEC.
- Specification of RQOs and implementation:
    - Setting of protocols with respect to (i) Groundwater stress, (ii) Groundwater utilization (use), and (iii) Groundwater quality status in GRU/IUAs; and
    - Typical narratives and numerical limits based on hydrogeological status/characteristics in the GRU/IUAs;
    - Measures (plus indicators) to consider for resource unit(s) prioritizing (Table 8.1 as in Step 6.2 of the Integrated Framework for groundwater resources); and
    - Protocols to implement RQOs in priority resource units.

In conclusion, there are a few complex estimations required in the groundwater component of the classification and resource quality objectives assessments – mainly because of the lack of time series datasets. It is therefore foreseen that capacity building activity will aim to highlight the processes and programs that are required to address these shortages – specifically at catchment level where monitoring networks and programs are required to generate specific datasets. An overview of different monitoring processes will be highlighted in reporting format.

Implementation of the narratives and numerical limitations requires physical actions through conditions and measures addressed in water use licenses and WUL audits. Links to these activities from a set of standardised outputs needs to be introduced through capacity building activities and reporting.

- **RQO determination (Resource Unit and sub-component prioritisation):**

  Training to create understanding and application of resource unit prioritisation and the tool will be given to trainees. The prioritisation of the resource units including the results and details of the application of the tool will be discussed. Participants will be given the opportunity to work through the tool.

  Training on sub-component selection and prioritisation will involve a participatory process were trainees will be taken through the sub-component prioritization tool, its application, the criteria and scoring and the prioritisation process. Thereafter the process will facilitate the identification of the priority subcomponents. The process will be interactive and provide opportunity for discussion on how to apply the RQO procedure and undertake the task of sub-component selection and prioritisation.

- **Evaluation of scenarios and determination of classes**

  A training workshop will be held on the following:

  - How to evaluate scenarios
  - Socio-economic implications of the different scenarios
  - The determination of the proposed water resource classes.

  Various aspects will be covered which include amongst others, ecological condition; ecological water requirement; scenario development, analysis and evaluation; interpretation of results; economic modelling and evaluation; discussion of implications and process from recommended scenarios to water resource classes.

- **Introduction to Estuaries:**

  Managing estuaries involves an understanding of how estuaries function, the goods and services that they provide and activities that threatens them. The sustainable use of these dynamic systems can only be achieved through sound governance and management practices. The *Management of Estuaries in South Africa* course aims to introduce trainees to useful management tools and was designed in response to a need to manage the estuarine environment effectively, considering issues such as managing freshwater resources and the integrity of estuaries and their functionality.

  The workshop will cover the following:

  - Value, structure and function of estuaries;
  - Threats to estuaries; and
  - The ecological reserve and determining the freshwater requirements of estuaries.

8.3. Stakeholder Empowerment:

Stakeholder empowerment sessions will be linked to the stakeholder meetings. The team will capacitate stakeholders through the various meetings and consultation forums that are created over the duration of the project. Each presentation will run through the process, tool applied or applicable approach so that stakeholders become familiar with the methodology applied. Where applicable supporting information will be made available to stakeholders.

8.4. Identified Recipients

The capacity building recipients are as follows:

Activity	Recipients	Topics/Aspect addressed
Mentorship	Mohlapa Sekoele	• Wetlands
	Mkhevu Mnisi Mohlapa Sekoele Esther Lekalake Adaora Okonkwo Lawrence Mulangaphuma Koleka Makanda	• Integrated Units of Analysis Delineation • Usutu Report Review
Training Workshops	Mohlapa Sekoele Molefi Mazibuko Mkhevu Mnisi Philani Khoza Koleka Makanda Nobubele Boniwe *Regional/other Directorate trainees still to be identified*	• Overview of the Classification and RQOs determination process • Socio-economic Analysis • Surface Water hydrology and Water Resource Modelling • Water Quality • Groundwater • Introduction to Estuaries • Evaluation of scenarios and determination of classes • RQO RU and sub-component prioritisation
Stakeholder capacity building	Stakeholders on database – attending the PSC, technical task team meetings and public meetings	• Overview of the Classification and RQOs determination process

A capacity building programme has been drafted and submitted as supporting deliverable to this inception report.

Task 7 Deliverables:

- Capacity Building Report (including all activities).

9 SUMMARY OF DELIVERABLES

The summary of deliverables for the study will include the following:

Table 10: Summary of Study Deliverables

Deliverables		**Due dates**
1	Inception Report	07 November 2019
2	Stakeholder database and project announcement	07 December 2019
3	Water Resources Information and Gap Analysis Report	15 January 2020
4	Specialist workshops report (estuaries; wetlands; groundwater)	15 February 2020
5	*Status quo* and delineation of Integrated Units of Analysis and Resource Units Report	15 May 2020
6	Report on linking the value and condition of water resource	13 August 2020
7	Preliminary Resource Units Report (selection and prioritization)	15 September 2020
8	Ecological Water Requirements Report	15 October 2020
9	Sub-components prioritization and indicators selection Report	13 November 2020
10	Scenarios and draft Water Resource Classes report	14 January 2021
11	Draft RQOs and numerical limits report	15 April 2021
12	Plan for implementation/operationalisation of the Water Resource Classes and the RQOs	15 August 2021
13	Project Steering Committee Meeting Minutes and updated Issues & Responses Register	6 times throughout the lifecycle of the project
14	Technical Task Group Meeting Minutes and updated Issues & Responses Register	2 times throughout the lifecycle of the project
15	Public Meeting Minutes and updated Issues & Responses Register	4 times throughout the lifecycle of the project
16	Classes and RQOs gazette template	14 July 2021

Deliverables		**Due dates**
17	Sectoral / one-on-one meetings and updated Issues & Responses Register	31 July 2021
18	Capacity building reports	6 times throughout the lifecycle of the project
19	Support with addressing of comments	5 December 2021
20	Project administration and management	Quarterly
21	Progress reports	Bi-monthly
22	Main report	15 January 2022
23	Project close-out report and Electronic information and data	15 January 2022

10 WORK PROGRAMME

The work programme of the study tasks is provided as a bar chart programme of the tasks as Appendix A. The study will be completed within the 30-month time frame as specified in the contract. In terms of the programme the study is expected to terminate in February 2022.

11 STUDY TEAM

The study team participating in the study are indicated in Table 11.

Table 11: Study Team Members

Team Member	Company Name	Project Role
Trevor Coleman	Golder	Study Lead, Water Resources Integration, Analysis
Lee Ann Boyd	Golder	Project Manager, WRCS and RQO Process Lead
Zinhle Sithole	Golder	Data Analysis and Collation
Priya Moodley	Golder	Study Co-ordinator, WRCS and RQO Process
Eddie van Wyk	Golder	Groundwater Lead
Amelia Basson	Golder	WQ Modelling
Manuella De Mendonca	Golder	Stakeholder Engagement Support
MmaKhumo Mogapi	Golder	GIS

Team Member	Company Name	Project Role
Kylie Farrell	Golder	Aquatic Ecologist (Inverts)
Andrew Zinn	Golder	Aquatic Ecologist (Vegetation)
Andre Joubert	Specialist	Stakeholder Engagement – Task Leader
Retha Stassen	Specialist	EWRs, Reserve Determinations
Gary Marneweck	Wetland Consulting	Wetlands Task Leader
Dieter Kassier	Wetland Consulting	Wetlands Ecology support
Liesl Hill	Specialist	Aquatic Ecologist Lead
Dr Marius Claassen	Specialist	Water Quality
Dr Mathys Vosloo	Zitholele	Estuarine specialist
Dr Gavin Snow	Specialist	Estuarine specialist
Johnathan Schroder	AECOM	Scenario Analysis/ Water Resource Modelling
Gerald De Jager	AECOM	Scenario Analysis/ Water Resource Modelling
Siyabonga Sikosana	AECOM	Water Resource modelling, Data Assessment
Jackie Crafford	Prime Africa	Water Resource Economist
Nuveshan Naidoo	Prime Africa	Water Resource Economics
Valmak Mathebula	Prime Africa	Water Resource Economics
Diptiseng Phaleng	Dihlashana	Support with tasks (Capacity Building SMME)
Phuti B Seanego	Dihlashana	Support with tasks (Capacity Building SMME)
Lazola Mnyaka	Dihlashana	Support with tasks (Capacity Building SMME)
Bennie Haasbroek	Specialist	Hydrologist

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APPENDIX A

WORK PROGRAMME

Task		Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22
Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	Project Inception																														
2	Information and Data Gathering																														
3	Determination of Water Resource Classes																														
4	Determination of Resource Quality Objectives																														
5	Gazetting Process																														
6	Communication and Liaison																														
7	Capacity Building																														
8	Study Management																														