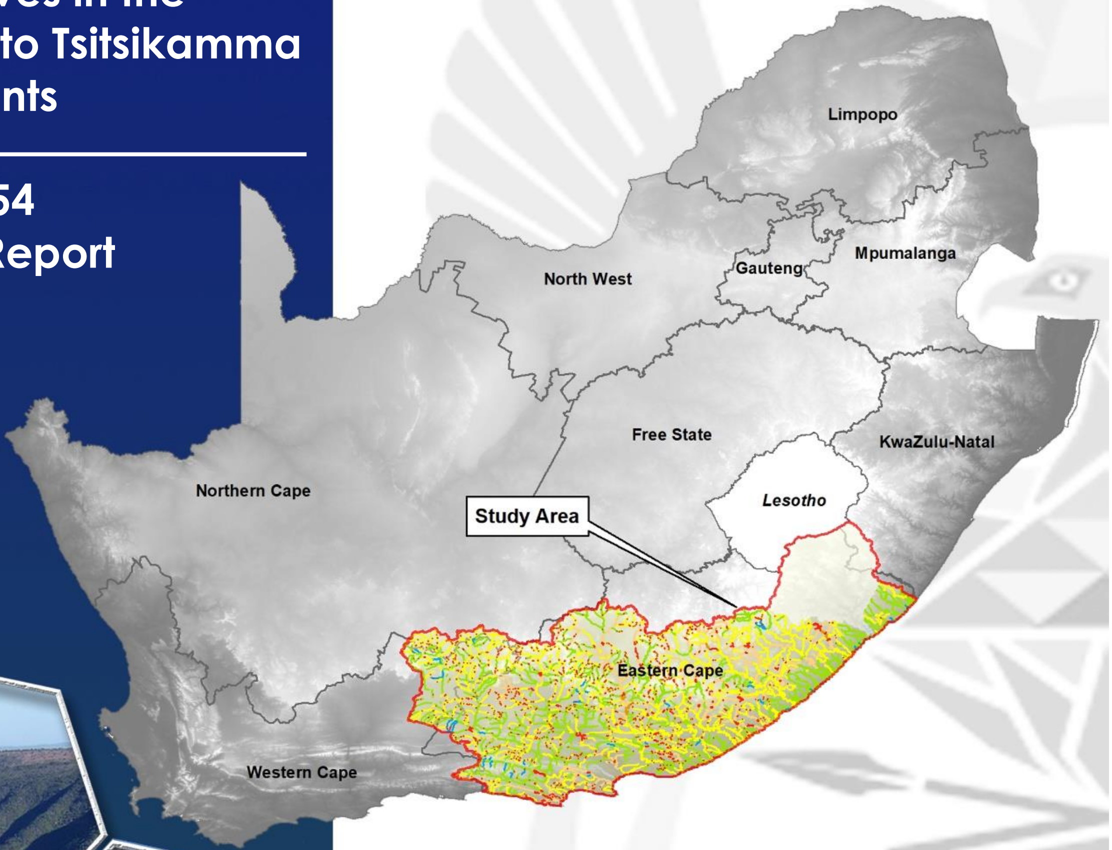
DEPARTMENT OF WATER AND SANITATION

Determination of Water Resource Classes, Reserve and the Resource Quality Objectives in the Keiskamma and Fish to Tsitsikamma Catchments

WP11354
Inception Report



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AEH	Aquatic Ecosystem Health
AQC	Analytical Quality Control
BHN	Basic Human Needs
BS	Basic services
BID	Background Information Document
CBA	Critical Biodiversity Areas
CD: WEM	Chief Directorate: Water Ecosystems Management
CS	Citizen Science
DRM	Desktop Reserve Mode
DSP	Decision-Support Protocol
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EI	Ecological Importance
EcI	Ecological Integrity
ES	Ecological Sensitivity
ESM	Ecosystem Services Module
ESA	Ecological Support Areas
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Areas
FIFHA	The Fish Invertebrate Habitat Assessment Model
FRAI	Fish Response Assessment Index
FSRM	Flow Stressor Response model
GIS	Geographic Information System
GRDM	Groundwater Resource Directed Measures
GDE	Groundwater dependent ecosystems
GRU	Groundwater resource units
GVA	Gross Value Added
GW	Groundwater
HFSR	Habitat Flow Stressor Response
IBA	Important Bird Areas
IEM	Integrated Economic Model
IFR	In-stream Flow Requirement
IHI	Index of Habitat Integrity

ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
MAP	Mean Annual Precipitation
MIRAI	Macroinvertebrate Response Assessment Index
MPA	Marine Protected Areas
NFEPA	National Freshwater Ecosystem Priority Areas
NWA	National Water Act
NWM5	National Wetland Map 5
NBA	National Biodiversity Assessment
NGA	National Groundwater Archive
NMBM	Nelson Mandela Bay Municipality
PES	Present Ecological State
• Category A	Unmodified, natural
• Category B	Largely natural with few modifications
• Category C	Moderately modified.
• Category D	Largely modified.
• Category E	The loss of natural habitat, biota and basic ecosystem functions is extensive
• Category F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota
PSC	Project Steering Committee
PSP	Professional Service Provider
RDM	Resource Directed Measures
REC	Recommended Ecological Category
REIZ	River-estuary interface zone
REMP	River EcoStatus Monitoring Programme
RHP	River Health Programme
RQO	Resource Quality Objectives
RU	Resource Units
RZ	Riparian zones
SASS5	The South African Scoring System Version 5
SAM	Social Accounting Matrix
SPATSIM	Spatial and Time Series Information Modelling (SPATSIM
SWSA	Strategic Water Source Areas
TEC	Target Ecological Category
ToR	Terms of Reference
SST	Sustainable Sea Trust
VEGRAI	Vegetation Response Assessment Index
WEM	Water Ecosystems Management

WARMS	Water use Authorization and Registration Management System
WAAS	Water Availability Assessment Study
WRPM	Water Resource Planning Model
WRYM	Water Resource Yield Model
WMA	Water Management Area
WR2012	Water Resources 2012
WRC	Water Research Commission
WRCS	Water Resources Classification System
WWTW	Wastewater Treatment Works

1. INTRODUCTION

The National Water Act, 1998 (No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without affecting the functioning of water resource systems. To achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of Resource Directed Measures (RDM). These measures are protection-based and include Water Resource Classification, determination of the Reserve and setting the associated Resource Quality Objectives (RQOs). These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources, while allowing economic development.

The provision of water required for the maintenance of the natural functionality of the ecosystem and provision of Basic Human Needs (BHN) is the only right to water in the National Water Act (No. 36 of 1998) (NWA). The other water users from a strategic use who are second in line to other water users are subject to formal gazetted General Authorization and water use authorization as per Section 21 of the NWA.

The Chief Directorate: Water Ecosystems Management (CD: WEM) has initiated a study for the determination of Water Resource Classes, Reserve and associated Resource Quality Objectives for the identified significant water resources in the Keiskamma, Fish to Tsitsikamma catchments. The water resource components included for this study are rivers, wetlands, groundwater and estuaries. The Reserve determination include both the water quantity and quality of Ecological Water Requirements (EWR) and Basic Human Needs (BHN). This will ensure the availability of water required to protect aquatic systems and that the human basics are directly dependent on these water resources.

1.1 Study motivation

The Keiskamma and Fish to Tsitsikamma catchments within the Mzimvubu to Tsitsikamma Water Management Area (WMA7) are amongst many water stressed catchments in South Africa. This study area is important for conservation and have recognisable protected areas, natural heritage, cultural and historical sites that require protection. As a number of rivers and estuaries are within these catchments with no major impacts, it is vital that their ecological integrity is retained.

However, water use from surface as well as groundwater for agricultural and other land use activities are high, especially in the more arid catchments, impacting on the availability of water resources for the protection of the aquatic ecosystems. Industrial practices and domestic water use are on the rise in some of these catchments, especially around the major towns and cities. Water transfers into the study area from adjacent Water Management Areas (WMA) and within the study area and numerous storage dams changes the flow patterns, impacting on the aquatic biota. Furthermore, various water use license applications and increasing land use impacts in the catchments (forestry, farming, eradication of alien vegetation, wastewater treatment works) are increasing.

Therefore, measures including the Classification of water resources, quantification of the Reserve and setting of Resource Quality Objectives (RQOs) for all identified significant water resources is required to ensure ecological sustainability within these catchments. This will ultimately assist the DWS in managing and protecting of the water resources in the study area in an integrated manner, as well as making informed decisions regarding the authorisation of future water use and the magnitude of the impacts of proposed developments.

Overall, the ultimate goal of this study is to provide information that is legally defensible and that the Management Class identified, set RQOs and the determined Reserve, will be gazetted and thus the outputs will be legally binding.

1.2 Study objective

The main objectives of the study are to determine (i) Water Resource Classes, (ii) the Reserve and (iii) associated Resource Quality Objectives (RQOs) and gazetting of all of these for the significant identified water resources in the Keiskamma and Fish to Tsitsikamma catchment area that would facilitate sustainable use of the water resources while maintaining the required ecological integrity. All the water resource components, including rivers, wetlands, estuaries and groundwater will be considered during this study and where applicable, integration between these components will be undertaken.

Furthermore, the determination of the Water Resource Classes, the Reserve and setting RQOs will depend on the integration of a number of disciplines in respect of water resources protection (i.e. instream and riparian health and Source Directed Control) that includes the with the needs of the water users present in the catchment area. This will be done through a consultative process with continual communication and liaison by involving the various stakeholders in the study area. Skills development and transfer through a number of workshops, training days, in-field surveys and day-to-day management of the study will be undertaken as part of the capacity building requirements of the DWS.

The key aims of this study are thus to (i) co-ordinate the implementation of the Water Resource Classification System (WRCS) through the published Regulation 810 (DWA, September 2010) and (ii) following the various methodologies for the determination of the Reserve and setting the RQOs as prescribed by the DWS. The integrated procedure as developed to Operationalise Resource Directed Measures (DWS, 2017) will be used to guide the overall process for this study. The study team understands that this study is linked to previous Reserve determination studies and other water resource management initiatives within the study area. Linking and integration with current parallel studies, including the development of a reconciliation strategy for the management of the water resources in the study area will be undertaken as part of this study.

The Water Resource Classes and associated RQOs will assist as input information when assessing potential authorisation of future water uses, provide guidance on the operation and management of the system and the evaluation of the impacts of the present and proposed developments, in the form of operational scenario evaluation. Furthermore, taking the economic, social and ecological goals to be attained, and considering and specifying the risks of non-compliance, with meeting of the Recommended Ecological Category (REC) and the potential loss of social and economic water use.

1.3 Purpose of this report

This Inception Report has been compiled to better define the scope of work, approaches and methodology that will be applied for the determination of Water Resource Classes, Reserve and associated RQOs for the significant water resources in the Keiskamma, Fish to Tsitsikamma catchments. Furthermore, the report highlights related considerations that could influence the study, identify key challenges and limitations of the study and confirm the stakeholder engagement process, capacity building activities, the study programme and timeframes.

All figures referred to in the main report are presented in Appendices.

2. STUDY AREA

The study area forms part of the Mzimvubu to Tsitsikamma WMA (WMA7) as indicated in Table 2-1. The water resources of the Mzimvubu catchment (T31 – T36) are not included as part of the study area for the purposes of this study. Secondary catchments T40 (Mtamvuna) and T50 (Mzimkhulu) form part of WMA4 (Appendix A, Figure 11-1).

Table 2-1: Main catchments and rivers in the study area

Catchment	Major Rivers
K80	Tsitsikamma and small coastal rivers
K90	Krom and small coastal rivers
L10 - L90	Gamtoos with main tributaries Groot, Baviaanskloof and Kouga
M10 - M30	Koega, Swartkops and small coastal rivers
N10 - N40	Sundays
P10 - P40	Kowie, Kariega, Boesmans and small coastal rivers
Q10 - Q90	Fish River with main tributaries of Little Fish, Koonap and Kat
R10 - R50	Keiskamma and small coastal rivers
S10 - S70	Great Kei River with main tributaries of Klipplaats, Indwe, White Kei, Black Kei
T10	Mbashe
T20	Mthatha
T60	Small coastal rivers (Mtentu, Msikaba, Mzintlava)
T70	Small coastal rivers (Mtakatye, Mngazi)
T80 & T90	Small coastal rivers

2.1 Rivers

The rivers in the study area ranges from large perennial to semi-ephemeral as well as small coastal systems that all drains towards the Indian Ocean (Appendix A: Figure 11-1). It consists of five large drainage basins (see Appendix B: Figure 11-2 to Figure 11-6) with a number of smaller rivers in-between. The larger drainage basins are the:

(i) **Great Kei River** (drainage region S), with its main tributaries of the **Black Kei River** (S31, S32), White Kei River (S10A to S10J), with its tributary, the **Indwe River** (S20A to S20D), the Tsomo River (S50A to S50H), and the **Thomas River** (S40A to S40E), **Kubusi River** (S60A to S60E) and **Xilinxa River** (S70C to S70E);
(ii) **Mbashe River** (part of drainage region T and includes T11, T12 and T13);
(iii) **Great Fish** (drainage region Q) with its main tributaries of the **Tarka** (Q41A-Q41B, Q41D, Q44A-Q44C)**, Little Fish** (Q80B – Q80E, Q80G), **Koonap** (Q92A – Q92C, Q92E, Q92G and **Kat rivers** (Q94A - Q94B, Q94D, Q94F);
(iv) **Sundays** (drainage region N) which falls mainly in the Great Karoo; and
(v) **Gamtoos River** (drainage region L) situated in the Karoo, with its major tributaries, namely **Groot** (L30C – L30D, L50B, L70B – L70D, L70F – L70G)**, Baviaanskloof** (L81A – L81D) and **Kouga Rivers** (L82B – L82E, L82G – L82H).

The smaller drainage regions include the following:

- Mthatha River (drainage region T20),
- Small coastal rivers in the Pondoland area (drainage regions T60 to T90) with estuaries of high conservation value (see further information in Section 2.5),
- Keiskamma, Buffalo, Nahoon and Gqunube Rivers (drainage region R, also known as the Amatole System),
- Kowie, Kariega and Boesmans Rivers (drainage region P or Albany Coast),
- Koega and Swartkops Rivers (drainage region M, part of the Algoa System),
- Krom and Seekoei Rivers (drainage region K90, also part of Algoa System), and
- Tsitsikamma and small coastal rivers in drainage region K80.

The topography of the study area is hilly to mountainous with plains and hills of the Groot Karoo, with the Drakensberg Mountains along the north-eastern boundary of the study area. The rivers are deeply incised in the coastal strip.

The study area consists of 345 quaternary catchments, covering a total catchment area of more than 143 000 km^2. The sub-catchments, associated rivers and catchment areas are listed in Table 2-2 for futher detail.

For the purposes of this report, an overview of the water resource developments and water uses are presented per the following drainage regions:

A. K80, K90, L10 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Koega and Swartkops);
B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans);
C. Q10 to Q90 (Great Fish);

D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei); and

E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems).

Table 2-2: The sub-catchments within the study area

Primary catchment	Sub-catchment	Main River	Associated Rivers	Catchment Area [(1)] (km^2)
K	K80A-F	Tsitsikamma	Elandsbos, Kleinbos, Storms, Elands, Groot, Klasies, Klipdrift	1 206
	K90A-G	Krom	Seekoei, Kabeljous	1 558
L	L11, L12, L21, L22, L23, L30, L40, L50, L60, L70, L81, L82, L90	Gamtoos	Sout, Buffels, Kariga, Plessis, Heuningklip, Groot, Baviaanskloof, Kouga	34 816
M	M10, M20, M30	Swartkops	Van Stadens, Maitland, Bakens, Papkuils, Coega	2 630
N	N11, N12, N13, N14, N21, N22, N23, N24, N30, N40	Sundays	Kamdeboo, Gats, Melk, Bul, Voel, Kariega	21 248
P	P10, P20, P30, P40	Boesmans	Diepkloof, Boknes, Kariega, Kowie, Kasouga, Riet, Wes-Kleinemonde, Oos-Kleinemonde	5 322
Q	Q11, Q12, Q13, Q14, Q21, Q22, Q30, Q41, Q42, Q43, Q44, Q50, Q60, Q70, Q80, Q91, Q92, Q93, Q94	Great Fish	Groot-Brak, Pauls, Tarka, Baviaans, Koonap, Little Fish, Kat	30 243
R	R10, R20, R30, R40, R50	Keiskamma	Tyume, Buffalo, Nahoon, Qinira, Gqunube, Kwelera, Kwenxura, Quko, Tyolomnqa, Gxulu, Bhirha, Mgwalana	7 936
S	S10, S20, S31, S32, S40, S50, S60, S70	Great Kei	White-Kei, Indwe, Klipplaat, Klaas Smit, Black-Kei, Tsomo, Kubusi, Gcuwa	20 485
T	T11, T12, T13, T20, T60, T70, T80, T90	Mbashe	Xuka, Mgwali, Mthatha, Mzamba, Mtentu, Msikaba, Mzintlava, Mntafufu, Mngazi, Mngazana, Mtakatye, Mdumbi, Nenga, Mncwasa, Xora, Nqabarha, Shixini, Qhorha, Kobonqaba	17 938
			Total catchment area	**143 382**

(1) WR2012 data

The main catchment developments and water users are summarised below per drainage region.

A. K80, K90, L10 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Koega and Swartkops)

The main water uses in this area is water for irrigation with the largest irrigated areas in the Gamtoos (L9) and the Kouga (L8) areas. Dryland cultivation occurs especially in the K8 (Tsitsikamma), K9 (Kromme) and M1 to M3 (Swartkops and Koega) with smaller areas in the Gamtoos catchment. Large parts of the Tsitsikamma catchment (K8) is afforested with smaller forestry areas in the Gamtoos (L9) and the Swartkops catchment (M10), which ends in a highly industrialised areas with an estuary of importance situation within it. Livestock grazing is present in all the catchments, especially in the Gamtoos catchment.

Gqeberha is the largest urban area with some smaller towns along the coast and sparsely populated areas in the interior of the catchment. A number of dams have been constructed for domestic water supply to the large metropolitan area, including Loerie, Haarlem, Kouga, Impofu and Kromriver Dams. Water is also supplied to Gqeberha from the Fish River via the Sundays River. Most of the smaller towns are dependent on small dams or groundwater for domestic water supplies.

B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)

Large areas of the lower Sundays River are irrigated (N1 to N4) from Darlington Dam with limited irrigation in the upper Sundays and the P region. Dryland cultivation occurs mainly in the P region as well as the lower reaches of the Sundays River. Almost no forestry is present in this drainage regions. Livestock grazing occurs throughout this area.

A number of small towns and rural areas are located in this catchment area, and includes Graaff-Reinet, Aberdeen and Peaston in the upper reaches of the Sundays River with Makhanda the largest town in the P region and a number of smaller coastal towns. Domestic water supply to Makhanda is mainly from Glen Melville Dam, an off-channel dam fed by water transferred from the Fish River. The other towns are reliant on local sources, including groundwater.

The largest dams in this drainage area includes Darlington (mainly for irrigation purposes) and Nqweba Dams on the Sundays River with smaller dams on the rivers in M10 to M30.

C. Q10 to Q90 (Great Fish)

The main water uses in this catchment is irrigation, especially along the mainstem of the Fish River. The irrigation water is mainly from the Gariep to Fish inter-basin transfer, except in the Koonap and Kat Rivers where local sources are used for irrigation. Forestry occurs in the Kat River catchment (Q9) and livestock grazing in the entire Fish River catchment.

Grassridge (Groot Brak), Kommandodrift (Tarka) and Katriver (Kat) Dams are the largest dams in this catchment. These dams supply water for irrigation and domestic water use. A number of the small towns are dependent on local sources, including groundwater. Cradock domestic water is supplied from the Fish River.

D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei)

The main activities in this sub-drainage region include large areas of dryland cultivation, irrigation, especially in the S3 (Klaas Smits and Black Kei Rivers) area, livestock grazing and afforestation in the catchments of the Keiskamma (R1), Buffalo (R2) and Kubusi Rivers (S6). The main crops being cultivated are lucerne, maize, vegetables and pastures.

A number of dams have been constructed in the catchments to supply irrigation water with the Cata, Mnyameni and Sandile Dams (R10B) and the Pleasant View and Binfield Park Dams (R10G) the largest in the R catchment. For the Kei River catchment, irrigation water use in the Queenstown area (S31E-G) is mainly from groundwater with the Waterdown Dam supplying irrigation water along the Black Kei River (S32G, H, K). Other dams in the S catchment supplying irrigation water include the Mitford (S32B), Tentergate (S32B), Thrift (S32A), Oxkraal (S32G), Bushmanskrantz (S32F), Lubisi (S20C) and Xonxa (S10E) Dams.

East London and King Williams Town/ Bisho (both in R2) and Queenstown (S3) are the largest urban areas with a number of smaller towns and villages throughout the R and S catchments.

A hydro-electric scheme forms part of the Ncora Dam in S50E.

There are several potable water supply schemes in the catchment, including regional schemes that provide water to the larger urban areas and regional rural water supply schemes to provide water to villages in the tribal areas. Some of the smaller towns have their own supply schemes either from rivers or groundwater (boreholes or springs).

E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems)

Land-use in this sub-catchment is mainly subsistence agriculture, with dryland sugarcane and some irrigation in the Mbashe (T12C), Mtata (T2) and Mngazi (T70A, T70B) catchments. Large areas of forestry occur in the Mbashe and Mtata catchments with smaller areas in T60. Livestock grazing is present in all the catchments within this sub-drainage region.

Mthatha (T2) and Lusikisiki (T6) are the largest urban areas within this sub-drainage region with a number of smaller towns and villages scattered throughout.

A number of hydro-electric schemes are present in this catchment, namely Collywobbles in T13D, and Mtata 1st Falls and 2nd Falls associated with Mtata Dam in T20D and T20E.

There are several potable water supply schemes in the catchment, including regional schemes that provide water to the main towns and regional rural water supply schemes to provide water to villages in the tribal areas. Some of the smaller towns have their own supply schemes either from rivers or groundwater (boreholes or springs).

2.1.1 *Water quality*

The review of the Water Situation Assessments that were undertaken as part of the development of the Internal Strategic Perspectives (DWAF, 2002) (ISP) notes the impacts of the mineralogical/ geological drivers to the water quality, particularly the conductivity and associated salts to some of the catchments within the study area. Due to these impacts being geologically driven, the current situation will remain largely unchanged from the 2002 assessments. A range of water qualities for domestic and irrigation use from near natural (ideal) with low conductivities and TDS, through to systems which are extensively brackish and with high TDS (making this water unacceptable) have been highlighted in these reports and include most of the L, M, N, Q, R and S primary catchment regions.

The following specific water qualities were noted in the assessment reports:

- Tsitsikamma catchment (K80) and upper Kromme River (K90A, B) were categorized as generally ideal but becoming marginal in the lower Kromme (K90C-E).
- Groot River catchments (L30, L50, L70) were categorized as poor to completely unacceptable for most uses due to the naturally high salinity of the groundwater and resulting high salinity in the base flows.
- Kouga and Baviaanskloof River catchments (L81, L82) were categorized as ideal with a similar increase in TDS downstream towards confluence with the Groot River.
- The Gamtoos River, after confluence of the Kouga and Baviaanskloof Rivers, was categorized as good water quality.
- Water quality in the upper Swartkops River (M10A, B) was found to be ideal, deteriorating to poor quality towards the middle and lower reaches in M10C and M10D due to anthropogenic impacts (Gqeberha and surrounding areas) and geological changes.
- The upper reaches of the Sundays River (N11, N12) were categorized as poor with Darlington Dam area (N23A, B) as marginal and the lower reaches of the Sundays River (N40) as poor water quality.
- Water quality in the upper reaches of the Fish River (Q12, Q13) was categorized as good to ideal with an increase in TDS towards the middle reaches (marginal) and poor in the lower reaches, due to the geology and irrigation return flows.
- The water qualities of the P catchments were categorized as unacceptable for the Bushmans River (P10A-D), poor for the Kowie River (P40A-C), and completely unacceptable for the Kariega River (P30) due to the underlying geology.
- The water quality of the R catchment (Buffalo, Nahoon and Keiskamma Rivers) was categorized as marginal to good with anthropogenic impacts noted in some of them (particularly in the lower reaches) due to towns, irrigation and forestry.
- The water quality of the Kei River (S70) was predominantly categorized as good with marginal quality in the S30 catchment (Black Kei River) due to irrigation.
- Water quality in the Kubusi River (S60) ranged from good to ideal.
- The water quality of the Mthatha River (T20) was categorized as unacceptable due to the untreated effluent from poorly performing WWTW in associated towns and general anthropogenic drivers of poor water quality.

Generally, there was limited to no data available for the classification of the water quality of the Mbashe River, and smaller Pondoland coastal rivers.

In contrast to the 2002 assessment reports, the microbiological/ water quality situation has undoubtedly deteriorated with extensive informal settlements in many of the urbanised and peri-urban areas. Many of these poorly serviced settlements are often without water borne sewerage and sanitation and/or local WWTW that are performing poorly, if at all, with a lack of maintenance and chemicals and human resources trained in their operation – as evidenced by their poor performance in the most recently available Green Drop Reports and IRIS reporting dashboards (https://www.dws.gov.za/Documents/GD/GDIntro.pdf) and http://ws.dwa.gov.za/IRIS/notice.aspx. The net effect of which has often been raw or very poorly treated sewage finding its way into local water courses and contaminating many of the water resources around the towns and villages in the study area.

Beyond the decline in the microbiological water quality of these systems, there are further impacts associated with the increased nutrient loading due to dysfunctional WWTWs (e.g. nitrogen (and associated species (NO3, NO2, NH3) and phosphorous, are the key drivers of this poor water quality, particularly in the small river systems. In many areas, and particularly during low flow periods, there is clear evidence of localised eutrophication within these systems.

Other increasing anthropogenic catchment drivers include the increased pressures on the riparian zones from invasive alien plants (IAP - weed) species (especially in the wetter T primary catchments, and often associated with escapees from commercial forestry in the upper catchments), the impacts of increased grazing pressures within the riparian zones (RZs) and its impact on the RZ integrity, and overgrazing generally in many of the catchments. This is most evident in some of the communal farming areas associated with the old Transkei and Ciskei homelands, and in the Q, S and T primary catchment areas, and where geologically this appears to have been exacerbated (broadly north of Craddock and Tarkastad and up to Middleburg). In many urban and associated areas, there is also evidence and impacts associated with informal/artisanal and formal sand mining operations within the rivers and RZs.

The net result of much of this pressure is the increased sediment (and total suspended solids) loads, and increased turbidity of the water associated with larger rainfall events. Having said this though, some of the shorter rivers associated with the Pondoland river system (primary T catchment, and associated with a different geology, the Natal Group Sandstones) are still surprisingly intact, with low anthropogenic pressures, limited geological drivers of higher TDSs, and as a result exhibit good water quality.

2.1.2 Integrity of the riverine ecosystems

In accordance with DWS, 2014, the PES of the river systems throughout the study area are primarily moderately modified (Category C) or largely natural with few modifications (Category B) (Table 2-3 and Table 2-4). Less than 1% and 10% of the rivers within the whole study area fall within a seriously (Category E) or critically (Category F) modified state respectively. Therefore, it is of vital importance to continue to preserve, maintain and manage these systems going forward to ensure these water resources do not further degrade from an ecological perspective, from continuous catchment pressures and future planned demands.

Refer to Table 2-5 for a detailed analysis of the ecological states of the varying river systems within each primary catchment in the study area.

Table 2-3: High level summary of the overall PES and the percentage thereof of the rivers throughout the study area

PES (DWS, 2014)	Length (m)	%
PES A	572 513.77	1.79%
PES B	10 475 346.19	32.79%
PES C	13 474 990.40	42.17%
PES D	4 182 072.88	13.09%
PES E	218 665.37	0.68%
PES F	2 954 640.15	9.25%
Data Deficient	72 762.48	0.23%
TOTAL	**31 950 991.24**	

Many of the river reaches which have a PES Category A (natural, near pristine) or B (largely natural with few modifications) (Table 2-4) occur within conservation areas, and any future human manipulation of these reaches or in adjacent catchments, would require very strong motivation within this study area.

Table 2-4: Varying river reaches within quaternary catchments categorized as either PES A or B through the study area

Primary Catchment	Within the following quaternary catchments
K	K80A-D, K90C-D, G
L	L11A-G, L12A-D, L21A—B, D-F, L22A-D, L23A-D, L30B-D, L40A-B, L50A-B
M	M10C
N	N11A-C, N13A-D, N21B-D, N22A-E, N23A, N24B-D, N30A-C, N40A-E
P	P10B, D-G, P20A-B, P30B, P40B-D
Q	Q11A-D, Q12A-C, Q13C, Q14A-C,E, Q21A-B, Q22A-B, Q30A-D, Q41A-B, D, Q42A-B, Q44A-C, Q50A-B
R	R10D, R20A, R30A-C, R40A, R50A-B
S	S10H, J, S20B, S31B,D-E, S32A-B, D-E, L-M, S40B-C, E-F, S50A-C, J, S60D, S70F
T	T11A-B, D, T12A, T13C-E, T60A-H, J-K, T70A-D, F-G, T80A-B, D, T90A-G

The exception lies within primary catchments M (Algoa) and K (Tsitsikamma). More than 50% of the rivers within the former primary catchment and 28% of the rivers within the latter catchment are largely modified (Category D), which is of concern. This is largely due to anthropogenic activities and other catchment pressures and impacts described above in section 2.1. Overall, the PES, along with current and more updated retrieved Ecological Category data, will aid in determining the ecological flow requirements for these catchments and the REC.

Table 2-5: Total percentages of the PES categories for all river systems within each primary catchment throughout the study area

PES (DWS, 2014)	Catchment "T" Mbashe		Catchment "S" Great Kei		Catchment "R" Keiskamma		Catchment "Q" Great Fish		Catchment "P" Bushmans		Catchment "N" Sundays		Catchment "M" Algoa		Catchment "L" Gamtoos		Catchment "K" Tsitsikamma	
	Length (m)	%	Length (m)	%	Length (m)	%	Length (m)	%	Length (m)	%	Length (m)	%	Length (m)	%	Length	%	Length	%
A	115 853.62	2.44%	28 283.17	0.56%	29 693.28	1.36%	30 419.23	0.45%	9 627.68	0.59%	67 828.39	1.54%	6 935.16	1.40%	283 873.22	4.74%	0.00	0.00%
B	2 139 344.65	44.99%	821 554.96	16.27%	411 698.87	18.81%	2 185 214.78	32.50%	523 832.96	32.22%	1 513 933.13	34.35%	0.00	0.00%	2 745 407.05	45.83%	134 359.79	18.91%
C	1 896 245.24	39.88%	2 390 284.11	47.33%	1 146 543.19	52.39%	2 691 491.93	40.03%	632 480.06	38.90%	1 662 594.90	37.72%	107 335.80	21.62%	2 759 548.16	46.07%	188 467.02	26.52%
D	446 807.59	9.40%	1 345 560.97	26.64%	436 305.37	19.94%	745 782.93	11.09%	164 811.16	10.14%	415 833.72	9.43%	248 946.08	50.14%	176 695.01	2.95%	201 330.04	28.33%
E	47 602.95	1.00%	47 785.87	0.95%	5 322.66	0.24%	75 873.62	1.13%	0.00	0.00%	9 160.27	0.21%	20 095.00	4.05%	12 136.26	0.20%	688.75	0.10%
F	108 864.06	2.29%	416 493.81	8.25%	158 722.65	7.25%	995 416.48	14.80%	295 233.82	18.16%	738 242.25	16.75%	43 834.11	8.83%	12 136.26	0.20%	185 696.72	26.13%
Data Deficient	176.60	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	0.00	0.00%	69 352.11	13.97%	3 233.76	0.05%	0.00	0.00%
TOTAL	**4 754 894.72**		**5 049 962.89**		**2 188 286.03**		**6 724 198.97**		**1 625 985.67**		**4 407 592.66**		**496 498.26**		**5 989 795.96**		**710 542.32**	

**Grey shaded areas indicate the dominant PES category per secondary catchment.*

2.2 Major dams and transfer schemes

A number of large dams and transfers between catchments are present within the study area of significance is the water that is transferred into the study area from the Gariep Dam (Upper Orange) to the upper reaches of the Great Fish River (Grassridge Dam) mostly for irrigation and domestic use within the Great Fish River catchment. Further to the latter is the transfer of water to the Algoa System for domestic water use. These transfers and dams provide water for domestic, industrial and irrigation water use. There are numerous other smaller dams within the catchment, mainly for irrigation and local domestic and rural water use purposes. The effects of the numerous dams and transfers on the water resources in the study area, have impacted on the wellbeing of the water resources health. The larger dams in the study area are listed in Table 2-6 below and Appendix B, Figure 11-2 to Figure 11-6.

Table 2-6: Larger storage dams characterising the study area

Dam	Associated River	Catchment	Volume (MCM)
A. K80, K90, L10 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Koega and Swartkops)			
Impofu	Krom	K90	87.0
Kromriver (Churchill)	Krom	K90	32.0
Beervlei	Groot	L30	90.0
Kouga	Kouga	L82	128.0
Haarlem	Haarlemspruit	L82	4.7
Loerie	Loerie	L90	3.17
Groendal	Swartkops	M10	12.3
Bulkrivier	Tributary of Elands	M10	0.65
Sand River	Sand	M10	2.67
Van Stadens	Van Stadens	M20	0.37
B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)			
Nqweba (Van Ryneveld Pass)	Sundays	N10	47.0
Darlington	Sundays	N20	187.0
Nuwejaars	New Years	P10	4.5
Howisonpoort	Palmiet	P30	0.8

Dam	Associated River	Catchment	Volume (MCM)
Settlers	Kariega	P30	5.57
C. Q10 to Q90 (Great Fish)			
Grassridge	Groot Brak	Q10	49.6
Lake Arthur	Tarka	Q40	10.95
Kommandodrift	Tarka	Q40	55.7
Elandsdrift	Great Fish	Q50	9.7
De Mistkraal	Little Fish	Q80	3.1
Katrivier	Kat	Q90	24.8
Glen Melville	Off-channel	Q90	6.13
D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei)			
Sandile	Keiskamma	R10	30.9
Cata	Cata	R10	12.1
Binfield	Tyume	R10	36.8
Laing	Buffalo	R20	21.0
Rooikrantz	Buffalo	R20	4.9
Bridle Drift	Buffalo	R20	101.7
Nahoon	Nahoon	R30	20.7
Xonxa	White-Kei	S10	126.0
Lubisi	Indwe	S20	135.0
Doringrivier	Doring	S20	17.84
Waterdown	Klipplaat	S30	36.6
Bonkolo	Komani	S30	6.95
Oxkraal	Oskraal	S30	17.8
Ncora	Tsomo	S50	120.0

Dam	Associated River	Catchment	Volume (MCM)
Tsojana	Tsojana	S50	9.35
Gubu	Gubu	S60	8.8
Wriggleswade	Kubusi	S60	91.2
Gcuwa	Gcuwa	S70	0.9
Xilinxa	Xilinxa	S70	14.5
E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems) Major storage dams			
Umtata	Mthatha	T20	228.0
Mabeleni	Mhlahlane	T20	2.0
Corana	Corana	T20	0.71
Mlanga	eMhlanga	T70	1.53

With regards to future proposed dams and water transfers, the DWS are investigating such options and thus will be covered by the Development of a reconciliation strategy (Algoa and Amathole systems) for S60 (Kubusi), R20 (Buffalo), R30E and R30F (Nahoon), K80, K90 Krom and Tsitsikamma, M10, M20, M30 (Koega and Swatkops), N40 (Lower Sundays downstream of Darlington Dam).

It is vital, that the above mentioned and considering the main future development options, that these are assessed to measure if the REC can continue to be met going forward.

2.3 Wetlands

There are 12 sub-catchments within the overall study area, of which the Kei, Mbashe, Tsitsikamma and Fish hold the largest areas of known wetlands (Table 2-7). The 12 sub-catchments provide broad management units within which wetland prioritisation and assessment can begin to be undertaken. A brief overview of wetlands and their ecological condition are given for each sub-catchment (Table 2-8), following a few key trends across these catchments that were identified.

Table 2-7: Area[1] of wetland per sub-catchment

Catchment	Sub-catchment	Primary catchment	Hectares	%
Fish to Keiskamma	Gamtoos	L	1274	4.2
	Sundays	N	899	3.0
	Fish	Q	3,296	10.9

Catchment	Sub-catchment	Primary catchment	Hectares	%
	Tsitsikamma	K	3,236	10.7
	Algoa	M	2,357	7.8
	Bushmans	P	634	2.1
Mzimvubu to Keiskamma	Kei	S	9,329	30.9
	Amatola	R	1,827	6.1
	Mbashe	T	4,304	14.3
	Mtata	T	1,102	3.7
	Wild Coast	T	1,913	6.3
Grand Total			**30,171**	**100**

[1]*Area of wetland was determined based on National Wetland Map 5 (NWM5), but supplemented with additional information for the Gamtoos, Sundays and Wild Coast, where a high level of under-mapping was confirmed.*

Table 2-8: Descriptions of the wetlands per sub-catchment

Wetlands per sub-catchment	
Gamtoos	
Although one of the largest sub-catchments, only about 170 wetlands systems have been identified within the Gamtoos area, totalling 1274 ha of wetland habitat. The majority of the wetland extent is either an A or B (natural to largely natural) PES category (86%). Channelled and unchannelled valley-bottoms and depression wetland HGM units (Figure 2-1 and Figure 2-2) cover the largest extent within the sub-catchment. Of the four bioregions in this sub-catchment, including the Albany Thicket, Eastern Fynbos-Renosterveld Bioregion, Lower Karoo Bioregion, and Upper Karoo Bioregion, the latter two dominate. Within the upper Karoo, the wetlands are concentrated in a few localized areas mainly within the highest altitude areas, predominantly in the Sneeuberg portion of the Great Escarpment, which corresponds with the highest mean annual precipitation (MAP) areas of the catchment. It is here also that the few extensive hillslope seepage areas occurring within the sub-catchment are confined. The limited Strategic Water Source Areas (SWSAs) present within the Gamtoos catchment do not correspond with any of these known concentrations of wetlands, but this will be investigated further. Since the localized concentrations of high-altitude wetlands referred to above were absent from the wetland layer in the NFEPA assessment of Nel *et al.* (2011), their conservation status was not assessed, but given their context in an otherwise much drier landscape, it is anticipated that they should be afforded a relatively high conservation status.	 **Figure 2-1:** A very narrow channeled valley bottom wetland in a confined section of valley in Gamtoos catchment headwaters, characterized by the sedge, Pseudoschoenus inanus, and with scattered trees of the invasive alien crack willow, Salix fragilis

Wetlands per sub-catchment

Figure 2-2: A typical depression wetland in the Gamtoos catchment, which is naturally unvegetated and ephemerally flooded

Sundays

This sub-catchment is one of the largest, but only 231 wetlands were identified, covering a wetland area of only 899 ha. The majority of the wetlands fall within the A or B PES category. The most common HGM units are depression wetlands (58%), and a combination of channelled valley-bottom and depression wetlands make up the majority (96%) of the wetland area. Unlike the Gamtoos, seepage slope wetlands are rare and confined to a few localized high-altitude areas of the Great Escarpment (Figure 2-3). Five bioregions are located within this sub-WMA, including Albany Thicket, Dry Highveld Grassland Bioregion, Eastern Fynbos-Renosterveld Bioregion, Lower Karoo Bioregion and Upper Karoo Bioregion, with Albany Thicket covering the majority of the wetlands within the sub-WMA.

Wetlands per sub-catchment

The upper reach of the sub-WMA is associated with the Eastern Upper Karoo Groundwater SWSA, highlighting an important water resource area within this portion of the sub-catchment. There are surface water SWSAs. Where wetland-specific information was available regarding the conservation status of the wetlands within this sub-catchment, roughly 35% of the wetlands have been categorised as critically endangered ecosystems with no protection, 29% are endangered with poor protection, 31% have been considered to be of least concern and only 5% have been marked as vulnerable.

Figure 2-3: An extensive high altitude (1834-1933 m) hillslope seep wetland in the Sundays River catchment on a southern slope in the Sneeuberg mountains, dominated by the tall hydric grass, *Merxmuellera macowanii*

Fish

This sub-catchment is another one of the larger catchments within the overall study area, and contains a total of 3,296 ha of wetland. Again, the majority (87%) of the wetlands are systems with an A or B PES category. Most of the wetlands are depressions or channelled valley-bottom wetland HGM unit types. There are a total of eight bioregions, including: Albany Thicket; Drakensberg Grassland Bioregion; Dry Highveld Grassland Bioregion; Eastern Fynbos-Renosterveld Bioregion; Lower Karoo Bioregion; Sub-Escarpment Grassland Bioregion; Sub-Escarpment Savanna Bioregion; and Upper Karoo Bioregion.

Wetlands per sub-catchment
The majority of the wetland systems (33%) are located within the Upper Karoo Bioregion, which mostly dominates the upper reaches of this sub-catchment and accounts for 55% of the overall wetland area. The Drakensberg Grassland Bioregion is the next most common. Majority of the wetlands identified within the sub-catchment (41%) have been categorized as critically endangered and are either poorly or not protected; with 23% being regarded as endangered with little to no formal protection. With over 60% of the wetlands within the sub-catchment being categorized as being endangered with little protection, it is likely that the wetland condition within this sub-catchment will continue to decline over the years. The upper north-eastern wedge of the sub-WMA has been categorized as a groundwater SWSA, making this small portion an important water resource area.
Tsitsikamma
Although being one of the smallest sub-catchments, the identified wetlands (278 wetland systems in total) cover a relatively extensive wetland area of 3,236 ha. The PES scores of the wetlands are fairly equally spread out across the scores between A-E, with tree plantations and cultivation being the primary land-uses accounting for those wetlands scoring low in terms of PES. The dominating HGM unit types are channelled valley-bottom and depression wetland systems, but the channelled and unchannelled valley-bottoms cover the largest areas of 44% and 34% respectively. The Tsitsikamma sub-area includes the Albany Thicket and the Eastern Fynbos-Renosterveld bioregions, with the latter dominating the majority (87%) of the wetlands and covering the highest wetland area (87%). A large proportion of the sub-catchment has been flagged as a surface water SWSA, making this sub-WMA an important water resource unit. According to the vegetation and wetland data, up to 53% of the wetlands have been categorized as critically endangered, with little to no formal protections, whilst 35% of the wetlands have been categorized as vulnerable to moderate to poor protection. With a large proportion of this sub-catchment being an important SWSA, and a high percentage of wetlands being critically endangered and vulnerable, opportunities for wetland protection and enhancement should be reviewed.

Wetlands per sub-catchment

Algoa

Overall, there are 2,357 ha of wetland habitat mapped within this sub-catchment, which is made up mostly of wetlands within a A, B and F PES categories, with urban-related land-use and intensive commercial agricultural operations primarily accounting for the wetlands scoring lowest in terms of PES. In addition, the main wetland types found within this region are depression and channelled valley-bottom wetland systems. The majority (48%) of the wetlands are located within the Albany Thicket bioregion, covering an area of 1,881 ha; whilst most of the remaining wetlands are located within the Eastern Fynbos-Renosterveld Bioregion, Seashore Vegetation and the Sub-Escarpment Savanna Bioregion. Depressions/flat wetlands and seepage wetlands are the most common wetland HGM unit types found within the sub-catchment.

A great proportion of the sub-catchment is characterised by both surface and groundwater SWSAs, which overlap slightly towards the middle of the sub-catchment. Due to the extensive coverage of SWSAs within this catchment, this area is extremely important in terms of water resource protection. With up to 50% of the wetlands within this sub-catchment being categorized as vulnerable and 17% critically endangered, the need to prioritise important wetlands for protection should become a priority within the near future.

Bushmans

The Bushmans sub-catchment is small relative to the majority of the areas, and the known extent of wetland (634 ha) is also relatively low. The majority of the wetlands are either natural or largely natural (68%) systems, with very few having been categorized below a C PES category. Most of the wetlands are of the depression HGM type.

Wetlands per sub-catchment

Three bioregions are represented, namely: Sub-Escarpment Savanna Bioregion, Eastern Fynbos-Renosterveld Bioregion and Albany Thicket, with the latter dominating the majority of the sub-catchment. A very limited areas within this sub-catchment has been earmarked as a surface water SWSA, however up to 85% of the wetlands within this catchment have been declared endangered with little formal protection. As such, these water resources are at risk of continued degradation should conservation efforts not be employed in the coming years.

An example of an unchanneled valley-bottom wetland and incorporating a depression wetland located within the Bushmans sub-WMA, is illustrated in Figure 2-4.

Figure 2-4: An example of a wetland type located within the Bushmans sub-WMA, which has been categorized as an unchannelled valley-bottom wetland incorporating a depression wetland

Kei

Within the Kei sub-catchment, 1,190 wetlands have been identified, covering an area of 9,329 ha of wetland habitat, which is much larger than any of the other sub-catchments included in the overall study area. Although seepage slopes and channelled valley-bottom wetlands cover the largest area of wetlands, a wide variety of HGM types are represented (Figure 2-5).

Wetlands per sub-catchment

With regards to the wetland PES, 86% of the systems are between a PES score of A to C. There are five identified bioregions, including: Drakensberg Grassland Bioregion, Dry Highveld Grassland Bioregion, Indian Ocean Coastal Belt Bioregion, Sub-Escarpment Grassland Bioregion and Sub-Escarpment Savanna Bioregion, with the latter two making up about 98% of the wetland extent in the sub-WMA. The Drakensberg Grassland Bioregion is mostly associated with the Drakensberg Escarpment, and is characterized by relatively high MAP and relatively low temperatures.

The Kei sub-WMA has limited presence of surface and groundwater sub-WMAs, occurring mostly along the boundaries of the sub-WMA. Majority of the identified wetlands within this sub-WMA have been categorized as endangered (41%), receiving a mixture of moderate to no protection, with 27% of the wetlands being considered least concern from a conservation perspective.

Figure 2-5: An unchannelled valley-bottom wetland (left) and a pan/depression wetland (right) found within the Kei sub-catchment (photograph courtesy of Matt Janks)

Wetlands per sub-catchment

Amatola

Overall, there are three different bioregions found within this sub-catchment, including: Albany Thicket; Drakensberg Grassland Bioregion; and Sub-Escarpment Savanna Bioregion. The majority of the wetlands are located within the Sub-Escarpment Savanna Bioregion (59%), followed by the Drakensburg Grassland and Albany Thicket bioregions. Of the 1,827 ha of wetland habitat located within this sub-catchment, about 79% of the total area of wetland are considered to have a PES between natural to moderately modified, i.e. with the PES scores ranging from A-C. Channelled valley-bottoms and seepage wetlands (Figure 2-6) are the most common wetland HGM unit types. The Amatola sub-catchment has eight main dams within the region, with the largest of them being the Bridle Drift Dam, located roughly 20 km inland of East London, one of the main drinking water supply dams for Buffalo City. Wetlands in the catchments where dams are considered to be particularly important, especially in terms of their water quality regulation and flood attenuation function.

The Amatola sub-WMA is one of the smaller sub-WMAs, with the northern and north-eastern boundaries being categorised with both ground and surface water SWSAs, whereby the surface water strategic areas are more prominent than the ground water. According to the wetland data available for this area, over 70% of the wetlands within this area are considered to be either critically endangered/ endangered, with only 14% of the systems categorized as least concern. This

Figure 2-6: A seepage wetland within the Amathola sub-catchment (Photograph courtesy of Matt Janks)

Wetlands per sub-catchment	
highlights the need to protect these systems in the future to avoid the loss of additional wetland habitat.	
Mbashe	
Within the Mbashe sub-catchment, which is a relatively small area, a total of 683 wetland systems and 4,304 ha of wetland have been identified. Eighty six percent of the wetlands range between a B to E PES category; showing that the majority of the wetlands within this region range from largely natural to seriously modified. In addition, the most common types of wetlands are seepage wetlands and channelled valley-bottom systems, making up 66% of the overall wetland coverage. Five bioregions occur, including: Albany Thicket; Drakensberg Grassland Bioregion; Indian Ocean Coastal Belt Bioregion; Sub-Escarpment Grassland Bioregion; and Sub-Escarpment Savanna Bioregion, with the latter accounting for roughly 68% of the total wetland area (Figure 2-7). With up to 60% of the wetlands within this sub-WMA having been characterised as critically endangered, and a large proportion of the sub-WMA having been identified as surface and ground water SWSAs, the need to protect these water resources should be made a priority in long-term strategic planning.	 **Figure 2-7:** A hillslope seep wetland located within the Sub-Escarpment Grassland bioregion in the Mbashe sub-catchment

Wetlands per sub-catchment

Mtata

Mtata sub-catchment, which is another fairly small area, has 323 wetland systems identified, covering 1,102 ha. The PES scores are fairly evenly spread out across the various PES categories, with the majority of the systems within the B, C and E PES categories. Three bioregions occur, including: Indian Ocean Coastal Belt Bioregion; Sub-Escarpment Savanna Bioregion; and Sub-Escarpment Grassland Bioregion. With the latter being the most extensive. Channelled valley-bottom wetlands cover the highest area (59%) and the greatest number of wetlands (37%) (Figure 2-8).

A large proportion of this sub-WMA has been categorized as surface water SWSAs, with smaller areas having been identified as groundwater SWSAs. With such a large area characterised as SWSAs, the need to protect and enhance these water resources should be defined as a high priority. In addition, over 50% of the identified wetlands have been regarded as being critically endangered, with little to no protection; further driving the need to protect these wetland systems where possible.

Figure 2-8: An unchannelled valley-bottom wetland in the Mtata sub-catchment, located near Qunu

Wetlands per sub-catchment

Wild Coast

The Wild Coast sub-catchment, which is one of the smallest areas, includes 1,913 ha of known wetland habitat. Many of the wetlands have been categorised as having a PES between a C and D category, which translates into wetland systems that are moderately transformed. Most of the wetlands have been identified as channelled valley-bottom wetlands, however, unchannelled valley-bottom wetland systems cover the highest area of wetland within the sub-catchment. Three bioregions are located within the Wild Coast sub-catchment, including: Sub-Escarpment Grassland Bioregion; Sub-Escarpment Savanna Bioregion; and Indian Ocean Coastal Belt Bioregion, with the majority of the wetlands falling within the latter.

The entire Wild Coast sub-WMA has been categorized as a surface water SWSA, with the western boundary also being a ground water SWSA. This makes the sub-WMA an extremely important area in terms of water resources; whilst 43% of the identified wetlands have been categorized as critically endangered from a conservation perspective. The state of the wetlands within this sub-WMA and the coverage of SWSAs across its entirety, the importance of protecting the water resources within this area is well noted.

Figure 2-9: An unchannelled valley-bottom wetland, located inland of Mkambati Nature Reserve in the Wild Coast sub-catchment

2.3.1 *A few key trends across the sub-catchments*

Wetland occurrence in relation to SWSAs: strategic water source areas (SWSAs) have been identified within all of the relevant study site sub-WMAs, with the ground and surface water coverages within each sub-WMA differing quite substantially. Overall, surface SWSAs dominate the more eastern, coastal reaches of the study site, whilst the ground water SWSAs were noted more inland, along the north-western study site boundary, with scattered areas along the coastal sub-WMAs. Especially in the case of the surface water SWSAs, the occurrence of wetlands within these areas was notably higher than those areas that were not considered important SWSAs. As such, the presence of these SWSAs within the various sub-WMAs are good initial indicators for increased areas of wetland habitat.

Wetland occurrence in relation to the aridity gradient: The hinterland of the overall study area extends broadly across a strong aridity gradient, being generally most arid in the west and becoming progressively less arid as one moves eastwards. In the extreme west, in the Gamtoos sub-catchment, the MAP is <400 mm for most of the area, with some portions even being < 200 mm MAP. This is followed by the Sundays sub-catchment, where the MAP is also predominantly <400 mm, but areas where MAP is 400-600 mm are slightly more extensive than in the Gamtoos. The Fish, where the area has <400 mm MAP, are still extensive, and the Kei with predominantly 400-800 mm MAP. East of the Kei, MAP is predominantly >800 mm, exceeding 1000 mm in extensive portions.

Such a wide gradient has important implications for wetland occurrence given that hydrology is a primary driver of wetlands. It is therefore not surprising that in the predominantly arid western sub-catchments (Gamtoos and Sundays) the total extent of wetlands is relatively low, but more to the east (i.e. in the Fish sub-catchment) it increases noticeably, further increasing in the next major sub-catchment (i.e. the Kei).

The coastal areas of the study area show a different pattern to the hinterland, with MAP being relatively high in the west (Tsitsikamma), declining in the Algoa and Bushmans sub-catchments then increasing again thereafter. Thus, it is not surprising that the Tsitikamma sub-catchment, where, although confined to a narrow coastal hinterland strip, has a relatively high wetland extent relatively to the overall small size of this area.

Some of the eastern sub-catchments, while having wetland extents that are higher than in the western hinterland, are lower than expected, given the high MAP and topography which is not very steep. Of note here are the Mtata and Wildcoast sub-catchments. In a known verified field area in the Wild Coast sub-catchment of 4097 ha inland of Mkambati Nature Reserve, 53 wetlands (totalling 385 ha) were encountered with none of these wetlands mapped in NWM5, suggesting considerable under-mapping for this catchment. A similar level of under-mapping is suspected for the Mtata sub-catchment, but this requires confirmation.

Extent of wetlands compared with the Mzimvubu: It is interesting to note that the total extent of wetlands in the combined 12 sub-catchments (30,171 ha) is considerably less than the 50,971 ha of wetlands in a single nearby sub-catchment, the Mzimvubu, which is not part of the study. This is possibly owing in particular to a lack of the very broad, gently sloped valley bottoms which are widespread in the Mzimvubu catchment and support some very large floodplain/valley bottom wetlands, largely absent from the study area.

Present ecological state in relation to land-use and the aridity gradient: The greatest proportion of wetlands in a D, E and F category was found in the Tstitsikamma sub-catchment, where high impact, land-uses associated with cultivation and plantation forestry are extensive, followed by Algoa sub-catchment, where high impact urban/industrial land-uses are extensive. Field verified assessments such as Hugo (2011), Tuswa (2016) and Larson (2019) suggest that the general land cover-based proxies used to derive the PES categories of wetlands in these sub-catchments are reasonable.

Wetlands least impacted in the three major arid to semi-arid sub-catchments (i.e. Gamtoos, Sundays and Fish), where most wetlands were placed in an A or B (natural to largely natural). While this may be a reasonable approximation, it should be acknowledged that certain impacts are poorly represented in the land-cover map used for the assessment, particularly those within areas mapped as natural vegetation. Studies such as Hoffman *et al.,* (1999) and Boardman *et al*., (2003) document widespread and extremely heavy livestock utilization of the natural vegetation in the Karoo from around 1900 through to the 1960s, leading to widespread degradation of the vegetation, in particular in the valley bottoms, where most of the naturally vegetated wetlands are located. Therefore, it is anticipated that a field-based assessment of the PES, would reveal that some of the wetlands in the arid to semi-arid sub-catchments, which are mapped with predominantly natural vegetation in the wetland and catchment, would have a somewhat lower PES category that what was assigned based on desktop assessment alone. Undertaking this important verification and adjustment requires further investigation.

2.4 Groundwater

The major aquifer systems associated with the Cape and Karoo Supergroups are mainly of a fractured type, where groundwater occurrence is as a result of secondary deformation relating to faults, fissures, fractures, bedding planes and joints (Appendix C, Figure 11-7). The Karoo Supergroup also constitutes a fractured and intergranular aquifer over widespread areas associated with intrusive and extrusive igneous rocks, i.e. dolerite sills and dykes and well as basalt. The Quaternary sand and alluvium constitute limited intergranular aquifers in the study area where groundwater occurrence is as a result of pore spaces between sand particles. Borehole yields in the fractured aquifers vary greatly depending on the lithological unit intersected during drilling and the arenacous: argillaceous ratio within the respective lithological units.

Groundwater quality is generally good over most parts of the catchment areas (Appendix B, Figure 11-8). The exceptions are found along parts of the coast and at some inland locations where the recharge is low and the geology is not favourable (Appendix C, Figure 11-9).

Several stressed quaternary catchments have been identified in the area where the estimated groundwater use exceeds the estimated groundwater recharge (Appendix C, Figure 11-10).

2.5 Estuaries

There are 251 coastal drainage systems within the Keiskamma, Fish to Tsitsikamma study area, comprising 154 estuaries and a further 97 microsystems. The latter are a relatively new category of estuary which accounts for very small systems (<2 ha, or <200m length) (Van Niekerk, *et al.,* 2020). There is insufficient data on many of these microsystems, and are therefore not considered further in this study. Refer to Appendix B, Figure 11-2 to Figure 11-6 which illustrates the various estuaries throughout the study area.

The estuaries are spread over two marine biogeographic areas, namely the Warm Temperate (98 estuaries) and Subtropical (56 estuaries) bioregions, each characterised by unique marine biophysical features and biological communities. These characteristics in turn influence coastal and estuarine ecosystem function and processes, community composition and distribution. The new South African estuaries classification system identifies nine different types of estuaries (Van Niekerk *et al.,* 2020). Within the study area, there are five different types of estuaries in the Warm Temperate bioregion, and four types in the Subtropical bioregion. In the Subtropical bioregion, the majority of the systems are small and temporarily open/closed (57%), yet in the Warm Temperature bioregion, there is almost equal proportion of small (39%) and large temporarily closed (35%) systems. These systems are disconnected from the ocean by a sand bar for varying periods of time and the closed phase constitutes a critical period of growth and high productivity in the River-estuary interface zone (REIZ) for the residing biota. Large fluvially dominated systems are rare (1%), with only one in each bioregion represented by the Great Kei (WT) and the Mbashe (ST) systems. These systems are mostly open throughout the year yet experience generally low salinities as a result of the dominant river processes, as well as high sediment turn-over.

In terms of the current health status, 65% to 75% of estuaries are in the Warm Temperature and Subtropical bioregions, respectively, and are in a near to largely natural condition with few modifications (Category A/B to B) (Van Niekerk *et al.,* 2020). These systems retain much of their natural functioning, habitat and biota. Approximately 5% of the estuaries in the study area are in heavily to critically modified state (Category D or lower), indicating that they have experienced a major shift in natural processes and function, and where a significant loss of biota and habitat has occurred. These systems are all located within the Warm Temperate bioregion, and their degraded state is associated with dense urban development, severe modifications and high to very high cumulative pressures, e.g. Papkuils, Baakens, Coega, Swartkops, Seekoei, Kromme, Buffalo, and Blind (Van Niekerk *et al.,* 2020).

The biodiversity importance of estuaries is based on individual assessments of size, type rarity, habitat biodiversity and biotic diversity (Turpie and Clark, 2007). Only 27% of the estuaries in the study area are ranked as being important to highly important in terms of the biodiversity they support, and most of these are located in the Warm Temperate bioregion. Nonetheless, nearly half (48%) are included in the national list of priority systems requiring protection to achieve national estuarine biodiversity targets (Van Niekerk, *et al.,* 2019). The majority of these are systems of low to average importance (61%) indicating the collective importance of these 'lesser' estuaries in protecting the country's estuarine resources. Furthermore, 25 systems in the Warm Temperature bioregion are adjacent to a Marine Protected Area, such as the Tsitsikamma, the Great Kei and the Pondoland Marine Protected Areas (MPAs) (Van Niekerk, *et al.,* 2019). Preserving the functioning of these systems is paramount as they contribute to the functioning and success of the MPAs through abiotic inputs, such as nutrients and detritus, but also by providing additional habitat, and sheltered environments for estuarine dependent marine species.

When considering the threat status of estuaries (Van Niekerk, *et al.,* 2019), 16% of all the systems in the study area are considered Endangered, that is, systems where a substantial portion of their natural extent has been modified. All of these are located in the Subtropical bioregion and comprise several estuary types, including large fluvially dominated (1), large temporarily closed (13) and predominantly open (10) estuaries. Given that the Mbashe Estuary is the only large fluvially dominated system in the Warm Temperature bioregion, which is categorized as Endangered, as it is still in a largely natural condition (Van Niekerk, *et al.,* 2019). Preserving this system should be the focus of resource planning and management for the region to prevent the loss or degradation of this rare estuarine type. Vulnerable systems that still have most of their original extent remaining in natural or near-natural condition make up 55%, while 29% are considered of Least Threatened (Van Niekerk, *et al.,* 2019).

Lastly, there are areas that are highly dependent on only ground water. This will further be verified during the following Gap Analysis phase of the study.

2.6 Natural, cultural and ecological important areas

The biodiversity within the Keiskamma and Fish to Tsitsikamma catchment study area is diverse in all its forms and all its interactions. It comprises eight (8) of South Africa's nine (9) biomes, in accordance with Mucina and Rutherford, 2006. These include:

- Indian Ocean Coastal Belt;
- Albany thicket;
- Grassland;
- Savannah;
- Nama-karoo;
- Fynbos (southern end of the study area);
- Succulent Karoo (southern end of the study area); and
- Forest (small patches within Tsitsikamma sub-catchment).

The study area encompasses a range of biodiverse, conservation, national parks, nature reserves, protected areas and heritage sites, all resulting in high tourism (economic gain) within the study area. These include *inter alia (*Appendix D, Figure 11-11):

- National Parks (Addo Elephant, Tsitsikamma, Garden Route, Mountain Zebra);
- Provincial Nature Reserves (Mkambati, Hluleka, Dwesa-Cwebe, Hamburg, Great Fish, Mpofu, Groendal, Baviaans Kloof, Formosa, Doubledrift);
- Private Nature Reserves (Black Eagle Nature Reserve);
- World Heritage Sites (Primary Catchment L includes portion of the Cape Floral Region); and
- Threatened Ecosystems (2011) (includes Langkloof Shael Renosterveld (CR), Albany Alluvial Vegetation (EN), Mount Thesiger Forest Complex (EN), Algoa Sandstone Fynbos (VU), Mthatha Moist Grassland (VU), Ngongoni Veld (VU), Transkei Coastal Forest (VU), Mthatha Moist Grassland (VU) and some Midlands Mistbelt Grassland (VU).

Critical Biodiversity Areas (CBA) are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as per biodiversity plans. Ecological Support Areas (ESA) are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of CBA and/or in delivering ecosystem services. These areas must be safeguarded in their natural or near-natural state owing to their importance and critical use for conserving biodiversity and maintaining ecosystem functioning (Driver *et al.,* 2012). Refer to Appendix D, Figure 11-11 which illustrates which CBA overlays the river systems in relation to the study area, along with descriptions. Much of the study area is categorized as Ecological Support Areas (ESA). Most of the protected areas lie within sub-catchments Q (i.e. Mountain Zebra National Park and Great Fish River Nature Reserve), N (i.e. Camdeboo National Park and Addo Elephant National Park), P and L (i.e. Baviaanskloof Nature Reserve and Formosa Provincial Nature Reserve). Critical Biodiversity Areas one and 2 predominantly lying-in sub-catchment S and northern parts of L, amongst other areas (Appendix D, Figure 11-11).

All water resource and future development and utilisations should take cognisance of these sites to ensure that activities do not threaten the integrity of these areas. This consideration is particularly pertinent where water resource development activities impact on the supply of water resources to these areas and hence their long-term ecological sustainability.

According to the current National Freshwater Ecosystem Priority Areas project, approximately 18% of the study area is categorized as riverine Freshwater Ecosystem Priority Areas (FEPAs), while 11% of the study area is categorized on the basis of supporting areas for fish species (i.e. as either fish support areas or as fish movement corridor) (Appendix D, Figure 11-12). A further 21% of the study area is categorized as Upstream Management Areas, while an additional 4% is categorized as Phase 2 FEPAs. Additionally, over 50% of the river reaches present within the study area are considered to be either Critically Endangered or Endangered according to the latest National Biodiversity Assessment (NBA, 2018), while several coastal river systems, and particularly those of the Mbashe, Mthatha and Wild Coast systems, are considered to be free-flowing rivers, with the Kobonqaba, Nqabarha, Mtakatye and Mtentu rivers categorized as Flagship rivers based on their representativeness of free-flowing rivers across the country, as well as their importance for ecosystem processes and biodiversity value.

The study area also extends across several freshwater ecoregions, including the Southern temperate Highveld, Amatolo-Winterberg Highlands, the Zambezian Lowveld, Karoo and the Cape Fold freshwater ecoregions. Consequently, the study area supports an array of fish fauna that display diverse affinities in most sub-catchments (Appendix D, Figure 11-12).

At least 30 naturally occurring indigenous fish species have been collected within the study area, with a further 11 alien species known to be present. In addition, various extralimital indigenous fish species also occur within the study area, some with native ranges within the study area but which have expanded their range as a result of translocations for various purposes such as angling, pest control, etc. Nevertheless, fish sanctuaries for at least 15 indigenous fish species as well as their catchment support areas have been designated as part of the National Freshwater Ecosystem Priority Areas project, many of which are associated with the Amatolo-Winterberg Highlands and the Cape Fold freshwater ecoregions.

The use of molecular data in taxonomic research has resulted in the discovery of new species and several historically isolated lineages within many groups of freshwater fishes that were previously considered to be single wide-ranging species. This is particularly true for the Cape Fold freshwater ecoregion in South Africa where new species, unique lineages and taxonomic conflicts have been discovered in various groups of fishes, with several new species located within the study area having been only recently described while others still remain to be described. Consequently, many of the naturally occurring indigenous fish species associated with the study area are listed as being of conservation concern and/or data deficient, with approximately 3% listed as Critically Endangered, 17% listed as Endangered, 13% listed as Vulnerable, 7% listed as Near Threatened, and 10% listed as Data Deficient.

Strategic Water Source Areas (SWSAs) in accordance with Lötter & Maitre, 2021 are described as areas of land that either:

a. supply relatively large quantity of mean annual surface water runoff, being cognisant of their size and thus considered nationally important;
b. Have high groundwater recharge and where the groundwater forms a nationally important resource/hotspot; or
c. Areas whereby surface and groundwater importance are integrated and whereby they include transboundary Water Source Areas that extend into Lesotho and Swaziland.

In accordance with Lötter & Maitre (2021), the SWSAs refer to the 10% of South Africa's land area which provides an uneven 50% of the country's water runoff. Consequently, these areas are considered to be strategically important at the national scale for both water and economical security for South Africa. Thus, understanding where these SWSA are, will contribute to the vital planning and management of the various water resources (surface and groundwater) within this study area.

In total, the SWSA throughout South Africa covers approximately 12% of the region, which includes the addition of the sub-nationally important Pondoland Coast (forming part of this study area) (Le Maitre *et al.,* 2018). These areas are becoming more important owing to the ever-fluctuating water flows, decreasing water quality, landcover changes, alien invasive plant encroachment, groundwater vulnerability and contamination, and threatening drought risks (both surface and groundwater).

The SWSA will be considered during the delineation of the Integrated of Units of Analysis (IUA) and prioritising Resource Units (RU) for the study area. Refer to Appendix D, Figure 11-13 for the SWSA within the study area.

3. INFORMATION REVIEW

3.1 Previous Studies

A number of studies have been conducted in this study area, with the most comprehensive being the water resource assessment studies in 2003, as part of the development of the Internal Strategic Perspectives (ISP). Reconciliation strategies for the larger metropolitan areas and smaller towns were developed for most of the study area. Detailed feasibility studies for water provision infrastructure have been undertaken for the construction of dams (e.g. Lukanji Regional Water Supply).

While DWS is responsible for monitoring water volumes and water quality for rivers and groundwater as well as aquatic ecosystem monitoring, the South African National Biodiversity Institute (SANBI) manages the biomonitoring data, using the Freshwater Biodiversity Information System (FBIS). The

Water Research Commission (WRC) is funding the development of a "Water Research Observatory" which collates water related data sources and applications in a single portal, for ease of access.

Table 3-1 lists available key sources of information available for use during this study.

Table 3-1: Previous studies conducted in the catchment area

Year	Study Name
General	
2002	Mzimvubu to Keiskamma Water Management Area: Water Resources Situation Assessment
2002	Fish to Tsitsikamma Water Management Area: Water Resources Situation Assessment
2004	Albany Coast Situation Assessment Study
2008	Development of a Reconciliation Strategy for the Amatole Bulk Water Supply System
2011	Water Reconciliation Strategy Study for the Algoa Water Supply Area
2020	Determination of water resource classes and RQOs for the Mzimvubu catchment. Government Gazette No. 43015
Rivers (quantity and quality)	
1995	The development of the Hydraulic Biotope Concept within a Catchment Based Hierarchical Geomorphological Model – Site descriptions for the Great Fish River as part of Wadesons PhD
2002	Fish to Tsitsikamma Water Management Area: Water Resources Situation Assessment – Main Report – Volume 2 of 2: Appendices
	The Value of water in the Fish-Sundays Scheme of the Eastern Cape. School of Economics University of Cape Town. WRC Report 987/1/02
2004	Eastern Cape River Health Programme. Technical Report: Buffalo River monitoring, 2002 – 2003. Compiled by Scherman et al. (2004)
2006	Conservation planning for river and estuarine biodiversity In the Fish-to-Tsitsikamma Water Management Area
	Assessment of the Geomorphological Reference Condition: an application for Resource Directed Measures and the River Health programme. The Kat River was used as example of GAI PES. Compiled by Du Preez and Rowntree
	Lukanji Regional Water Supply Feasibility Study: Appendix 2 – Ecological Reserve (Quantity) on the Kei River

Year	Study Name
	Eastern Cape River Health Programme. Technical Report. Mthatha River Monitoring 2004 – 2006.
2008	State of Rivers Report No. 14. Mthatha River System
	Development of a reconciliation strategy for the Amatole bulk water supply system. Final report. Department of Water Affairs and Forestry.
2010	Algoa Water Resources Bridging Study (DWS)
2011	Water Reconciliation Strategy Study for the Algoa Water Supply Area: Algoa reconciliation strategy. Department of Water Affairs.
2012	Amatole water supply system reconciliation strategy: status report 2012 – Rev 3. Department of Water Affairs.
2013	Municipal Services Strategic Assessment (MuSSA) for Eastern Cape Province 2012
	The Development of Water Supply and Drought Operating Rules for Stand-Alone Dams or Schemes Typical of Rural/Small Municipal Water Supply Schemes: Southern Cluster – Final Report April 2013. Prepared by IWR on behalf of the Department of Water Affairs, Directorate Water Resource Planning Systems
2014	A Desktop Assessment of the PES, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reache for Secondary Catchments in South Africa. Compiled by RQIS-RDM.
	Support to the Implementation and Maintenance of Reconciliation Strategies for Towns in the Southern Planning Region: Status Report Eastern Cape October 2014. Prepared by Umvoto Africa (Pty) Ltd in association with WorleyParsons and UWP Consulting on behalf of the Directorate: National Water Resource Planning. DWS Report No. 14/4/12/12/2
2015	Water Resources of South Africa 2012 (WR2012) (WRC)
2018	National Biodiversity Assessment
	River Ecostatus Monitoring Programme State of Rivers Report 2017-2018.
	Mzimvubu-Tsitsikamma Water Management Area: Validation and Verification (V&V) of Existing Lawful Water Use (DWS)
	Algoa Reconciliation Strategy Status Report: Status Report 5. DWS. Ref. 112546
Groundwater (quantity and quality)	
2010	Eastern Cape Groundwater Masterplan
2015	Water Resources of South Africa 2012 (WR2012) (WRC)

Year	Study Name
2017 to Current	Groundwater exploration in the Nelson Mandela Bay Municipality area
2018	Algoa Reconciliation Strategy Status Report: Status Report 5. DWS. Ref. 112546
Wetlands[1]	
2009	The Wetland Rehabilitation Project in the Kromme River Wetlands, Eastern Cape (Haigh et al. 2009)
2010-2021	Department of Environmental Affairs (DEA). Environmental Programmes: Natural Resource Management. Working for Wetlands Phase 1 and 2 wetland rehabilitation planning assessment reports (within the Eastern Cape, but excluding the Mzimvubu catchment - a number of reports exist but need to be sourced and reviewed in detail to obtain the relevant information).
2011	NFEPA Wetlands Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and Nienaber, S. 2011. Technical report for the national freshwater ecosystem priority areas project. WRC Report No. 1801/2/11. Water Research Commission, Pretoria, South Africa
2014	SANRAL N2 Wild Coast Toll Highway: Specialist Aquatic Assessment Report (Eco-Pulse 2014) [permission required for release of data]
2015-2017	Factors influencing wetland distribution and structure, including ecosystem function of ephemeral wetlands, in Nelson Mandela Bay Municipality (Schael et al. 2015; Melly 2016; Melly et al. 2016; Melly et al. 2017)
2016	An evaluation of the ecological outcomes at the Wetland Management Area 01, Hogsback, Eastern Cape
2018	Focused Wetland Prioritization and rehabilitation Planning in Amathole District Municipality as part of the Local Action for Biodiversity (Eco-Pulse 2018b, c and d)
	National Wetland Map 5 South African National Biodiversity Assessment. Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa. Report Number: CSIR report number CSIR/NRE/ECOS/IR/2018/0001/A; SANBI report number http://hdl.handle.net/20.500.12143/5847.
2019	Integrated health assessment and ecosystem service provision of two urban wetlands in Port Elizabeth (Larson 2019).

[1] *The studies listed deal explicitly with wetland extent, PES and EIS, and in the reference section several additional studies are given relating to wetland origin, structure and/or function, including, amongst others: Glenday (2015), Hugo (2011), McNamara (2018), Pulley et al. (2018), Rebelo et al al. (2015; 2018), Smith-Adao (2016), and Tanner et al. (2019).*

Year	Study Name
	Department of Environmental Affairs (DEA). Environmental Programmes: Natural Resource Management. 2019. Working for Wetlands: Eastern Cape Provincial Strategic Plan: 2019-2024. Unpublished Report.
	Department of Environmental Affairs (DEA). Environmental Programmes: Natural Resource Management. 2019. Working for Wetlands: Western Cape Provincial Strategic Plan: 2019-2024. Unpublished Report.
2020	Ellery WN, 2020. The current status of the Ngciyo Wetland and the Ghio Wetland Nature Reserve. Unpublished report. Geography Department, Lucas Avenue, Rhodes University, Makhanda
2021	A project to predict wetland occurrence and type in the Western Cape for improved mapping and management (Kotze and Rivers-Moore 2021)
	Characterising wetland features and occurrence near Hogsback (Eichhoff in prep) [scheduled for completion in Dec 2021]
Estuaries	
2004	Turpie *et al.* Contributions to information requirements for the implementation of resource directed measures for estuaries: Vol 1; Improving the biodiversity importance rating of South African estuaries
2007	Turpie JK, Clark B. Development of a conservation plan for temperate South African estuaries on the basis of biodiversity importance, ecosystem health and economic costs and benefits. Final Report. Anchor Environmental Consultants.
	Whitfield and Bate. A Review of Information on Temporarily Open/Closed Estuaries in the Warm and Cool Temperate Biogeographic Regions of South Africa, with Particular Emphasis on the Influence of River Flow on These Systems
2015	Van Niekerk L, Taljaard S, Adams JB, Fundisi D, Huizinga P, Lamberth S, Mallory S, Snow G, Turpie J, Whitfield A, et al. Desktop Provisional Ecoclassification of the Temperate Estuaries of South Africa. Report to the Water Research Commission by Council for Scientific and Industrial Research. 156p.
2016	Adams, J., Cowie, M. and Van Niekerk, L. Assessment of completed ecological water requirement studies for South African estuaries and response to changes in freshwater inflow. WRC Report No. KV 352/15
2019	Van Niekerk L, Adams JB, Lamberth SJ, MacKay CF, Taljaard S, Turpie JK, Weerts SP, Raimondo DC. South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A. Pretoria: South African National Biodiversity Institute.
2020	Van Niekerk L, Adams JB, James NC, Lamberth SJ, MacKay CF, Turpie JK, Rajkaran A, Weerts SP & Whitfield, AK. An Estuary Ecosystem Classification that encompasses biogeography and a high diversity of types in support of protection and management, African Journal of Aquatic Science, 45:1-2, 199-216, DOI: 10.2989/16085914.2019.1685934

Year	Study Name
Socio-economics	
2011, 2016	National Census data (Stats SA), General Household Survey (latest population densities)
2018	DEA (egis.environment.gov.za) (Latest land use/cover)
2018/Latest Municipal IDPs	Stats SA (Supply-use table/ Municipal IDPs (Economic contributors)
2016	Department of Water and Sanitation (DWS) (catchment boundaries)
2011	South African National Biodiversity Institute (SANBI) (water resources)
Latest	Google Earth™ (Satellite imagery)

3.2 Reserve Studies

Several Reserve studies have been undertaken in the catchment area, although at different levels of detail and not for the entire catchment. These include:

- Rapid level 3 studies were done pre 2005 on the small coastal systems in the Pondoland area and the Tsitsikamma coast with very little information available from these studies.
- Intermediate Reserve studies have been undertaken for the following rivers and estuaries:
    - Tsitsikamma River and Estuary (2005)
    - Kat River (2006)
    - Kei River and main tributaries
    - Great Fish River
    - Kromme/ Seekoei Rivers and Estuaries (2006)
    - Buffalo, Kubusi and Nahoon (2003)

Additionally, a number of desktop studies have also been conducted to evaluate water use licenses. Where information from previous studies is available, it will be used during this study to enhance the confidence in the final EWR results for the evaluation of management scenarios and for trade-offs.

Reserve studies for groundwater are not well documented.

Various estuarine Reserve studies have been conducted for the estuaries (approximately 20 estuaries) on various levels of detail (Adams *et al.,* 2016). These include studies for the Kromme, Seekoei, Tsitsikamma, Sundays, Great Fish, Nahoon, Mthatha, Xora, Mngazi, Mtakatye, etc. The results from these studies will be evaluated and updated where required. The information from these studies is presented in Table 3-2.

Table 3-2: Estuarine information from previous Reserve studies in the study area

Estuary name	Latitude	Longitude	Date	Level
Groot	-34.059895	24.195019	2003	Desktop
Tsitsikamma	-34.135593	24.438326	2003	Rapid
Kromme	-34.142967	24.842728	2007	Comprehensive
Seekoei	-34.086670	24.910743	2007	Intermediate
East Kleinemonde	-33.539026	27.049325	2008	Intermediate
Sundays	-33.721836	25.853725	2008	Intermediate
Great Fish	-33.495228	27.140684	2013	Rapid
Nahoon	-32.986438	27.951704	2001	Intermediate
Mbanyana	N/A		2000	Desktop
Ntlonyane	-32.194703	28.956662	2000	Desktop
Xora	-32.158634	28.995585	2000	Rapid
Mncwasa	-32.082706	29.076077	2000	Desktop
Mpako	-32.040237	29.107695	2000	Desktop
Nenga	-31.985485	29.151810	2000	Desktop
Mnenu	-31.807562	29.330090	2000	Desktop
Mngazi	-31.677184	29.463134	2000	Rapid
Mtata	-31.952963	29.183758	2000	Intermediate
Mdumbi	-31.931450	29.216299	2000	Desktop
Mtakatye	-31.859270	29.270247	2000	Desktop
Mngazana	-31.692177	29.422861	2000	Desktop

3.3 Current and parallel studies

A number of studies have been initiated in the study area and include:

(i) Algoa Water Assessment and Allocation Study for the Kouga, Baviaans, Gamtoos and Krom Rivers;
(ii) Development of a Reconciliation strategy for Algoa and Amathole Systems; and

(iii) SANBI wetland inventory in the Wild Coast catchment area (ongoing project between SANBI and Department of Economic Development, Environmental Affairs and Tourism).

3.4 Hydrological Data and Modelling

A. K80, K90, L10 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Kouga and Swartkops)

The hydrological data and models to be utilised for this sub-area are based on the latest work done by the DWS for the Algoa Water Supply System (WSS) Reconciliation Strategy. This Reconciliation Strategy includes the Nelson Mandela Bay Metropolitan area. The last complete update of the Reconciliation Strategy for the Algoa WSS, was completed in 2012. However, the hydrology was last updated to September 1999 (Kouga below Kouga Dam and Gamtoos), September 1992 (Swartkops), and the remained (included Kouga above Kouga Dam and the Krom) to September 2005.

The DWS has commenced with another phase of implementation and update of the Reconciliation Strategies in the whole of the Southern Planning region of the country. This covers the study area to be addressed by this classification study. However, the timing of the update of the different sub-areas and individual Reconciliation Strategies still needs to be clarified, as this phase of Reconciliation Strategy update in the Southern Planning region has only recently commenced. The PSP study team will work closely on understanding the process and timing of the update of hydrological information and models for that study, and what can practically be used by this study team for the Classification Study.

The Study team is also aware that the DWS is busy with a new Water Availability Assessment Study (WAAS) for parts of this area. This WAAS study will focus on the Krom and the Kouga, Baviaanspoort and Gamtoos catchments and aim to update the hydrology and models according to the following estimated dates:

- Rainfall update - January 2021;
- Hydrology – June 2022; and
- WRYM – August 2022.

Again, our team will work closely with the WAAS study team to assess timing of the new information and ability to incorporate it into the classification.

The last other relevant hydrological and model data source is the System Operating Rules Study, also being conducted by the DWS for the whole of the Southern Planning Region. This study will also be of value, particularly for the current water requirements and situation, and the focus of the drought operating rules and associated annual operation analyses (AOAs), is the next 5-year horizon, and often focused on the current and subsequent year. Liaison between the two study teams will be important.

We believe it is very important to use the same hydrology and models as used to develop and update the latest version of the Reconciliation Strategy and planning purposes for the catchments. This will hopefully also talk to the models and data being used for the system operation. Using the same hydrological data and models will assist with consistency across the studies and the ability to integrate the results and findings as both studies progress forward. In this regard the latest WRYM model configurations are anticipated to be the most suitable for this classification study, but the team will confirm with the DWS and Reconciliation Strategy study team.

B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)

The Sundays is an important part of the greater Algoa Water Supply System and the hydrological data and models will be handled as per the approach listed in point 1 above. A key matter will be the transfer from the Orange River via the Fish River to the Sundays River. This will be managed through appropriate engagements with the DWS central planning regional managers and teams. It is not recommended that the whole of the Orange River system is linked in a model, but that the appropriate transfer volume as per the Orange River Reconciliation Strategy is included as a support to the Sundays River.

For the smaller catchments in this area (P primary catchment), the hierarchical phased approach will be:

- Identify and utilise existing catchment specific models and hydrology developed for either the All Towns studies Reconciliation Strategies, or the Drought operating rules studies. These focused system specific studies and models provide a good platform to proceed for the classification;
- The DWS will be engaged with, to confirm if there are any catchment specific studies and models that have been set-up for focused studies, outside of the two main studies mentioned in point above. These could include feasibility or planning studies; and
- Utilise the country wide Water Resources (WR2012) study and associated hydrology and model set-ups and data on land and water use for the catchments, where no existing WRYM has been configured. The WR2012 data and Pitman model (WRSM), will be developed into WRYM configurations. These will allow the catchments to be analysed for different scenarios.

Where the quaternary level catchments have multiple small rivers that are included within a tributary, these will be lumped and dealt with as a single resource to assess and classify, unless a specific high importance risk is identified at a sub-quaternary level.

C. Q10 to Q90 (Great Fish)

The Fish River is linked to the Sundays River through the water transfer scheme from the Gariep Dam on the Orange River. The Upper two-thirds of the Great Fish River is linked to the transfer, after which the last 100km of the Sundays River in the adjacent catchment is relevant. The classification process will need to assess the catchments considering both the transfers and impacts on water availability, but also the remainder of the users and catchment.

The modelling of the Fish will need to be conscious of the transfer into and out of the catchment, but also consider and model the resources in an integrated manner. The main concern is the change to the natural operating state of the water and the assured resource systems impacts related to a change in the natural quantity and quality of the receiving system, in which water is transferred.

D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei)

Similar to the area A (Krom, Tsitsikamma, Gamtoos, Kouga and Swartkops), this area is the focus of a Reconciliation Strategy Study, namely the Amatole Water Supply System Reconciliation Strategy. This Reconciliation Strategy, as well as possibly the hydrology and the models will also be updated over the course of the next 2 and a half years. Again, the timing of the update of the hydrological information (if being conducted), and the models still needs to be confirmed. Closer liaison with the representatives in the planning sector will be essential.

The operations of this system and effort being put into the operating rules study for this region is high due to the critical situation of very low storage in the main dams in the area. Thus, the Operating Rules study will be an important source of information with which to collaborate and align the work. This will be of particular interest when determining the operational scenarios and assessing the impacts in achieving the REC.

The hydrology of the Amatole Water Supply system was reportedly updated in 2015. This is the latest available data to be used for the classification study. The Classification Study team will review if the planned updates by the teams on either the Reconciliation Strategy, or the Drought operating rules studies will become available in time. The approach will be to assess the timing of the availability of this updated information, i.e. if the updated information is projected to become available close to the time that it is required for the classification study, then the existing data and models will be utilised. The risk of waiting for new hydrology and models on delaying the classification process needs to be carefully managed. This excludes the update of current actual water requirements and supplied / transferred volumes. These will be updated as required.

E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems)

There are a number of smaller catchments in this area, as per the P catchments described in area B (N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)). The same hierarchical approach for the hydrological data and models as described for area B will be used for the smaller catchments in this area.

The Mthatha catchment and dam, as examples of a system with existing hydrological data and models as currently being used for the drought operating rule analyses. The list of dams and associated catchments for which operating rules and model set-ups exist, are provided in Table 3-3, below.

It must be noted, that in some cases, the hydrological data and the WRYM configured for the Drought operating rule studies may also have been based on the WR2012 study and data. This will be confirmed, but still provides a more advanced model and data set to utilise for the classification process.

Table 3-3: List of catchments and dams with operating rules with WRYM models

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Dam with operation rules
A. K80, K90, L10 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Koega and Swartkops)					
Impofu	Krom	K90	87	Domestic water supply	

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Dam with operation rules
Kromriver (Churchill)	Krom	K90	32	Domestic water supply	To be confirmed with study teams undertaking the development of the Reconciliation Strategy and Water Assessment and Allocation
Beervlei	Groot	L30	90	Irrigation water supply	
Kouga	Kouga	L82	128	Domestic water supply	
Haarlem	Haarlemspruit	L82	4.7	Domestic water supply	
Loerie	Loerie	L90	3.17	Domestic water supply	
Groendal	Swartkops	M10	12.3	Domestic water supply	
B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)					
Nqweba (Van Rynevelds Pass)	Sundays	N10	47	Domestic water supply	N/A
Nqwebe	Sondags	N10		SBDM: Graaff Reinet	Yes
Darlington	Sundays	N20	187	Irrigation	N/A
Settlers	Kariega	P30	5.57	Makana LM: Mkhanda & Irrigation (Grahamstown System)	Yes
Sarel Hayward	Kowie	P40	2.5	SBDM: Port Alfred	Yes
Klipfontein	N/A	L60	1.8	SBDM: Klipplaat	Yes
C. Q10 to Q90 (Great Fish)					
Grassridge	Groot Brak	Q10	49.6	Balancing dam for water transferred from Gariep	N/A
Lake Arthur	Tarka	Q40	10.95	CHDM: Irrigation	Yes
Kommandodrift	Tarka	Q40	55.7	CHDM: Irrigation	Yes
De Mistkraal	Little Fish	Q80	3.1	Transfer of water	N/A
Katrivier	Kat	Q90	24.8	ADM: Fort Beaufort RoR, Seymour, Irrigation	Yes
Andrew Turpin	eNyara	Q90	N/A	ADM: Bedford	Yes
Glen Melville	Brak	Q90	6.13	Makana LM: Mkhanda & Irrigation (Grahamstown System), balancing dam	Yes
D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei)					
Sandile	Keiskamma	R10	30.9	ADM: Middledrift & rural & Irrigation; BCMM: Dimbaza & rural; Ngqushwa: Peddie, Hamburg & Rural; Mnyameni & Cata: ADM: Keiskammahoek & rural & irrigation	Yes
Cata	Cata	R10	12.1	Irrigation	N/A
Binfield Park	Tyume	R10	36.8	ADM: Alice & rural & Irrigation	Yes
Pleasant View	Tyume	R10	2.0	ADM: Alice & rural & Irrigation	Yes
Debe	Debe	R10	6.0	ADM: Rural	Yes
Laing	Buffalo	R20	21	Domestic water supply	N/A
Rooikrantz	Buffalo	R20	4.9	Domestic water supply	N/A
Bridle Drift	Buffalo	R20	101.7	Domestic water supply to East London	N/A
Nahoon	Nahoon	N30	20.7	Domestic water supply	N/A

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Dam with operation rules
Xonxa	White-Kei	S10	126	Irrigation	N/A
Lubisi	Indwe	S20	135	CHDM: Irrigation & rural	Yes
Doringrivier	Doring	S20	17.84	CHDM: Indwe & rural	Yes
Waterdown	Klipplaat	S30	36.6	Queenstown System	Yes
Bonkolo	Komani	S30	6.95	CHDM LM: Komani, Sada, Whittlesea, rural? & Irrigation	Yes
Oxkraal	Oskraal	S30	17.8	Queenstown System	Yes
Bushmankrantz	Oskraal	S30	4.62	Queenstown System	Yes
Sam Meyer	Thorn	S40	0.5	ADM: Cathcart	Yes
Ncora	Tsomo	S50	120	CHDM: Rural & Irrigation & hydroelectric & ADM: rural, Tsomo	Yes
Tsojana	Tsojana	S50	9.35	CHDM: Cofimvaba Rural	Yes
Gubu	Gubu	S60	8.8	Domestic water supply	N/A
Wriggleswade	Kubusi	S60	91.2	Transfer of water to R2 catchment for domestic use	N/A
Xilinxa	Xilinxa	S70	14.5	ADM: Butterworth, rural & augmentation to Dutywa & Kentane	Yes
Toleni	Toleni	S70	N/A	ANDM: Rural	Yes
E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems)					
Macubeni	Mgwali	T10	1.85	CHDM: Ngcobo	Yes
Mthatha	Mthatha	T20	228.0	ORTDM: Mthatha & Rural & Hydropower	Yes
Mabeleni	Mhlahlane	T20	2.0	ORTDM: Mthatha peri-urban & rural	Yes
Corana	Corana	T20	0.71	ORTDM: Rural	Yes
Bulolo	Bulolo	T70	0.255	ORTM: Port St Johns & rural	Yes
Mhlanga	Mngazi	T70	1.96	ORTDM: Libode & rural	Yes
Nzwakazi	Mtakatye	T70	N/A	ORTDM: Ngeleni & rural	Yes
Nqadu Weir	Nqadu	T90	N/A	ORTDM: Rural	Yes

3.4.1 Scenarios

Management scenarios will be identified using the Reconciliation Strategies that were developed and the integrated strategy that is currently being developed for the catchment area. Any additional scenarios specifically relevant to the ecological function or well-being of the water resources, e.g. the operation of releases from the larger dams will be discussed with DWS before finalisation. The final set of selected scenarios for the evaluation of ecological consequences will be modelled using the selected systems models as described above.

Future scenarios are important considerations. The future scenarios will be based on the reconciliation strategy. This will either be the latest existing approved strategy report, from the previous completed phase, or the new approved interim strategies based on updates by the Strategy Steering Committees (SSCs) to be held during the parallel studies. Collaboration with the DWS and their study teams will be required to confirm the most relevant updates if any. It is recommended that suitable time periods be considered based on the anticipated dates of major interventions. Lacking these, a minimum of a present and long term (say 2050 development horizon) scenarios will be developed.

3.5 Groundwater Studies

Available data and information from WR2012 will mainly be used on a high level for the delineation of groundwater resource units. Additional reports on “Overview of water resources – Availability and Utilisation: Upper Orange Water Management Area”, “Internal Strategic perspectives for the Mzimvubu to Keiskamma WMA and Fish to Tsitsikamma WMA” and “All Towns Reconciliation Strategies” are useful to gain knowledge of the overall catchment dynamics. However, additional specialist studies and local knowledge will be required to identify certain “hot spot” areas (fast growing regions which will become reliant on the groundwater resources), notably where the groundwater potential is low and the demand will be high.

The DWS “Eastern Cape Groundwater Plan” divides the catchments into geohydrological regions and provides the main economic activities for each region and the potential for groundwater development, utilisation, protection and management to contribute towards the relevant economic activities.

The DWS Eastern Cape Groundwater Monitoring project conducted from about 2011 to 2014 involved field verification of municipal boreholes, pump testing of the successful ones and siting and drilling of long-term monitoring boreholes. Recent groundwater exploration work in the Nelson Mandela Bay Municipality has been acknowledged. The latter work explored the Table Mountain Group aquifer of the Cape Supergroup in more detail. The work was also expanded to areas to the west in the Kouga Municipality.

3.6 Wetland Studies

At the inception phase of the project the prioritisation of wetland systems has largely been informed through a desktop screening process, making use of the various national spatial layers relating to wetlands, their importance and possible delivery of specific ecosystem services. Since majority of these spatial layers have been created at a national scale, the extent and associated attributes may not be accurate at a fine scale. As such, infield verification of these sites will be necessary to review the characteristics of the wetlands that have been prioritised and amend the final prioritisation accordingly. The need for infield verification is supported by the observations made in terms of the wetland extents recorded in Table 2-4, especially for the Gamtoos, Sundays and Wild Coast catchments.

The following information was sourced and utilised in the identification of priority wetlands for consideration in this study:

- National Wetland Map 5 (NWM5) spatial dataset;
- National Freshwater Ecosystem Priority Areas (NFEPAs) wetland shapefile;
- Important Bird Areas (IBAs);
- Crane sightings and nest sites;

- GIS coverage of important water supply dams;
- Wetlands which interacted with the surface and ground water strategic water source areas (SWSAs);
- Wetlands with a Present Ecological State (PES) of A/B;
- HGM unit type, which was used to determine the level to which each system may provide services associated with:
    - Flood attenuation;
    - Stream flow regulation;
    - Erosion control;
    - Sediment trapping; and
    - Water quality enhancements (assimilation of phosphates, nitrates and toxicants).
- Wetlands greater than 50ha (larger wetland systems, especially those which are relatively intact, provide greater opportunities for the provisioning of ecosystem services, benefitting those systems downstream and the surrounding water users);
- Those systems that were categorized as *Critically Endangered or Endangered*;
- Wetlands located upstream of important water supply dams;
- Identified water-stressed catchments/basins from the river Reserve process; and
- Top 5% of the quaternary catchments identified by Working for Wetlands for the Eastern and Western Cape Province.

3.7 Socio-Economic studies and analysis

The study area is mainly rural with some major towns (i.e. Gqeberha, East London, Mthatha, and Makhanda). Economic activity is concentrated in the south-western portion of the study area, within the Gqeberha /Kariega area, as this area is regarded as the economic hub of the Eastern Cape Province, contributing more than 40% of the Gross Geographic Product of the whole Province (DWS,2011). The proximity of extensive commercial agriculture contributes to growth in the Nelson Mandela Bay Municipality (NMBM), providing permanent and seasonal jobs, as well as value-added activities for communities, both within and on the fringe of the NMBM.

The following data sources will be used to analyse the socio-economic status of the study area (Table 3-4).

Table 3-4: Data sources for socio-economic analysis for the study area

Data required	Possible Source	Scale
Latest Population densities	National Census data (StatsSa)	Ward Level
Latest Land Use/Cover	DEA (egis.environment.gov.za)	National
Economic contributors	StatsSa, IDPs	Provincial
Catchment boundary	DWS	National

Data required	Possible Source	Scale
Water resource	South African National Biodiversity Institute (SANBI)	National
Infrastructure	DEA (egis.environment.gov.za)	National
Satellite Imagery	Google EarthTM	National

3.8 Stakeholder Engagement

Several stakeholders/interest groups will be identified, with the assistance of the DWS, which will be involved and invited to the four (4) proposed stakeholder engagement meetings. It is proposed that two meetings are held early in the project and two meetings towards the end of the project when the trade-off assessment has been completed and the final proposed water resource classes for gazetting have been determined. These stakeholders should have a good understanding of the catchment and encouraged to share information, data and to even assist during the various activities of the project.

4. APPROACH OVERVIEW

This study is of technical nature being supported by extensive stakeholder engagement and consultation. The project approach and methodology will be in accordance with the process as outlined in Regulation 810 (Government Gazette 33541) dated 17 September 2010, as well as the methodologies as prescribed by the DWS for Reserve determinations of rivers, wetlands, groundwater and estuaries and the determination of Resource Quality Objectives (RQO). The integrated steps as developed through the 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017)' will be used to guide the various activities (see Figure 4-1).

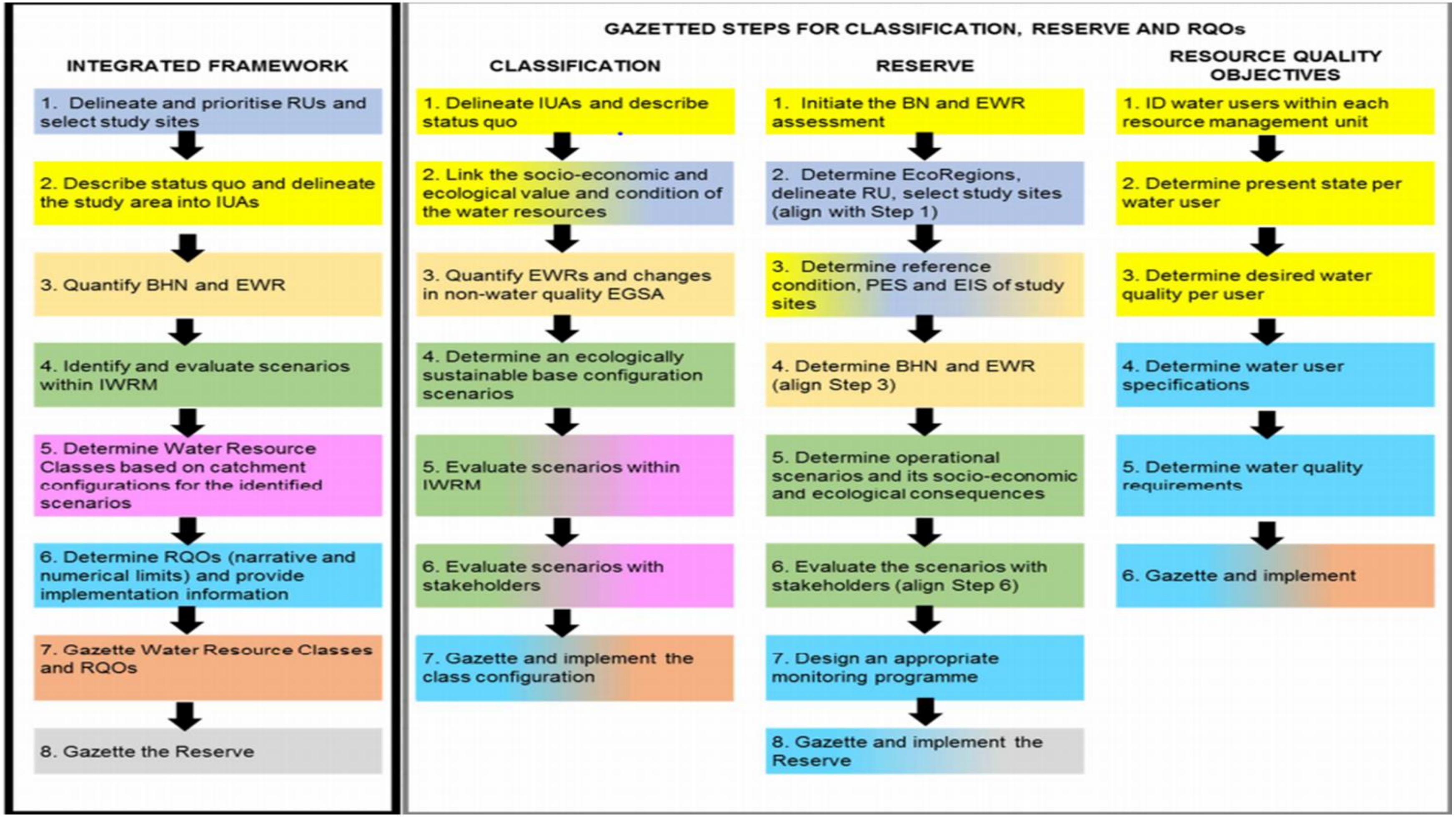

Figure 4-1: Integrated framework for determination of Water Resource Classes, Reserve and RQOs

The following main aspects will be addressed through the study which include:

- Review and analysis of existing information for all components;
- Assess the PES/EI/ES (DWS, 2014) database as baseline biological data;
- Identifying and filling in of the ecological and socio-economic gaps identified;
- Status quo assessment of the water resource availability and quality, water resource issues, existing monitoring programmes, infrastructure, institutional environment, socio-economics, sectoral water uses and users, etc. for the catchment area;
- Delineation of the Integrated Units of Analysis (IUA), priority Resource Units (RU) and identification of the hydronodes;
- Quantification of the EWRs for the priority RUs for rivers, estuaries, groundwater and wetlands and the Basic Human Needs (BHN);
- Undertaking scenario analysis and operational considerations and apply 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);
- Applying the RQO procedure to determine the RQOs (identification and prioritisation of sub-components and establishment of numerical limits);
- Formulation of practicable indicators for compliance monitoring and monitoring of the ecological health and integrity of the water resources in the study area;
- Development of an Implementation/operationalization Plan of the Water Resource Classes and the RQOs; and
- Preparation of the gazette templates (management classes, RQOs and the Reserve).

These aspects will be supported through (i) stakeholder engagement, co-operative governance and consultation processes and (ii) study management and capacity building which will continue throughout the duration of the study. The study tasks are for the most part not linear and will run concurrently over the project timeframe of 36 months. The general approach that will be followed is shown in Figure 4-2.

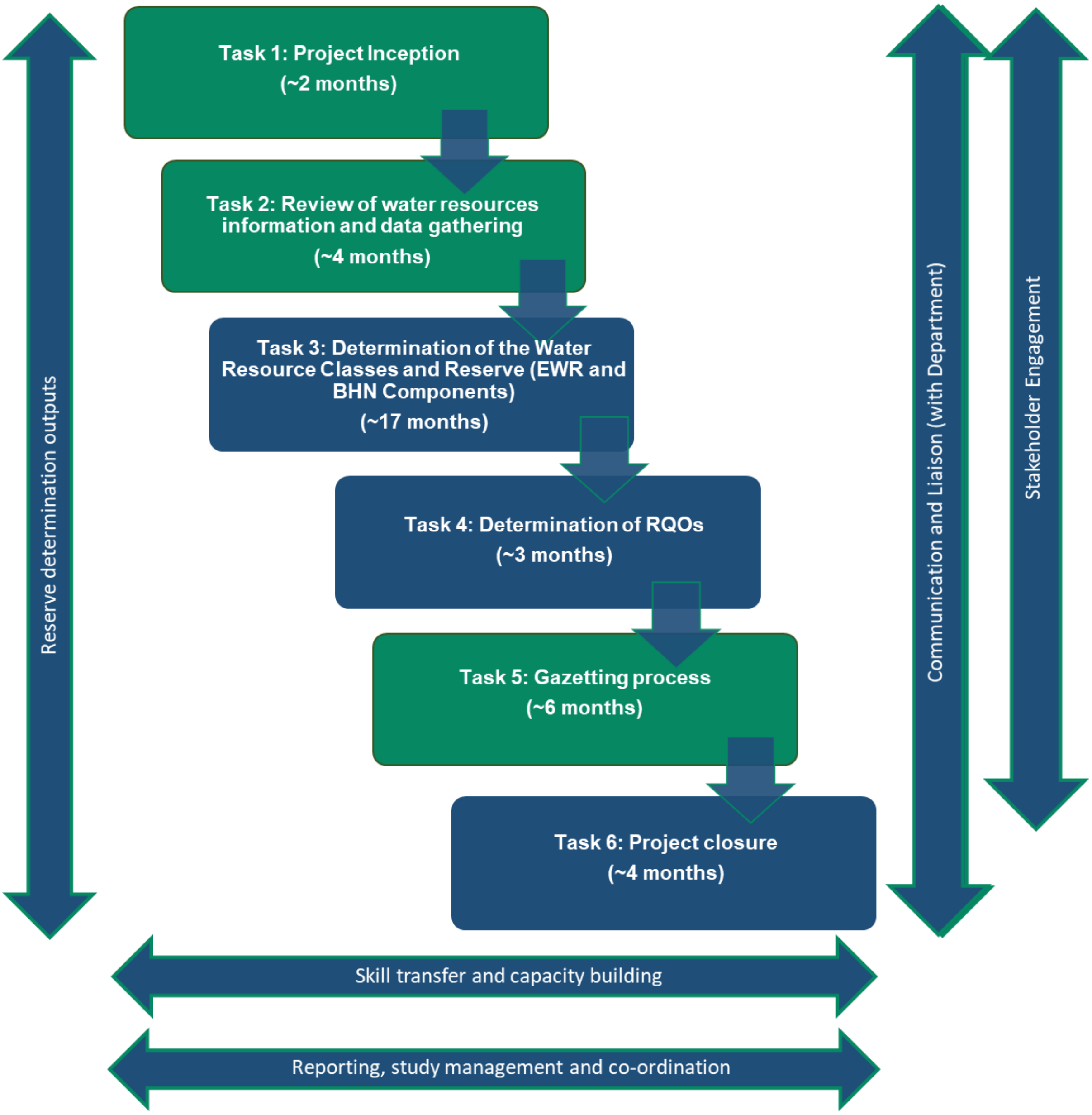

Figure 4-2: Proposed tasks and approximate timelines

5. DETAILED SCOPE OF WORK / METHODOLOGY

5.1 Task 1: Project Inception

The study team views the inception phase as critical as it provides a platform for assessing and understanding the nature of the scope of the project to ensure alignment between DWS's expectations for the study and the actual product delivered by the study team. The aim of this Phase is for the PSP to initiate the project, mobilise the project team and consult with the Client regarding the development of an Inception Report.

The purpose of this phase was to clearly define the project scope, proposed approaches for the various water resource components and socio-economic assessment, 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 the following:

- A study team liasison and pre-initiation meeting was held on 29 September 2021 whereby the team was mobilised and a presentation providing the study area, overview, proposed approach and deliverables were discussed;
- An initiation meeting with members of DWS was held on 3 November 2021, to confirm the study terms of reference and client's specification in terms of study management, communication and liaison, stakeholder engagement and contractual aspects. Please refer to Appendix E for the meeting agenda, meeting minutes and presentation provided by both DWS and by Groundtruth (PSP);
- The project inception meeting was held on 29 November 2021. Feedback and guidance on the proposed approaches and tasks were provided by the DWS and incorporated in this report;
- A preliminary review of available information and models was undertaken and data identified that will be used as base for this study (see Table 3-1);
- Key challenges and constraints were envisaged and identified;
- All approaches were outlined for the tasks of the key components to be undertaken through the study process;
- A capacity building and mentorship plan has been developed and included in the inception report as indicated in the study's terms of reference; and
- The requirements of the stakeholder engagement, communication and implementation actions were defined during the inception phase.

Specific emphasis will be placed on the following available data, information and models during Task 2 (Review of water resources information and data gathering) of the project :

- The desktop PES/EI/ES study (DWS, 2014);
- Previous preliminary Reserve results (rivers, estuaries, groundwater, wetlands), water resource availability and planning studies, various water quality studies; reconciliation strategies to inform possible scenarios; etc.;
- NFEPA identified priority catchments and any other relevant conservation information will be utilised to confirm the priority resources and the scope and level of Reserve determination required for the selected rivers, estuaries, wetlands and groundwater-driven systems;
- National Biodiversity Assessment for estuaries (NBA 2018);
- Obtaining of the latest water resource models for updating;
- Identification of management scenarios utilising existing individual reconciliation strategies as well as the current updating of the reconciliation strategy for the stuay area; and
- Socio-economic information to assess impacts of scenarios and inform trade-offs.

The specific linkages and alignments with the above-mentioned studies will be done during Task 2 to inform the status quo and gaps report and assist with the delineation of the IUAs, prioritisation of RUs and selection of hydronodes. However, it must be noted that owing to the scale of the catchment area and the associated water resources (rivers, wetlands, groundwater areas and estuaries), depending on the level of stress / impacts on the system/adjacent catchment impacts / catchment transfers etc, will determine whether desktop, rapid, intermediate and/or comprehensive studies are conducted for each priority site for this study. This will ensure the study is conducted within budget and the prescribed timeframe of three (3) years.

5.2 Task 2: Review of Water Resource Information, Data Gathering and Status Quo assessment

Part of this task will run concurrently with Task 1, the inception phase, as the outcome of the information gap analysis will guide the rest of the project programme. The main focus for this task will be a gap analysis and review of all existing literature, reports, maps, models, aerial photographs and any other relevant information on the study area that is supportive and required for the classification of the significant water resources, determination of the Reserve and setting of RQOs.

The gap analysis will specifically put emphasis on previous studies undertaken, coupled with the previous preliminary Reserve determination studies for the various components (rivers, estuaries, groundwater and wetlands).

The gap analysis will further include information from water resource assessment and planning studies, other related Resource Directed Measures (RDM) studies, water quality studies, socio-economic information, augmentation and reconciliation strategies and implementation and operational plans. It will also include recommendations on the review of the preliminary Reserve results to include methods supported by the DWS that have been developed since previous studies.

Furthermore, information from the River EcoStatus Monitoring Programme (REMP), Working for Wetlands studies and other related studies will also be assessed in performing a gap analysis to determine if there is any other additional work required.

This task will also include the sourcing of the applicable Water Resources Models and Water Quality models and any other relevant models that have been used for the study area during previous studies. The models will be used to support the results obtained and improve the confidence level of the study results (implementation and achievability).

All of the above will be used to identify any data and information shortfalls. Specific recommendations will be made as to the collection of additional data and/or the extrapolation of existing data. This will be discussed with the client before finalization.

The information and data collated during this step will be used to describe and document the status quo of the various components such as water resources and systems, water use, economy, river, wetland and estuarine ecology, groundwater considerations, water quality problems and ecosystem services and attributes. This information will be used to:

(i) define and delineate the IUAs that are the spatial units that will be defined as significant water resources and represents a homogenous socio-economic area which requires its own specification of a water resource class;
(ii) identify priority RUs that are smaller reaches, wetlands, groundwater areas or specific priority estuaries within an IUA where EWRs are specified; and
(iii) select hydronodes that are nodes where water resource modelling of scenarios will be undertaken for the evaluation of ecological consequences.

5.3 Task 3: Quantification of the EWR and BHN and define preliminary Water Resource Classes

This task will form the primary component of the study programme (~17 months) and the results will form the main elements for the water resource classification process through determination of the EWRs and BHN, socio-economic and scenario analysis and trade-offs. See Figure 5-1 for the various steps (Steps 3, 4 and 5) that will be followed to address the key requirements of this task. Steps 1 and 2 have already been done as part of Task 2. The details for steps 3, 4 and 5 are addressed in further detail below in Table 5-1.

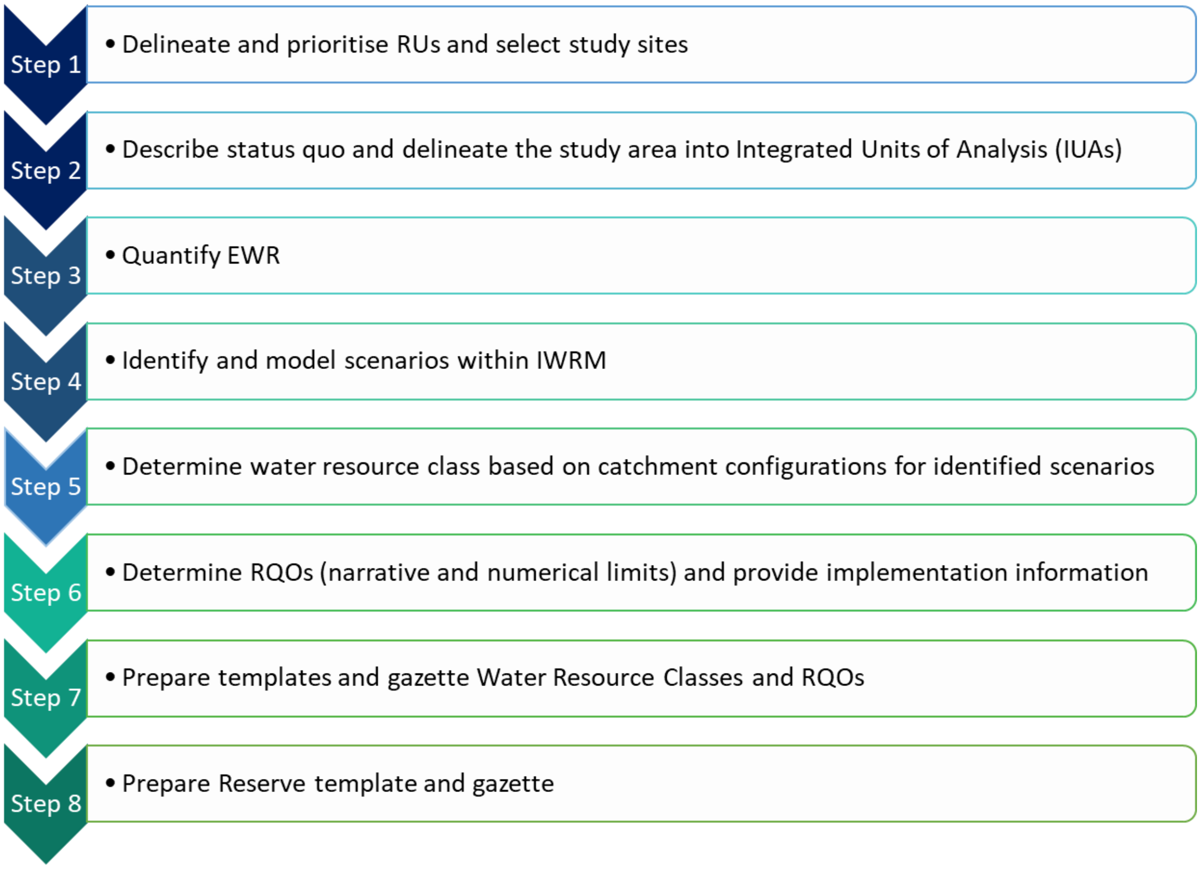

Figure 5-1: Integrated steps for the classification, determination of the Reserve and setting RQOs

Table 5-1: Detailed scope for steps 3, 4 and 5 as part of Task 3 (quantification of EWR and BHN, socio-economic analysis and define Water Resource Classes)

Steps	Description of approach
Step 3	Quantify the EWR components that describe the Reserve, aimed at being conducted at a high level of confidence for groundwater, rivers, wetlands and estuaries in the study area. However, owing to the scale of the study area, desktop, rapid and/or intermediate studies may be conducted to cover a larger number of resources. The BHN will be quantified from surface and/or groundwater using the latest census or other data available for the study area. Undertake socio-economic analysis and ecosystem services The details are discussed in sections 5.3.1 to 5.3.5.
Step 4	A preliminary identification and description of operational flow scenarios within the Integrated Water Resources Management (IWRM). These scenarios will then be tested to evaluate the ecological consequences to finalise the EWRs that can be met, taking in consideration the system constraints (e.g. dam release capacities). The primary aim of this task will be to determine any consequences of the EWR requirements through the running of the appropriate Water Resource Models (WRYM or WRPM) (i.e. what would the risk be should the REC not be met?). The operational scenarios will take cognisance of any potential scenarios assessed previously for Reconciliation Strategies or any other studies and taking into consideration water transfers from the rivers in the catchment to other catchments or transfers into the study area (e.g. Orange transfer from Gariep Dam to Fish River). These scenarios will be evaluated by the project team in terms of ecological and socio-economic consequences. A final set of scenarios will be presented to the DWS and stakeholders for discussion and decision as to the most appropriate scenario to implement. The final scenarios will form the basis for the finalisation of the Reserve as part of step 6. Refer to section 5.3.6 for more detail.

Step 5	Water resource classification describes the desired condition of the water resources related to its ecological configuration and socio-economic activities. The Water Resource Class is described as Class I to III being minimally to heavily used/altered respectively. This step will involve the determination of the water resource classes for each IUA based on the catchment configurations and the results of the selected operational scenarios. Ultimately, an analysis will be undertaken to determine the best-balanced option (trade-offs) between protection (ecology) and use (socio-economic) for each IUA, where: • Protection is described as an ecological state usually expressed as ecological categories A (near natural) to F (critically modified). • Use is expressed in terms of the water balance, quality aspects and socio-economics. The implications of not meeting the ecological objectives (REC), are identified and the best-balanced option, the Target Ecological Category (TEC) is selected with appropriate motivations. After input from both internal and external stakeholders, as well as liaison with relevant government institutions that play a role in IWRM, or who are affected, recommendations for the legal notice are made. Further, as part of step 5, is an overview of the socio-economic water use in the study area as described in Section 5.3.5. This aspect of the study will be guided by the WRCS Socio-Economic Guidelines (DWAF, 2007) and newly developed approaches, specifically the procedure to describe the present-day socio-economic status of the catchment and community well-being, with a focus on socio-economic water use and socio-cultural importance. The guidelines identify the following relevant aspects: • Population density figures and related statistics (e.g., urban vs rural, demographics); • Overview of the economy in terms of the relative contribution of different sectors (example data sources Statistics South Africa, Municipal documents such as Integrated Development Plans (IDPs)); • Land-use and related economic activities; and • The current wellbeing of the communities – a description of various aspects of each community that will gives a sense of the levels of financial, physical, human, social and natural capital assets available to those communities (e.g., household characteristics - income category, services and infrastructure, education levels, community cohesion, etc.); The cultural value of catchments includes their contribution to education, scientific knowledge, and the spiritual wellbeing (Huggins *et al.,* 2010). Assessment of the socio-cultural value of the catchment reflects a qualitative assessment of how aquatic ecosystems contribute to community wellbeing.

5.3.1 Rivers

The Ecological Water Requirements (EWRs) for the priority rivers will be determined using the following:

- Results from previous preliminary Reserve determination studies determined in the study area, as well as information from other water resource management initiatives;
- Information collected during the field surveys (proposed to be seasonal surveys - dry and post wet - in order to provide high confidence results);
- Results from the Eco-classification process (PES/EcoStatus), Ecological Importance (EI), Ecological Sensitivity (ES), Recommended Ecological Category (REC)) will be the basis for the updating/ and or revision with field survey results and to propose Target Ecological Categories;
- The Desktop Reserve Model (DRM), Revised DRM and the Flow Stressor Response model (FSRM)/approaches within Spatial and Time Series Information Modelling (SPATSIM) will be used for the integration of data produced from the surveys and Eco-classification to quantify the EWRs for rivers;
- Results from the hydraulic modelling (cross-sectional profile and discharge) to evaluate the DRM requirements and specification of stress curves; and
- Evaluation of the water quality at specific selected sites where quality was identified as an issue.

A combination of the following three (3) approaches will be used at the selected priority sites within the identified RUs for the study which will include the following, along with descriptions:

(i) Biological level:

- Using the best available and updated biological data (MIRAI, FRAI) and Rapid Index of Habitat Integrity (IHI), 1996 model, to determine PES/EcoStatus, Ecological Importance (EI), Ecological Sensitivity (ES) and Recommended Ecological Category (REC). Furthermore, the DRM/RDRM will be run to determine the EWR. Some biological sites will also include diatoms to assess the physico-chemical measurements/ecological water quality. Where information from EWR sites on rapid or higher levels is available, the charcteristics of these will be used to extrapolate the EWRs for the biological sites. The use of the RDRM will be investigated to provide desktop hydraulic information to enhance the confidence in final extrapolated results.

(ii) Rapid level 3:

- Using the best available and updated biological data (MIRAI, FRAI) and Rapid IHI, 1996 model to determine PES/EcoStstatus, EI-ES and REC, including the hydraulics surveyed data to verify the DRM/RDRM results and cross sections; and

(iii) Intermediate or higher level:

- The habitat-flow-stressor response (HFSR) approach will be followed in order to determine the EWR. The Fish Invertebrate Flow Habitat Assessment (FIFHA) will be run to assess fish and macroinvertebrate responses to the various ecological consequences and operational scenarios during high and low flow conditions.

Table 5-2 provides details of the preliminary EWR sites selected for initial planning purposes. These will be revised with the completion of Task 2 (IUA delineation and selection of priority RUs). The results from the prioritisation of the RUs will be used to select the final set of rivers where the Reserve will be determined and to determine the level of assessment (e.g. desktop, rapid, intermediate, etc.).

Table 5-2: Details of preliminary EWR sites for initial planning purposes

No.	Tertiary Catchment	Description
1	Q10 – Q90*	Fish River with main tributaries of Little Fish, Koonap and Kat
2	P10, P20, P30, P40	Kowie, Kariega, Boesmans and small coastal rivers
3	N10, N20, N30, N40	Sondags
4	M10, M20, M30*	Koega, Swartkops and small coastal rivers
5	L10 – L90	Gamtoos with main tributaries Groot, Baviaanskloof
6	K90*	Krom, Seekoei and small coastal rivers
7	K80A – K80F*	Tsitsikamma and small coastal rivers
8	R20, R30*	Buffalo, Nahoon and Gonubie
9	S10 – S70*	Kei River with main tributaries of Black Kei, Klipplaats, White Kei and Kubusi
10	T90A – T90F	Small coastal rivers
11	T20*	Mtata River
12	T11 – T13*	Mbashee River with main tributary Xuka
13	T60, T70, T80*	Small coastal rivers
* Rapid and intermediate assessments were undertaken for these rivers		

5.3.2 Wetlands

Key priority wetland sites will be identified during the inception and gap analysis phase. The protocols that have been developed for the rapid assessment of wetlands PES (i.e. the Decision-Support Protocol (DSP)) guides an assessor through the following prescribed steps:

Step 1: the key wetlands visited will be categorized in accordance with the Hydrogeomorphic (HGM) classification system first described by Brinson (1993) and modified for application in South Africa by Marneweck and Batchelor (2002), Kotze, Marneweck, Batchelor, Lindley and Collins (2007) and SANBI (2009). Furthermore, the categorization will determine the level of assessment required.

Step 2a: Confirm that the aquatic ecosystem is an inland wetland.

Step 2b: Delineate the wetland and type the wetlands in terms of the HGM unit functions (i.e. categorize the wetland type/s) and identify “assessment units”.

Step 3a: Describe the perceived natural reference state of the (naturally occurring) wetland assessment unit.

Step 3b: Select and fill in scoresheets to derive PES Scores and Ecological Categories for individual components of wetland PES (by navigating via the main matrix table included in the 'DSP Home' worksheet).

Step 3c: Select component weightings to derive an Overall PES Score and Ecological Category for the wetland assessment unit (using the second matrix table included in the 'DSP Home' worksheet).

Step 3d: Generate a summary of results.

A more detailed description of each of these steps is provided in the sections below.

Approach and Methodology

Step 1: Collation of Existing Spatial Data

Given the extent of the study area, and based on experience of the wetland databases available, it is expected that the PES and EI-ES information will not be available for most systems. As such, numerous national wetland coverages that exist for the whole of South Africa, each differing in the way, scale and accuracy to which they were developed, will be considered. These coverages provide a good indication of the probable presence of wetland habitat within the landscape and will guide the identification of the priority wetland systems within the broader study area. These layers include the National Freshwater Ecosystem Priority Areas (NFEPA) and the National Wetland Database produced by SANBI. In addition to these national spatial coverages, existing projects (such as Working for Wetlands sites) and smaller scale spatial coverages will be reviewed to incorporate any relevant existing information into the database. Key drivers are essentially automatically derived as part of the HGM categorization. This is the strength of the HGM system as each HGM wetland type has conceptually distinct hydrological drivers based on the input and output of flows of water (see Kotze *et al.,* 2020). This process will further be strengthened by taking a catchment-based approach and considering possible groundwater links.

Using surrogate information such as land use datasets and the derived eco-categorization of the additional priority wetlands, and based on known threats or pressures for development within the 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 the trajectory of change of the identified systems depending on the pressures they are currently experiencing or based on additional threats or pressures going forward. By taking this approach, it is envisaged that the team will be able to provide information to the DWS which will assist with filling in the gaps in the current wetland Reserve dataset, predominantly in relation to the identification of additional priority wetlands that may be under threat, and which should be considered for inclusion in the wetland Reserve for the main river systems.

Step 2: Desktop Mapping

The desktop mapping of the prioritised wetland systems would be undertaken in accordance with the Guidelines for Mapping Wetlands in South Africa (SANBI 2018). Mapping would be undertaken in Quantum GIS (QGIS) to create a GIS spatial coverage of the wetlands within the study area. Desktop mapping encompasses the overlaying of numerous GIS coverages to determine the probability of wetland systems, which primarily includes aerial imagery, contour data, river coverages and existing wetland inventories. The combination of these layers assists in determining the probability of wetland habitat within the landscape; as wetland identification is normally based primarily on differences in vegetation patterns between wetland habitat and terrestrial areas, as well as landscape setting based on topography. In highly transformed landscapes, where natural vegetation and drainage lines have been entirely altered, the identification of various anthropogenic land use practices that could be seen as indicators of likely wetland habitat is undertaken. For example, features such as ridge-and-furrow drainage or herring-bone drainage systems in agricultural settings, are often visible in aerial imagery. Infield verification in these areas is particularly important. The mapping of prioritised wetland areas will be undertaken at a scale of 1:5000 using GIS.

Step 3: Desktop Assessment of Wetland Condition and Determination of HGM Unit Type, prioritisation and infield verification

The state of the prioritised wetlands within the study area would be assessed at a desktop level using the WET-Health Level 1B wetland assessment tool (Macfarlane *et al.,* 2020), which is a land-cover type tool considered appropriate in circumstances where a large number of wetlands need to be assessed across a variety of different landscapes. The land-cover assessment tools consider the impact of different land-cover types on wetland habitat, taking into account both catchment and within system impacts. Rapid application of the tool at a desktop level will provide an indication of the likely state of the surveyed wetland systems. The wetlands would be categorized as either 'degraded', 'functional' or 'pristine'. In addition to the desktop determination of the selected wetlands within the study areas, the HGM unit types will be categorised where possible. Many of the existing inventories will provide the HGM Unit type categorization, however where this is not possible, the HGM unit type will be defined based on topographical features and verified infield (where possible).

Selected wetland systems will be identified at a desktop level, and verified infield, according to their condition and potential threats to the functioning of the system. These wetlands will be identified for conservation prioritisation, especially in terms of protecting the water resource. The prioritisation of wetlands within the broader study area will be based on the following objectives:

- Encourage the protection of systems which are still fairly intact;
- Protect and maintain catchments upstream of water supply dams to secure the provisioning of water quality provision services;
- Protect those wetland systems that link to groundwater and major rivers and/ or estuaries;
- Encourage the inclusion of wetland systems associated with important National Freshwater Ecosystem Priority Areas (NFEPAs); and
- Further prioritise those systems where rehabilitation has been undertaken in the catchment in the past (or in the near future).

Sustainable and achievable management recommendations will be provided for the prioritised wetland systems, relating specifically to the management of catchment impacts and the implementation of buffers to protect the systems from further degradation.

Site visits for the wetland team will be undertaken to verify portions of the desktop mapping and assessment of the selected wetland systems. Given the extent of the study area, detailed delineation and assessment of all wetlands would be an expensive and time-consuming exercise. Therefore, infield verification of the desktop assessments would be undertaken at predetermined locations. The aim of the site visit would be to:

- Verify the presence of wetland habitat visually and, where necessary, in accordance with the Department of Water and Sanitation (DWS) guideline document and best practice guidelines. The location and identified impacts to the wetlands will be recorded utilising a mapping grade Global Positioning System (GPS). The subsequent information will be used to adjust the desktop mapping if required; and
- Verify the state of the wetland habitat. The site visit would target a sample of degraded, functional and pristine wetlands situated within a variety of different land-cover types. This would provide an indication of the accuracy of the desktop assessment and the scores for wetlands' present ecological state and ecological sensitivity. The results of which will be tabulated to verify the prioritisation of the wetland systems and determine whether the impacts identified at a desktop level are applicable. Verify the wetland HGM unit type and describe the specific functions that each HGM unit type provides. This will also be provided in a table format.

5.3.3 Groundwater

Groundwater resources within the study area are mainly linked with the Cape Supergroup and Karoo Supergroup aquifers. The Mzimvubu to Keiskamma sub-catchment area is mainly covered with Karoo Supergroup sediments whilst the Fish to Tsitsikamma sub-catchment area is covered with Cape Supergroup, Karoo Supergroup, as well as Uitenhage Group. Quaternary sand deposits also occur in the Coega region close to Gqeberha, whilst significant alluvial deposits occur in parts of the Great Karoo.

(i) Mzimvubu to Keiskamma

Groundwater is mainly used for rural domestic purposes and stock watering as well as for supplies to towns and rural settlements. Substantial irrigation from groundwater is practised in the vicinity of Queenstown, where some over-exploitation of groundwater is also experienced. The quality of groundwater is generally of a high standard. However, water of high salinity is found along parts of the coast and at some inland locations where the rainfall is low and the geology is not favourable.

(ii) Fish to Tsitsikamma

Groundwater is used for municipal, rural settlements, rural domestic and stock watering purposes. Towns in the Karoo region generally have a greater dependence on groundwater with some town's almost entirely dependent on groundwater for their existence. Recent exploration of groundwater in the Nelson Mandela Bay Municipality in particular is to supplement the diminishing surface water supplies in the region caused by a decline in rainfall. In this region, the Table Mountain Group (TMG) of the Cape Supergroup generally provides the best option for groundwater development in terms of borehole yield and quality. Groundwater quality is generally good with minor treatment required at municipal level.

The Groundwater component of the Reserve determination study has the following objectives:

- Execution of the Groundwater Resource Directed Measures (GRDM) determinations for the set of groundwater resource units, including groundwater dependent ecosystems (GDEs), identified in the study;
- Address both the quantity and quality of the EWR and the BHN components of groundwater resources;
- Integration of the GRDM determination results with those of the surface water Reserve determination studies regarding rivers, wetlands and estuaries following prioritisation of groundwater resource units (GRUs)/GDEs in terms of current use, future potential use and degree impacted (stress on the groundwater resources);
- Seek the protection of groundwater resources with due consideration to equitable and sustainable use thereof; and
- Presentation the results in a manner that is supportive of the managerial and administrative procedures that inform implementation of the groundwater Reserve.

Scope of Work

The study envisages to meet the requirements of a high level GRDM determination. This is informed by factors such as the significant degree of groundwater use, the measure of negative impact on and threat to groundwater quality, and the uncertainty regarding the importance and sensitivity of GDEs in the study area.

The study will interrogate various literature sources and databases for groundwater information, including the National Groundwater Archive (NGA), the Water Authorisation and Registration Management System (WARMS), the Water Resources of South Africa 2012 Study, Reconciliation strategies for towns, Water Resources Assessment documents, DWS and Water Research Commission (WRC) technical reports, Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP) reports, Consultant reports and published scientific papers.

The study will further utilise site-specific information where available and generate groundwater quality information for GRUs where data in this regard are poorly represented or absent. Data assessment methods will be tested during this study that may be reviewed and formalised in the on-going development of the GRDM methodology. The proposed methodology is described below.

Step 1: Project Inception and Gap Analyses

The project inception will initiate the project, mobilise the project team and consult with DWS on the understanding of project objectives to be aligned with DWS requirements. The latter will feed into a project plan for the determination of the groundwater component of EWR and BHN.

Furthermore, any gaps identified from a groundwater perspective, coupled with recommendations will be included within the Gap Analysis Report.

Step 2: Review of water resources information and data

This phase will comprise a literature review task and may run concurrently with the inception phase. The detailed tasks include the following:

- Review of all previous studies in the WMA including water resources planning, EWR and BHN determinations, water quality, socio-economic, augmentation and reconciliation strategies specific to groundwater;
- List available water resources models and evaluate their applicability in the study; and
- Undertake a gap analysis and compile recommendations on how to deal with information and data gaps.

Step 3: Determination of the EWR and BHN components

The study implementation phase will inform the essence of the study and will deliver the main product, i.e. a determination of the groundwater component of EWR and BHN (groundwater quantity and quality) in the study are, through the sequential execution of an eight step procedure. The basic tasks for this phase are outlined below:

- **Preparation and re-assessment of TOR**

The Inception Report may highlight the large number of forums and other Interested and Affected Parties (I&AP) groupings in the study area. The largely unknown relationship that exists between the groundwater regime and wetlands that might constitute groundwater (or aquifer) dependant ecosystems (GDEs) in the study area will be identified as a further challenge to the GRDM determination. Since uncertainty in this regard may also extend to riparian areas, it is envisaged that the level of detail and site-specific hydrogeological data available for such settings may be sparse or deficient. Contribution of groundwater to rivers and estuaries will be assessed and included in the GRDM determination.

- **Description of study area**

This can be accomplished on the basis of existing available information obtained from various sources. Limited provision is made for the sourcing of new geohydrological data and information by means of focused field surveys and approaches to organizations such as irrigators, mines and industries for localised data. This task facilitates a conceptual understanding of the groundwater environment that inform the subsequent tasks within the framework of a GRDM assessment, namely the delineation of GRUs, classification of groundwater resources, quantification of the Reserve and the setting of RQOs.

- **Defining the present status**

The present status category will be assessed for each GRU on the basis of factors such as the environmental impacts, level of stress, groundwater usage, groundwater contamination and land use. The present status category, in turn, inform the derivation of a water resource category for each GRU, the setting of the Reserve itself, as well as the derivation of appropriate RQOs.

- **Quantification of the Reserve**

This activity will seek to establish the volume of groundwater that contributes to sustaining the surface water EWR and BHN. This is a necessary prerequisite to determining the quantity of groundwater potentially available for allocation to users and potential users.

- **Setting of Resource Quality Objectives**

This aspect of GRDM is generally the most difficult to achieve, since developing a substantive set of objectives requires a holistic appreciation of the groundwater environment that recognises both the requirements of all users and the impacts of some users whilst at the same time being practical, implementable and measurable.

- **Compile a Monitoring Programme for GRUs**

This task will draw on the understanding of the groundwater resources gained from the study results to develop a multifunctional groundwater monitoring programme for the study area that will meet different demands in terms of variables, frequency, etc. required to implement appropriate management and protection of the various GRUs.

- **Data Sources and Software**

Significant groundwater and associated data exist for the WMA in databases managed by the DWS, the WRC and the Council for Geoscience. Processed data and assessments of groundwater recharge and use such as are contained in the WR 2012 repository may prove to be invaluable to this study. The various sources used for this Reserve Determination will be listed in table format.

5.3.4 Estuaries

Considering the large number of estuaries for which estuary EWR studies have not been completed in the study area, it is not considered feasible to base this EWR study on site-specific detailed field investigations for all estuaries. Rather, a phased approach is recommended where initially a strategic, broad-based assessment would be conducted to prioritise the estuaries where more detailed investigations will be conducted.

First, it is proposed that a comprehensive desktop assessment be conducted on all systems within the area using available information, Google Earth imagery, and expert knowledge and judgement. Previous EWR studies will be revisited if additional data is available to improve on results. The estuary team will verify the rankings applied on all 154 estuaries as part of the 2018 NBA. Considering the overall diversity in estuary types in the study area (e.g. temporality open, permanently open, estuary size and catchment characteristics), it is anticipated that about 15 estuaries should be included in the more detailed investigation phase (e.g. ranging from field surveys to exploratory field observations). A prioritisation process to select resource units / estuaries using estuary importance, sensitivity and threat status/water-use priority will be applied and a matrix developed to select the priority group of estuaries.

Estimates of the river inflow (m^3/s) to the individual estuaries in the study area will be provided by the systems modellers. These estimates will be monthly reference condition (natural) and present state flows and if any development scenarios are identified for the catchment, future flows. Where possible an indication will need to be given of the degree to which the floods and base flows have been reduced, e.g. 90% of reference condition. Thereafter the EWR will be quantified as a desktop EWR to allow the Reserve to be set. Operational scenarios will be evaluated and the ecological consequences and RQOs for the priority estuaries determined. These will be used to prepare class configuration information and RQOs for gazetting.

5.3.5 Socio-economic assessment and ecosystem services

The socio-economic assessment for the study area requires the definition, understanding and classification of social, economic and ecological components. This is done through a stepwise process whereby the primary characteristics within each component are identified and changes thereof are analysed against various scenarios. An overview of tasks in this process is given in Figure 5-2. Figure 5-3

Task 1: **IUA Delineation**

IUAs are a combination of Socio-Economic Zones (SEZ), catchment boundaries and fine scale ecological information. In determining SEZ the following will be investigated on a high-level resolution:

- Ecological infrastructure hotspots (i.e., wetlands, rivers, estuaries, protected areas and dams);
- Social condition (i.e., population density, education level, employment level, and direct use of water); and
- Economic landscape: (i.e., agriculture, industries, urban areas, tourism areas, etc.).

The output of this analysis (i.e., SEZ) will be one of the inputs in IUA's delineation.

Task 2: Describe communities and their wellbeing

The aim of this step is to describe the wellbeing of communities within each IUA and this is through identifying wellbeing of communities, especially on their reliance on the ecological infrastructure.

Task 3: Describe use and value of water

Water Accounting Module

The Water Accounting module aims to define the use of water through physical flows and financial transactions. This allows analysis on how economic changes impact the environment and conversely how changes in water availability impact the economy.

Catchments support various water users. It is important to identify these users and quantify the volumes of water they use in order to understand the water economy within the catchment, and understand water availability for future events which could include increased volumes of transfers to neighbouring catchments. This is done through water accounts. Water accounts framework follows the System of Environmental-Economic Accounting (SEEA) Central Framework. The SEEA Central Framework is an international statistical standard for environmental-economic accounting.

The structure of water accounts refers to the nomenclature of the sectors (or statistical units) in the water value chain that engage in water transactions. The structure of the accounts captures the water economy and reflects the relevant components of the water value chain.

In implementing the water accounts, it is essential to understand and define the statistical units of the economy as they interact with each other and with the natural environment. The economy abstracts water from the environment. Water is exchanged and used within the economy and discharged into the environment.

The water accounting process starts early in the WRCS process, when IUAs are analysed using socio-economic techniques. A wide range of data sources are used, both spatial and socio-economic, to describe and quantify economic activity in each IUA. This includes sectors that link to ecosystem services.

Water accounts consist of physical and monetary accounts. Physical water flow accounts provide information on the volumes of water exchanged between the environment and the economy (abstraction and returns) and water exchanged within the economy. The rows represent the supply, and the columns represent the end-use. This information can also be used to identify beneficiaries of aquatic ecosystem services. Monetary accounts have a similar structure to the physical account but its measures water transactions in monetary terms.

Task 4: Develop an inventory of Aquatic Ecosystem Services

The purpose of this task is 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. This is done through the Ecosystem Services Module.

Ecosystem Services Module (ESM)

The Ecosystem Services Module functions to standardise the identification, quantification and prioritisation of services. The Socio-Economic Comparison Tool (SEcT) (Naidoo *et al.,* 2017) is used as the platform from which to frame relationships between various components. Although inputs drew largely from data collected (and presented) in the status-quo report, additional data inputs are identified and included where necessary. Key data that are used as inputs into the module include the following:

- The presence of Ecological Infrastructure segregated into type, extent and condition per IUA;
- The socio-economic wellbeing of communities within the catchment represented by demographic breakdowns and spatial indicators of land use per IUA as well as indicators of vulnerability and wellbeing; and
- Classification of beneficiaries per IUA into representative beneficiary categories present within standard Social Accounting Matrix (SAM). These are further segregated into formal and informal recipients of ecosystem services.

Utilising the data inputs, ecosystem services are prioritised against the risk of impact on socio-economic wellbeing through impact to ecological infrastructure. The process involved undertaking a comparative risk assessment per IUA looking at the likelihood and consequences of impact to beneficiaries.

The resulting output is a prioritised list of Ecosystem Services that are spatially aggregated in each IUA.

Task 5: Setting up *Quasi-Social Accounting Matrix Module*

The Quasi-Social Accounting Matrix (QSAM) aims to quantify the size of the study area economy. The QSAM module is developed from the Supply and Use tables published by Statistics South Africa (Stats SA) for the desired base year. The first step is to develop an Input-Output table. An Input-Output table is a representation of National or Regional economic accounts that records how industries produce and trade between themselves (i.e., flows of goods and services). The flows for input are recorded in the columns of the Input-Output table and the outputs are included in the rows of the table. These flows are recorded in a matrix, simultaneously by origin and destination (OECD, 2006). An input-output analysis is the standard method for measuring the propagation effects of changes in final demand for a product in an industry or sector (Surugiu, 2009). The Input-Output table is then extended into a QSAM by incorporating labour (compensation of employees) and households.

The macro-economic indicators estimated in the QSAM model for the WMA are Gross Value Added (GVA) and Compensation to Employees as described in Table 5-3 below.

Table 5-3: Macro-economic indicators estimated in the economic model

Indicator	Unit	Description
Gross Value Added (GVA)	Rand Millions	Economic productivity metric measuring the contribution of Loskop scheme to the economy
Compensation to Employees	Rand Millions	Component of the GDP measuring the change in total salaries paid

The QSAM model also estimates economic multipliers from the Leontief inverse matrix. Multipliers indicate the increase in final income arising from the expenditures within economic sectors.

The major economic sectors of the study area is identified using information sourced from the socio-economic profiles and spatial economic overviews of the municipalities that fall within the catchment. Stats SA data is used to determine the total number employed per sector (formal and informal) and together with the Stats SA quarterly employment statistics information the total average salaries per sector are calculated. The WMA GVA is determined per sector based on the national QSAM GVA to compensation of employees' proportion. These values are used to construct the WMA QSAM. Finally, the multipliers are derived from the QSAM.

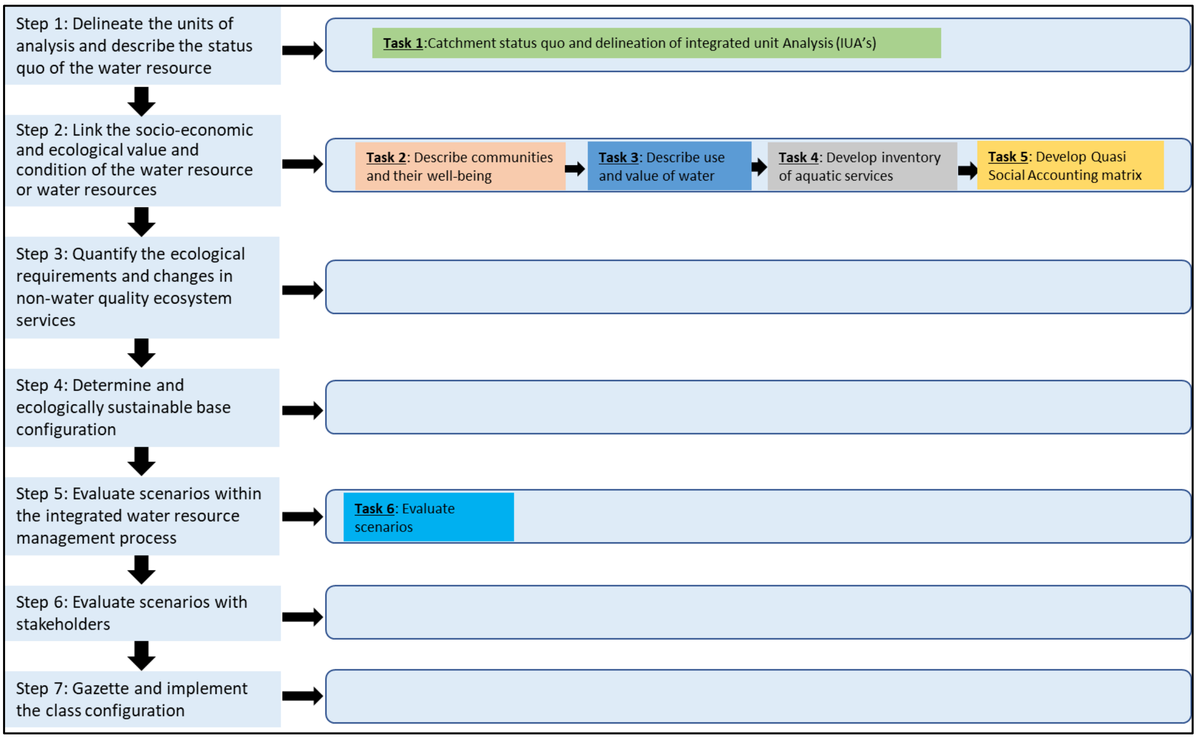

Figure 5-2: Framework to be utilised in assessing socio-economic and ecosystem services for this process

Task 6: Evaluate scenarios

The final step of the socio-economic assessment is to evaluate the socio-economic impacts of the various scenarios. The scenario analysis takes the form of a cost-benefit analysis where the effects of each scenario are quantified, and modelled and quantified at the hand of the water accounts- QSA, and Ecosystem module. The broad approach taken to develop the IEM is provided in Table 5-3. Key inputs, components and outputs of the process include:

i. Comparative risk assessment to identify Ecosystem Services at risk in each scenario; and
ii. The socio-economic response to change in development scenario, which in this case is presented through key economic indicators such as GVA, jobs and value of ecosystem services.

At this point the socio-economic response represents the current status-quo of the catchment. This assessment is done using QSAM module that aims to quantify the size of the study area economy. The QSAM combines the suppliers and consumers of economic products into a single matrix (table of interacting economic sectors) in order to determine the magnitude of the macro-economic indicators of the study area economy.

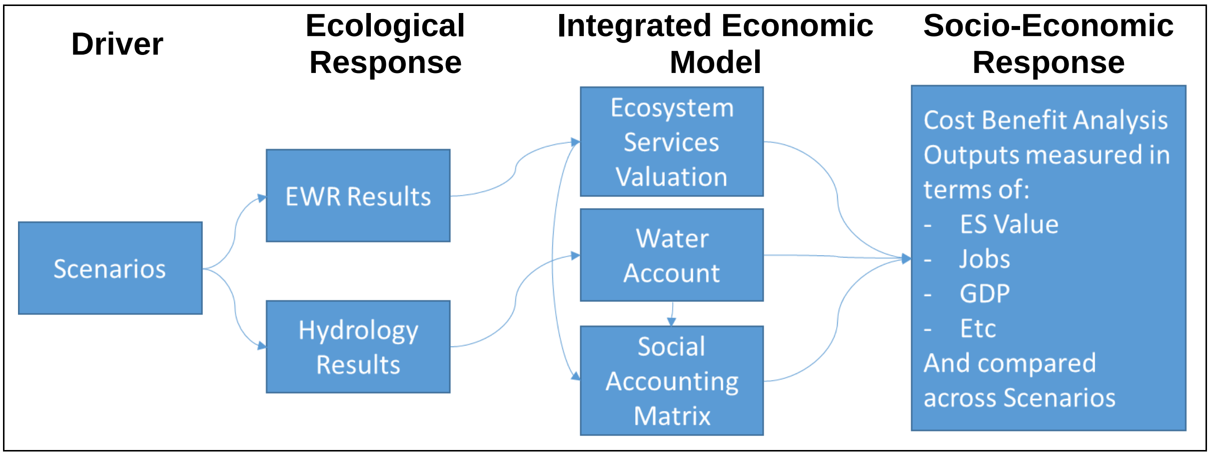

Figure 5-3: Approach to the development of the Integrated Economic Model that Demonstrates the Socio-Economic Linkages in the WRCS scenario process (Arrows indicate flow of data from input to output)

Towards ensuring a robust and defendable output, this approach uses well established methodologies that have been formalised through the literature. At this point of the WRCS 7-step process, the methodologies are used to establish the IEM architecture and populate the modules using the best available data obtained at a desktop level. The IEM will be updated as additional primary data becomes available.

5.3.6 Water Resources Modelling

The standard Water Resources Systems Models (WRYM or WRPM) will be used for this analysis depending on availability of these models for the larger study catchment. Preference will be given to model configurations for integrated water resource systems (e.g. Algoa water supply system for Port Elizabeth (Gqeberha) - local sources and transfer from Gariep to Fish and Sundays Rivers, Amatole water supply system for East London - Nahoon, Buffalo and Kubusi (Kei River)). Where available, models for the other, smaller systems (e.g. Mtata, Mbashe, etc.) will be sourced from DWS. These models and datasets will be reviewed with respect to the confidence and usability thereof. The next important aspect will be the linking of models. The linking of models will be driven by the following factors:

A. The extent of existing or planned transfers or common supply as part of a water supply system, e.g. the Algoa or Amatole Water supply systems. The linking may be required to be maintained in the assessments, to understand how impacts on local resources through proposed classes and ecological water requirements, impact the greater water supply systems through existing or proposed systems operations.
B. The hydrological data period. Here the longest available hydrological period should be used, but where systems need to be analysed as connected integrated systems, then the longest common (overlapping) period of hydrological data has to be used.

Consideration of the above 2 points, and associated pro's and con's in combining systems, will determine how the various catchments are modelled.

Where WRYM/ WRPM models are not available, especially for the smaller coastal systems, the results from the WR2012 study for natural and present-day flow time series (1920-2009) will be utilised. The following assessments will be undertaken prior to the simulation of scenario flows:

- Recommendations of how to ensure consistent simulation periods for the study area, especially for the linked systems;
- The Integrated Orange River Model's linkages to the Algoa System will be updated with the latest water use and proposed scenarios for this study;
- The hydrology within the models will be adjusted to the final selected EWR sites and priority estuaries. This might require sub-division of the quaternary or unit hydrology to provide hydrology at the node or site of focus;
- Setup of the WRYM for selected smaller catchments (priority river and/ or estuary) to undertake future scenario simulation; and
- The following scenarios will be modelled at the identified sites:
    - Natural
    - Present Day – Present Day Demands
    - Approximately 5 scenarios for future demands. The number of scenarios will be confirmed and may vary for different catchments, depending on level of development already planned for and the confidence in those projections of future developments.

The future scenarios will be combinations of different target levels of protection (classification), and different levels of water resource development. The water resource development driven scenarios will be identified in collaboration with the DWS and their teams conducting the reconciliation strategy updates and implementation and focus on the preferred reconciliation scenarios (water requirement projections and water resource development / availability).

The WRYM model is expected to be used in preference to the WRPM model, unless a more up to date WRPM model is available than the current WRYM model. The models will be run for the single longest sequence available for the catchment(s) in focus, and supply potential be provided. These supply statistics will include the average supply volume per user (socio-economic or environmental). Where necessary, supply statistics such as the recurrence level of non-supply, e.g. 1:25 years of non-supply might also be needed to augment the assessment of the extent to which a scenario negatively impacts users.

For large dam resources, the change in yield may be an alternative option to assessing water availability impacts, as an alternative to assessing the supply impacts to current or projected water users. The preference if conducting a firm yield analysis over a water supply impact analysis will be driven by the socio-economic impacts envisaged and which method is easier to assess from an economic perspective. This will be assessed on a case-by-case basis.

5.4 Task 4: Determination of RQOs

The objective of Task 4 is to determine Resource Quality Objectives (RQOs), that are narrative and numerical limits for priority resource units and includes the selection of sub-components and indicators. The RQOs will be determined using the DWS document "Procedure to determine and Implement RQO".

The RQOs are essentially clear goals relating to the quality of water resources. The RQOs for the rivers, aquatic environment, including major dams (coupled with seeking guidance from the way they are being operated within the system, especially the Algoa and Amatola systems), the estuarine environment, groundwater and wetlands will be defined in line with the Water Resource Classes in a numerical and qualitative manner and will be used in monitoring and implementation to determine if the overall goals as gazetted are being met. The various tools as developed to prioritise RUs, identification of sub-components and numerical indicators and limits will be used to determine the RQOs.

Depending on the priorities of the RUs as determined in Task 2, different levels of detail will be provided for the RQOs. High priority RUs will comprise detailed RQOs for a variety of components which will be gazetted while low and moderate priority RUs will comprise broad and mostly narrative RQOs. This information will be communicated to the stakeholders during the stakeholder consultation process, in preparation of gazetting the RQOs.

The EWR results from the various water resource components for the Target Ecological Category (TEC - quantity, quality, 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, quality, habitat and biota requirements.

5.5 Tasks 5: Implementation Plan

An implementation plan will be compiled to provide a context of the integrated water resource management environment in the Keiskamma, Fish to Tsitsikamma study area and provide recommendations on implementation actions for the attainment of the Reserve.

5.6 Tasks 5 & 6: Gazetting process and project closure

This step will involve preparing a Legal Notice containing the required information to allow the Minister to approve the Water Resource Classes and associated RQOs. This Legal Notice will be provided for public comments and then be gazetted. The Reserve will only be gazetted once the Classes and RQOs are gazetted.

Lastly, the team will further ensure that the findings (socio-economic and ecological) are documented in a format that can be used by the DWS to support the implementation of the Class, Reserve and RQOs.

5.7 Stakeholder Engagement Strategy

Given the technical context of the classification process, the stakeholder engagement component will seek to:

(i) Inform the broader public of the project and what water resource classification means to them and the catchment; and

(ii) Engage key stakeholders involved in the study area to provide additional information to ensure a better understanding of the water resource activities and impacts on the water resources of the study area.

Thus, a Stakeholder Engagement Strategy (SES) will be developed and form part of the study to engage stakeholders in the process to ensure stakeholder input is incorporated during the determination of the Water Resource Classes, RQOs and Reserve. A robust and focused SES will be undertaken that is aligned to the technical steps of the study. Every effort will be made to link and align to existing structures and forums in the catchment area, especially those identified through the current study to develop a reconciliation strategy for the study area. However, the idea is not to try to consult with everybody, but rather with representatives of specific sectors of society.

The classification, determination of the Reserve and RQOs in the study area will thus require the selection of appropriate points in the technical process that allow for optimisation of stakeholder involvement with required outcomes. The level of stakeholder engagement will range between technical involvement and consultation.

The COVID-19 pandemic poses a significant risk to achieving some of the objectives of this study. Whilst there may be restrictions on numbers permitted at stakeholder gatherings, given the social/physical distancing restrictions, etc., the GroundTruth team have developed a flexible programme to initiate these vital interactive engagements through webinars/zoom/skype platforms.

All plans will be fully compliant with regional COVID 19 protocols. Overall, given the dynamic nature of this pandemic, GroundTruth remains flexible and committed to a close working relationship with the DWS to achieving the most productive and useful outcomes from the study, and within the timeframes available.

Overall, it is envisaged that the stakeholder outputs may include the following:

5.7.1 Consolidated stakeholder database

Stakeholder databases that have been compiled through earlier initiatives will be reviewed and expanded to include stakeholders relevant to the catchment area, including those databases from current parallel studies. The format of the database will be maintained to ensure the reviewed database can be integrated with existing databases if required.

5.7.2 Consultation with the Client regarding project progress

An appropriate process will be developed, in consultation with the Client, to engage the representatives to assess and monitor the progress on the project.

5.7.3 Background Information Documents (BID):

Following the approval of the Inception Report, a BID will be compiled for distribution to all identified stakeholders. The purpose of these documents will be to announce that the DWS is undertaking the determination of Water Resource Classes, Reserve and setting of RQOs for the study area, the process to be followed, anticipated activities, proposed timelines, as well as how stakeholders will be involved in the project, through the Project Steering Committee (PSC) meetings and public meetings. The BID will further introduce the stakeholders to the study and aim to explain the necessity and the context of the study. The BID will accompany an invitation letter inviting stakeholder to the planned and proposed public meetings.

Stakeholders will be given feedback towards the end of a project after the scenario evaluation, selection of the Class and the setting of RQOs. The BID and invitation letter will be circulated to the stakeholders for a second round, inviting them to the final public meetings whereby the results and outcomes will be discussed.

5.7.4 Stakeholder communication and sectoral workshops

Four (4) public engagement meetings will be undertaken for this study at central venues (possible venues East London and Gqeberha). Two (2) meetings will be held at the onset of the study to introduce the study to the stakeholders. The final two (2) stakeholder engagement meetings will be held towards the end of the study to provide the results to the stakeholders.

The stakeholder engagement process will be based on a sectoral approach, i.e. ensuring communication and liaison with stakeholder representatives of the key sectors across the catchment.

5.7.5 Issues and Response Report

The capturing of information and concerns from stakeholders is considered important to the classification process. An Issues and Responses Report will be compiled and updated throughout the study period of the project. This report will list all the comments from stakeholders (to be received at meetings, workshops, emails etc.) and the responses from the project team.

5.8 Communication and liaison

A component to the water resource classification, Reserve determination and setting of RQOs for the study area, is the communication and liaison function. The study team will be responsible for the function and arrangement of various meetings and specialist workshops, PMC meetings, sectorial workshops, ad-hoc technical liaison and stakeholder engagement meetings.

The following workshops/meetings are proposed to be conducted:

- Technical workshops with the specialists on the team will be held at strategic phases throughout the project to ensure co-ordination and integration across the technical focus areas of the project. This collaboration will also feed the capacity building and mentoring/skills transfer objectives discussed within that section below. These meetings will be scheduled in accordance with the study execution and deliverable schedule. Meeting members will be kept informed and updated as and when required;
- Ten (10) Project Management Committee (PMC) meetings held between the PSP and the DWS;
- Six (6) Project Steering Committee (PSC) meetings to be held between the PSP, the DWS, as well as members from various sectors with strategic interests and guidance for the study;
- Four (4) Technical Task Group (TTG) and sectoral meetings will also be held where required; and
- Sectoral meetings will also be held where required.

It must be noted that all secretarial services namely agenda's, registers, minutes and the presentations will be provided by the PSP for the PSC, TTG and sectoral meetings. Meeting minutes for the PMC meetings will be compiled and provided by the DWS.

The communication and liaison reporting structure will include the following with the aim to keep the DWS updated with the project progress:

- Monthly progress reports covering:
    - Progress of work against the programme;
    - Actual expenditure against cash flow estimates;
    - Significant findings and outcomes thereof;
    - Corrective actions taken in respect of work programmes; and
    - Cash flow estimates.
- Quarterly progress reports – these will be similar to the monthly progress reports, but provide detail feedback on the progress of the previous quarter.
- Technical progress reports (interim milestone reports). These will be submitted to the DWS following each defined deliverable which will document the methodology and procedures followed and results achieved.

5.9 Capacity Building and skills transfer

The study team is cognisant of the DWS's and specifically the CD: WEM's imperative to build capacity and transfer skills in water resource management and protection. A capacity building programme has been developed and is included as Appendix F. This programme is based on a model well received by DWS officials on previous projects implemented by this team which includes introductory training before each key workshop, and mentoring of DWS officials by specialists during field surveys, EWR and scenario workshops etc. DWS officials are also encouraged to select specialist fields where they would like to learn more, and pair-up with that specialist during field surveys and workshops. This programme will be updated during the project and following each training session with final participants and comments from the DWS participants.

Furthermore, specific mentorship programmes have been developed and compiled for Mr Henry Maluleke, Mr Lawrence Mulangaphuma, Ms Rendani Makhwedzha and Ms Tinyiko Neswiswi. Each member will complete their programmes in terms of their participation and involvement through the integrated steps as developed through the 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017)' (Appendix F) during the three-year study period.

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

- **Mentorship:** Mentoring of the DWS team - which will involve dedicated, one-on-one guided sessions with the identified specialists on the team addressing rivers, wetlands, estuaries and groundwater as the subject matter;

- **Stakeholder Engagement/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, tools/ methods applied, or applicable approaches followed so that stakeholders become familiar with the methodology applied. Where applicable supporting information will be made available to stakeholders;

- **Specialist workshops:** Various specialist workshops will be held during this study, further providing a platform for identified DWS official, the DWS team and/or trainees.
    - 22 capacity building events are envisaged for this study, which will meet the needs to DWS members. Refer to Table 5-4Table 5-4 for the preliminary capacity building plan/schedule for these workshops/opportunities around rivers, groundwater, wetlands and estuaries that will be held throughout the duration of this study with more detail in Appendix F.
    - All workshops and training sessions will be held virtually, until such time the regulations around the Covid-19 pandemic are alleviated. However, should there become an opportunity for physical face-to-face workshops, whereby these are much more interactive and where the specialists can collaborate with the DWS members, this will be done.
    - The various workshop platforms will be communicated to the DWS well in advance.

- **In-field capacity building:** Various surveys are envisaged for this study, particularly wet and/or dry seasonal surveys for rivers, wetlands, and estuaries, to obtain in-field insight, all which are incorporated into the below-mentioned tools and models, which will be trained upon during the workshops (Table 5-4). DWS indicated that they will be undertaking rapid level 3 EWR studies together with the specialist team as part of an initiative to build capacity within the DWS to undertake future studies; and

- **Training Workshop:** Participation of identified DWS officials – in a one-day dedicated workshop on water resource components, Regulation 810 (Government Gazette 33541), methodologies as prescribed by the DWS for Reserve determinations of rivers, wetlands, groundwater and estuaries and the steps for the determination of the RQO, coupled with specific technical content. The following Reserve determination tools that the PSP will offer the officials will include the following:
    - Hydrology - Hydrological Driver Assessment Index (HAI);
    - Resource quality (aquatic ecology);
        - Geomorphology Driver Assessment Index (GAI);
        - Physico-chemical Driver Assessment Index (PAI);
        - Invertebrate Habitat Integrity Assessment (IHIA);
        - Fish Response Assessment Index (FRAI);
        - Macro Invertebrate Response Assessment Index (MIRAI);
        - Riparian Vegetation Response Assessment Index (VEGRAI);
    - Wetlands and Estuarine Reserve Determination approaches and tools;
    - Groundwater:
        - Groundwater modelling (conceptual, numerical etc);
        - Groundwater Resource Unit Delineation (GRU);
        - Recharge estimation per delineation (GRU);
        - Baseflow estimation per delineation (GRU);
        - Determination of the groundwater component/contribution to Baseflow;
    - Socio-economics;
    - Geographic Information System (GIS);
    - Water Resource System Analysis; and
    - Hydraulics.

- **Citizen Science:** The potential use of citizen science (CS) to assist during the various in-field verifications and monitoring using the selected river approach levels will be assessed. Beyond the lifespan of this project, this will allow for more data to be collected at more sites, encourage community involvement in water resource management, complement data collected, and upskill community members. Where appropriate, CS tools will be defined and materials describing the implementation and their potential application will be provided. Ideally officials with a specific mandate to monitor and/or engage with communities will be specifically identified to co-create the opportunities for the translation and then application of CS tools into longer term monitoring programmes to achieve and meet the monitoring requirements.

The programme developed details:

- The proposed workshops dedicated to training DWS officials. These will take place before or during key tasks in the project (e.g. field surveys, EWR workshops, Scenario and trade-offs workshops, RQO workshop etc.);
- DWS officials' involvement in the day-to-day management of the project (throughout the duration of the project); and
Contents of the progress reports.

Table 5-4: Capacity building preliminary schedule

Capacity Building opportunity		Proposed month
1	Approach for RU delineation and level of assessment	Jan'22
2	Key gap discussion around all components	Jan'22
3	Selection of priority river, estuary, wetland and groundwater RUs	Feb'22
4	EWR site selection	Apr'22
5	Wetland surveys	Apr'22
6	River surveys	May'22 and Feb'23
7	Estuarine surveys	May'22 and Feb'23
8	Socio-economic outline and Socio-Cultural Importance (SCI)	Sep'22
9	River ecoclassification (EcoStatus models)	May'22 and Mar'23
10	River EWR quantification workshop (DRM, RDRM, HFSR)	Jul'22 and May'23
11	Groundwater workshop (PES, quantification and setting RQOs)	Nov'22
12	Wetland's workshop (WET-Health, functioning, EIS)	Apr'23
13	Stakeholder workshop 1 (Citizen Science)	Jul'22
14	Scenarios and Water Resource Modelling	Nov'23
15	Ecological consequences	Nov'23
16	Trade-off workshop	Jan'24
17	Setting of RQOs (Rivers and Estuaries)	Feb'24
18	Setting of RQOs (GW)	Feb'24

Capacity Building opportunity		Proposed month
19	Setting of RQOs (Wetlands)	Feb'24
20	Integration between components (rivers, wetlands & groundwater)	May'24
21	Stakeholder workshop 2 (Citizen Science)	Nov'22
22	1-day Wrap-up training (all components)	Jul'24

5.10 Task 6: Communication, Liaison, Study Management and Co-ordination

An important component to this study is the communication and liaison function. The study team will be responsible for the function and arrangement of various meetings and the specialist workshops, PSC meetings, sectoral workshops, ad-hoc technical liaison and stakeholder engagement meetings.

Technical workshops with the specialists on the team will be held at strategic phases throughout the project to ensure co-ordination and integration across the technical focus areas of the project. This collaboration will also feed the capacity building and mentoring/skills transfer objectives.

A reporting system will be instituted whereby progress reports, technical memoranda and other material necessary to inform the DWS and other stakeholders will be prepared. Monthly progress reports will be submitted to the DWS to advice on progress and status, coupled with the actual expenditure against cash flow estimates, significant findings and outcomes and corrective actions taken in respect of work programme and cash flow estimates. These progress reports will be submitted monthly and more detailed ones quarterly.

A complete record of proceedings of all meetings will be maintained and appropriately archived.

Technical progress reports will be provided after each defined deliverable in the form of an interim milestone report. These reports shall describe the procedures and methodologies followed and the results achieved. The latter shall be prepared and submitted to the Client according to the milestone programme. These reports will be used as supporting documents for the final Main Report.

5.11 Project Closure

The purpose of this phase is to (i) consolidate the results of the project and to (ii) ensure that all documents, maps, data, etc. are transferred to the DWS for future reference and use. A close-out report will be presented with the final main findings of the study, capacity building initiative and recommendations for future studies.

Refer to Appendix G for the full study programme.

6. *STUDY LIMITATIONS AND CONSIDERATIONS*

Below are various potential limitations/risks and considerations identified for this study. These risks will be monitored throughout the project and the client will be informed should a risk pose a serious threat to the study progress.

6.1 Study area and sub-reaches within the study

Owing to a considerable number of sub-reaches identified within the Keiskamma, Fish to Tsitsikamma catchments, including those reaches which are episodic, we would like to aim to optimise assessing the whole catchment – although pragmatically and within budget. This limitation will be discussed with the DWS during the Inception Meeting to be held on 29 November 2021, as to consider the way forward.

6.2 Seasonal surveys

There is great variation of rainfall through these catchment areas. The northern, north-western, north-eastern and central parts of the catchment area generally receive rainfall between March and May, while along the coastal regions, rainfall is all year round, peaking during the months of December and January (DWS, 2002). Consequently, the wet and dry season surveys will be conducted during May 2022 and February/March 2023 respectively, although depending on the weather conditions.

6.3 Floods or prolonged droughts

The study area is known for its adverse weather patterns, especially in the drier interior. These include prolonged droughts, with major floods afterwards. These will be taking into consideration for the various planned surveys. However, if no flows are available in some of the priority rivers during the duration of the study, other, lower priority rivers will be selected for surveys and assessment. Similar, planned surveys will be postponed if major floods occur just before surveys, as the ecology need time to re-establish after these events. The flows in the rivers will be monitored if any floods occur during surveys, to ensure the safety of the specialists and DWS officials.

6.4 Covid-19 and Riots

The current COVID-19 pandemic poses a significant risk to achieving some of the objectives of this study, particularly virtual platforms when requiring PMC, PSC, SE and the capacity building training component of the project. However, this risk will somewhat be alleviated as time goes by and the vaccination programme continues and improves. Either way, COVID-19 restrictions in place or not, GroundTruth plan to continue this study to the best of their ability in conducting the field surveys and improving SE and training opportunities, where it be hybrid workshops, especially for those workshops where face to face interaction is imperative and necessary.

As COVID-19 is the greatest current risk to the project, GroundTruth have an established and robust COVID-19 Health and Risk Workplace Policy under relevant SA legislation which will be adhered to. For this study, we have integrated this risk and designed suitable mitigation strategies (first aid kits, mobile contactless IR thermometers, face masks, PPE, sanitising etc.) to allow work and field-teams to operate safely, and limiting the risk to vulnerable communities. We also have suitable backstopping options with back-up field teams if needed, should any team member fall ill. These risks and mitigation strategies are continuously updated to industry best practise.

With the recent riot and lootings that occurred within South Africa, should such situations arise while the teams are on-site, the surveys will stop immediately and postponed and continued until safe to do so.

6.5 Aquatic Monitoring

SASS5 sampling will only be carried out in available and accessible habitats, as per the standard SASS5 protocol (e.g. must be flowing water, ideally all substrate types/biotopes present, no flood conditions, wadeable water depth, etc.), and according to health and safety protocols. Elevated flows, lack of habitat etc. may impact on results and the ability to sample.

Diatoms can only be collected when suitable substrate exists in-stream – this is generally not such an issue as there is generally always some available.

In terms of fish sampling, sites will be stratified according to importance based on available velocity-depth and cover types, and intensive fish sampling will only be carried out at the selected sites. Specific fish sampling techniques will be carried out in relation to site specific conditions (e.g. larger systems will require fyke netting/seine netting over longer periods compared to smaller systems where basic electro-shocking sampling and cast netting will suffice).

6.6 Scenarios and Stakeholders

Should the scenarios proposed and presented to the stakeholders during the consultation stage (step 6 of the WRCS process) not be accepted, and furthermore trade-offs cannot subsequently be agreed upon - this could have time and budget implications for the study. The PSP will ensure that the process to develop scenarios will be explained to stakeholders from the onset of this study and the stakeholders will be required to provide their inputs in the development of the scenarios. Therefore, the team will always, at each possible event explain the WRCS process, its aims and objectives to ensure that stakeholders internalize the process.

7. SUMMARY OF STUDY DELIVERABLES AND TIMEFRAME SCHEDULE

The summary of deliverables for the study is included in Table 7-1 below.

Table 7-1: Summary of the study deliverables

Deliverables	Deliverable No.	Due Date
Study Inception meeting, data gathering and Inception Report	4.3.1	December 2021
Water Resources information gap analysis and models Report	4.3.2	January 2022
Desktop Ecological Categorisation, Stress Index analysis, IUA delineation and Status Quo Report	4.3.3	February 2022
RU Prioritisation report	4.3.4	March 2022
Rivers		
Rivers site verification and survey report 1	4.3.5	May 2022
Rivers site verification and survey report 2	4.3.10	March 2023
Rivers Ecoclassification report	4.3.11	July 2023
Report on Quantification of the EWR for Rivers and changes in EGSAs	4.3.14	June 2023
Estuaries		
Estuarine site verification and survey report 1	4.3.5	June 2022
Estuarine site verification and survey report 2	4.3.10	February 2023
Estuaries Ecoclassification report	4.3.11	July 2023
Report on Quantification of the EWR for Estuaries and changes in EGSAs	4.3.14	August 2023
Final Estuarine report	4.3.14	August 2023
Groundwater		
Groundwater site verification and hydrocensus report	4.3.5	July 2022
Define Groundwater PES and quantification of Reserve report	4.3.10	December 2022
Final groundwater report	4.3.11	May 2023
Wetlands		
Wetlands site verification and survey report	4.3.5	August 2022
Wetland ecoclassification workshop and report	4.3.11	May 2023
Final wetlands report	4.3.14	August 2023
Water resources modelling report		
Ecological Base Configuration Scenario Report	4.3.12	December 2023
Management Scenarios report	4.3.13	February 2024
Stakeholder engagement		
Stakeholder engagement plan	4.3.8	December 2021
Stakeholder database and BID 1	4.3.9	November 2021
PSC meeting documentation (6 meetings)	4.3.19	6 throughout lifecycle
Public stakeholder meetings documentation (4 meetings)	4.3.16	4 throughout lifecycle
Sectoral and technical task team meetings documentation (8 meetings)	4.3.17, 18	8 throughout lifecycle
Stakeholder engagement process, record of issues and response report	4.3.9	throughout lifecycle
BID 2	4.3.14	March 2024
Gazetting process - 60 days -(WR Classes, RQOs, Reserve) issues and responses	4.3.24	September 2024
Socio-economics		
Report on Linking the value and condition of the Water Resource	4.3.6	October 2022
BHN report	4.3.7	October 2022
Final socio-economics report	4.3.15	November 2023
July 2024		
Ecological consequences of scenarios Report	4.3.15	February 2024
Water Resource Classes report	4.3.15	January 2024
Setting of RQOs/RU, numerical limits and confidence Report	4.3.17	March 2924
Monitoring programme to support RQOs and Reserve Implementation	4.3.18	July 2024
Water Resources Classes and RQOs Gazette Template	4.3.20	March 2024
Capaity building Report	4.3.21	June 2024
Final Integrated Main Report	4.3.22	July 2024
Project Close Out Report	4.3.23	September 2024

8. STUDY PROGRAMME

The programme of the study tasks is provided in Appendix G. The study will be completed within the 36-month time frame as specified in the contract. In terms of the programme the study is expected to terminate in August 2024.

9. STUDY TEAM

The study team participating in the study are indicated in Table 9-1 and Figure 9-1.

Table 9-1: Study team members

Name	Proposed project role	Organisation
Project Management		
Dr Mark Graham	Project Director/Water Quality Specialist	GroundTruth
Kylie Farrell	Technical Lead/Invertebrate Specialist	Independent
Rivers		
Byron Grant	Fish	Independent
Kylie Farrell	Macroinvertebrates	Independent
Dr Bennie van der Waal	Geomorphology	Independent
James MacKenzie*	Riparian vegetation	Independent
Trevor Pike	Hydraulics	GroundTruth
Khwezi Mncwabe	Hydraulics	GroundTruth
Retha Stassen	Technical integration/Hydrology	Independent
Dr Mark Graham	Water quality	GroundTruth
Groundwater		
Regan Rose	Groundwater/Geohydrology Specialist	JG Afrika
Andile Gumede	Groundwater/Geohydrology	JG Afrika
Estuaries		
Nicolette Forbes	Estuarine Specialist: macroinvertebrates, birds	Marine and Estuarine Research (MER)
Prof Anthony Forbes	Estuarine Specialist: fish, birds	Marine and Estuarine Research (MER)
Derek Stretch	Hydro-dynamics	Marine and Estuarine Research (MER)

Name	Proposed project role	Organisation
Sphamandla Gabela	Estuaries: capacity building and support	Marine and Estuarine Research (MER)
Catherine Meyer	Estuarine Specialist: macroinvertebrates and support	GroundTruth
Wetlands		
Craig Cowden	Wetland Specialist	GroundTruth
Fiona Eggers	Wetland Specialist	GroundTruth
Steven Ellery	Wetland	GroundTruth
Dr Donavan Kotze*	Wetland Ecologist	Independent
Systems modelling		
Jonathan Schroder	Environmental Engineer	Aecom
Gerald de Jager	Environmental Engineer	Independent
Keanu Singh	Systems Analysis	GroundTruth
Socio-economics		
Jackie Crafford	Socioeconomics/BHN Specialist	Prime Africa
Dineo Maila	Socioeconomics/BHN	Prime Africa
Joe Mulders**	Socioeconomics/BHN	Prime Africa
Karen Eatwell	Socioeconomics/BHN	Prime Africa
Vallie Mathebula	Socioeconomics/BHN	Prime Africa
Stakeholder engagement		
Khulile Lamula***	Stakeholder engagement	FutureWorks
GIS and project support		
Carla Hardman	GIS	GroundTruth

**Proposed team member changes awaiting authorisation from the DWS.*
*** Team member which has resigned, although will not be replaced as other team members will take over the tasks*
**** Team member has resigned from study team. Formal resignation letter and a motivational letter for team member change have been submitted to DWS.*

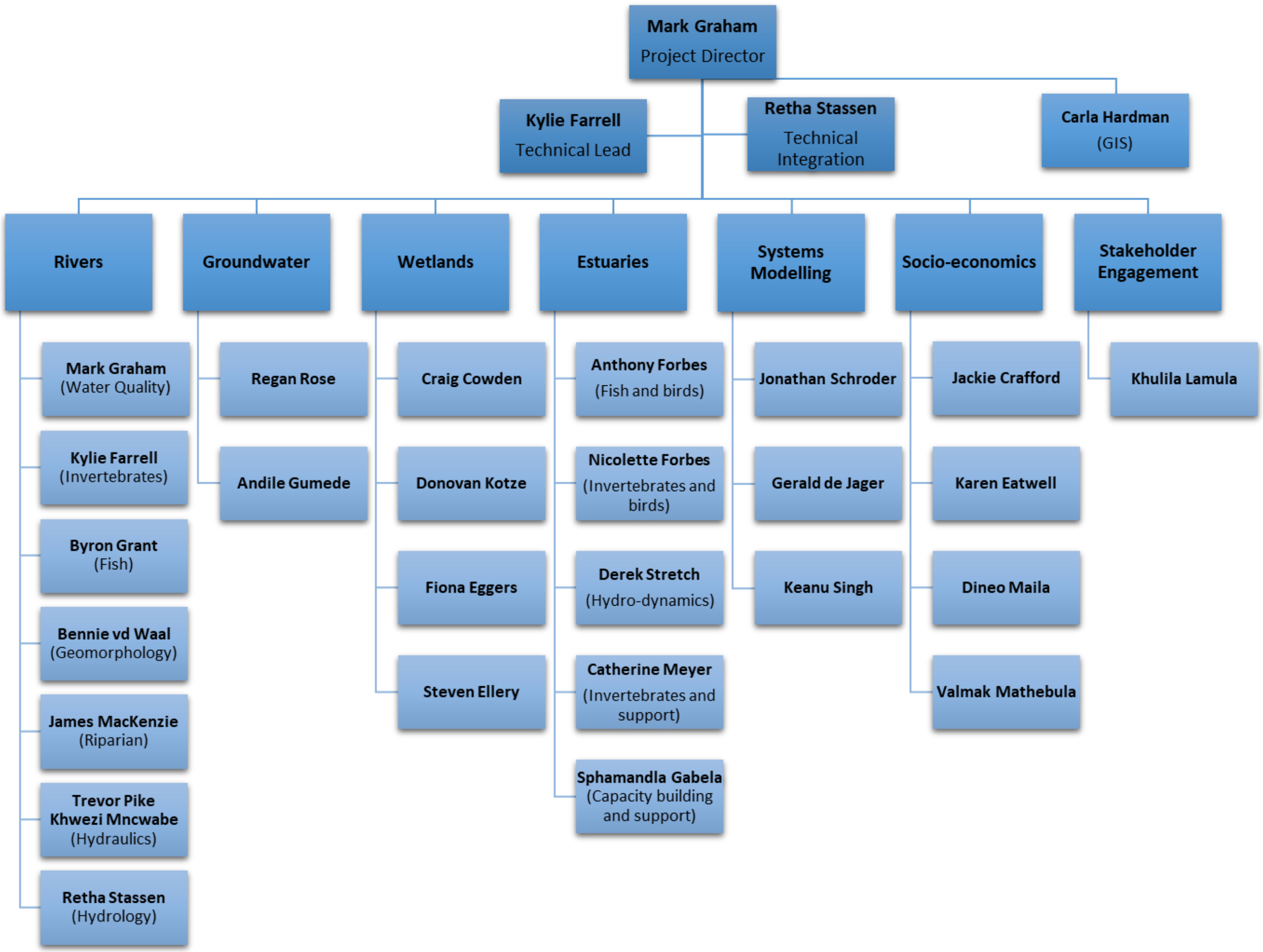

Figure 9-1: Organogram of the project team and their key roles and areas of expertise

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11. APPENDICES

Appendix A: **Study area**

Appendix B: **Figures for rivers per main drainage region**

Appendix C: **Figures for groundwater**

Appendix D: **Figures for ecological important areas**

Appendix E: **Pre-initiation meeting agenda, presentation and minutes**

Appendix F: **Detailed capacity building programme**

Appendix G: **Study programme**

Appendix A: Study area

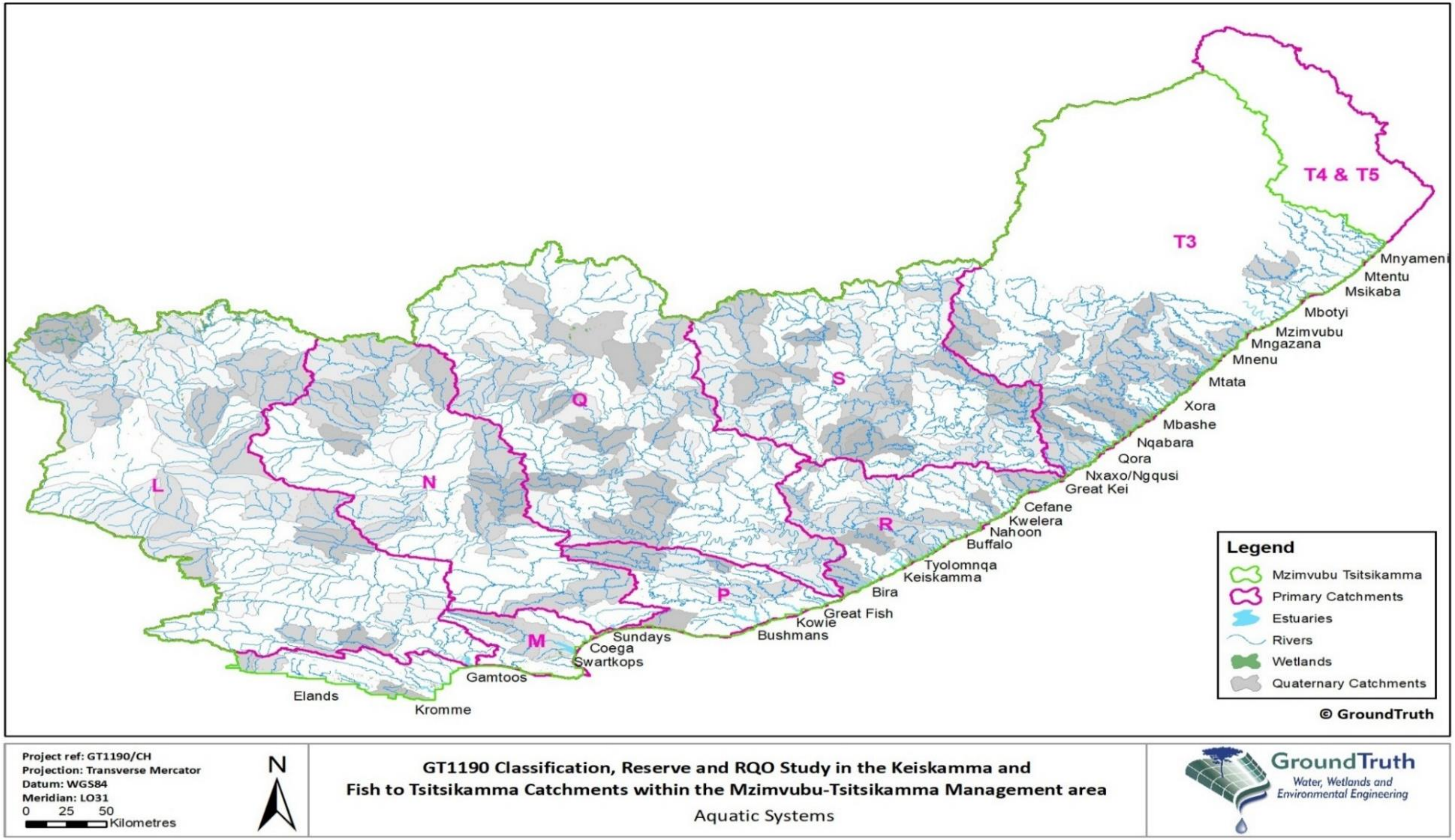

Figure 11-1: Study area of the Keiskamma, Fish to Tsitsikamma

Appendix B: Figures for rivers per main drainage areas

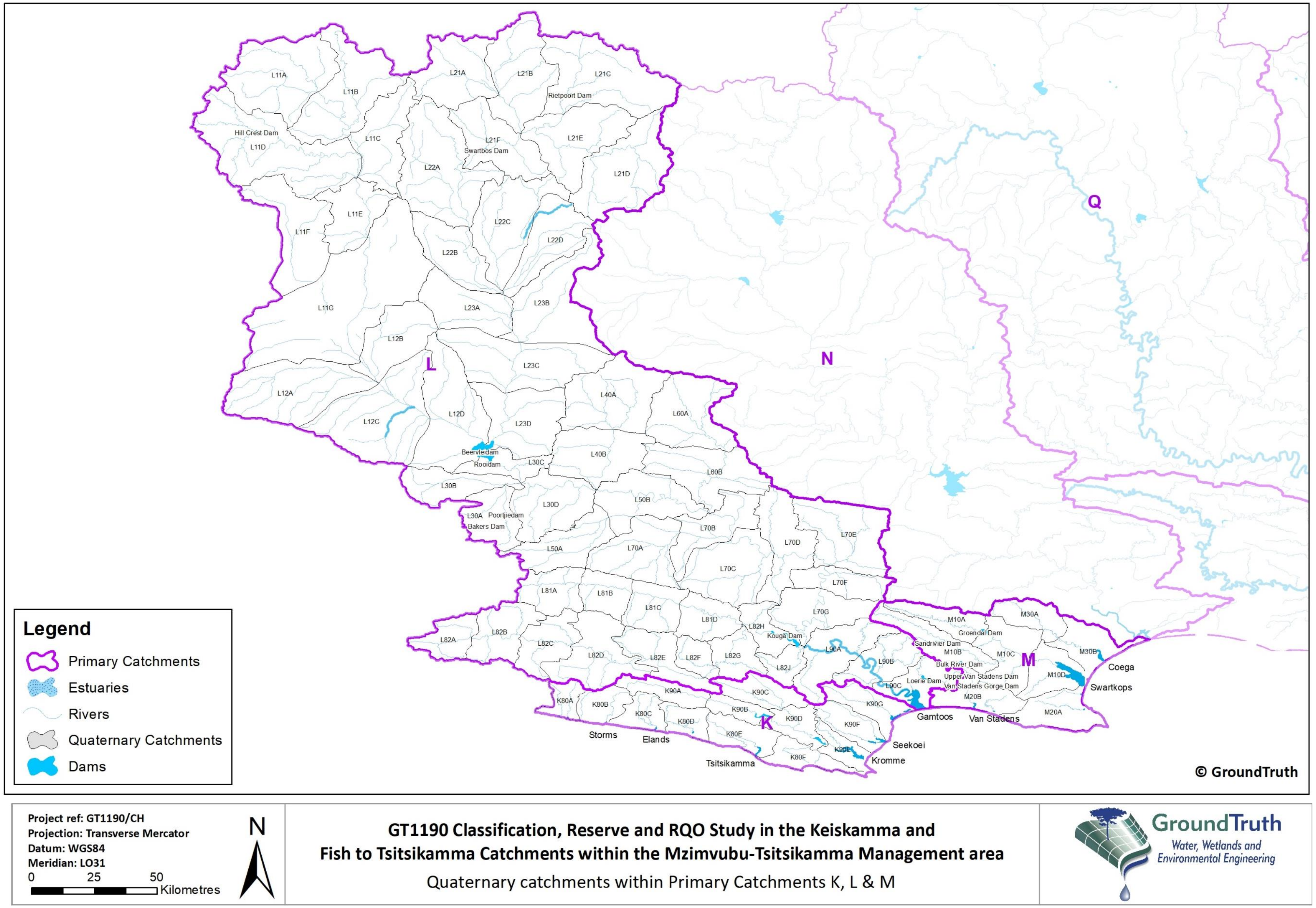

Figure 11-2: Sub-catchment areas within drainage regions M, L, K80 and K90

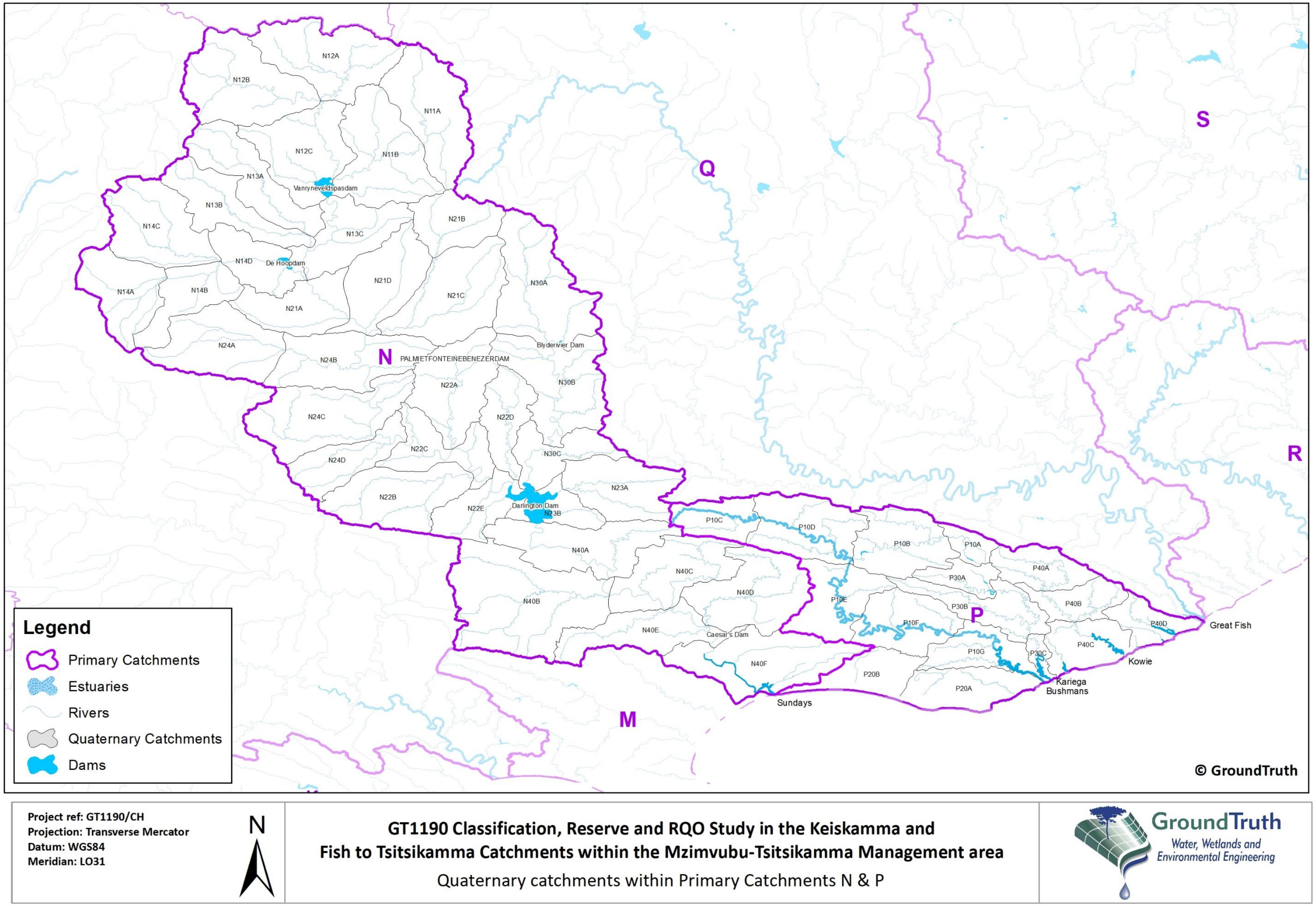

Figure 11-3: Sub-catchment areas within drainage regions N and P

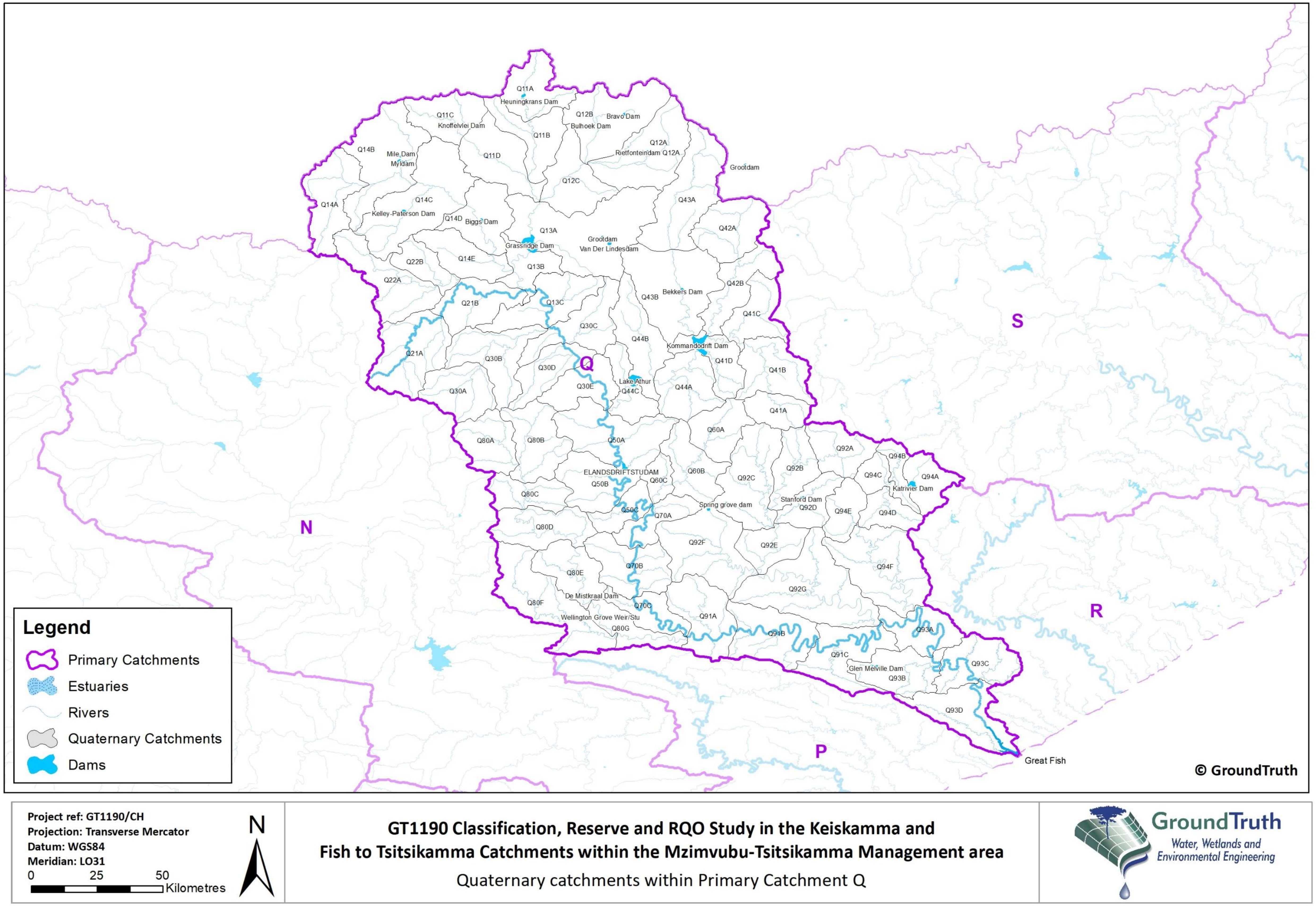

Figure 11-4: Sub-catchment areas within drainage region Q

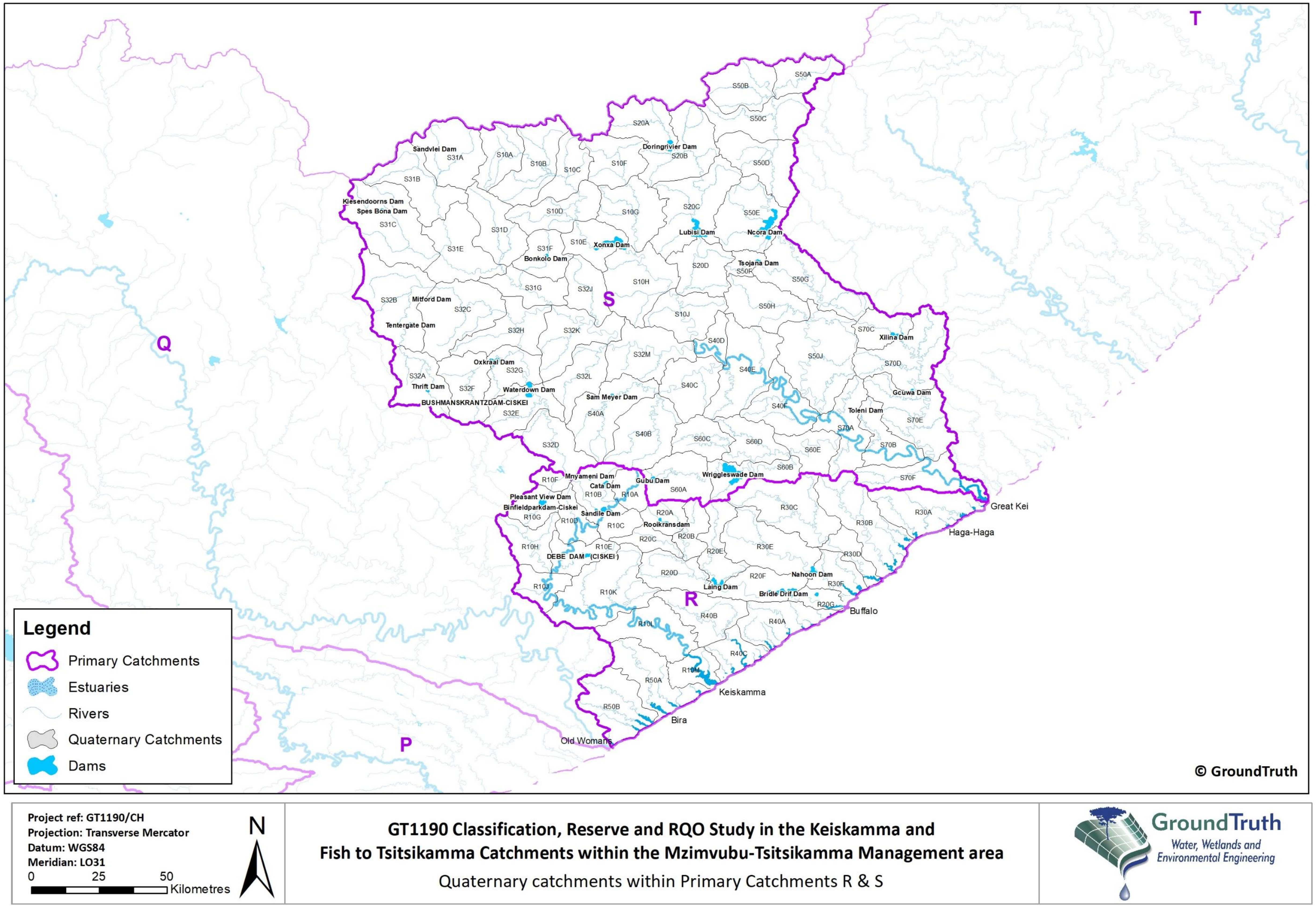

Figure 11-5: Sub-catchment areas within drainage regions R and S

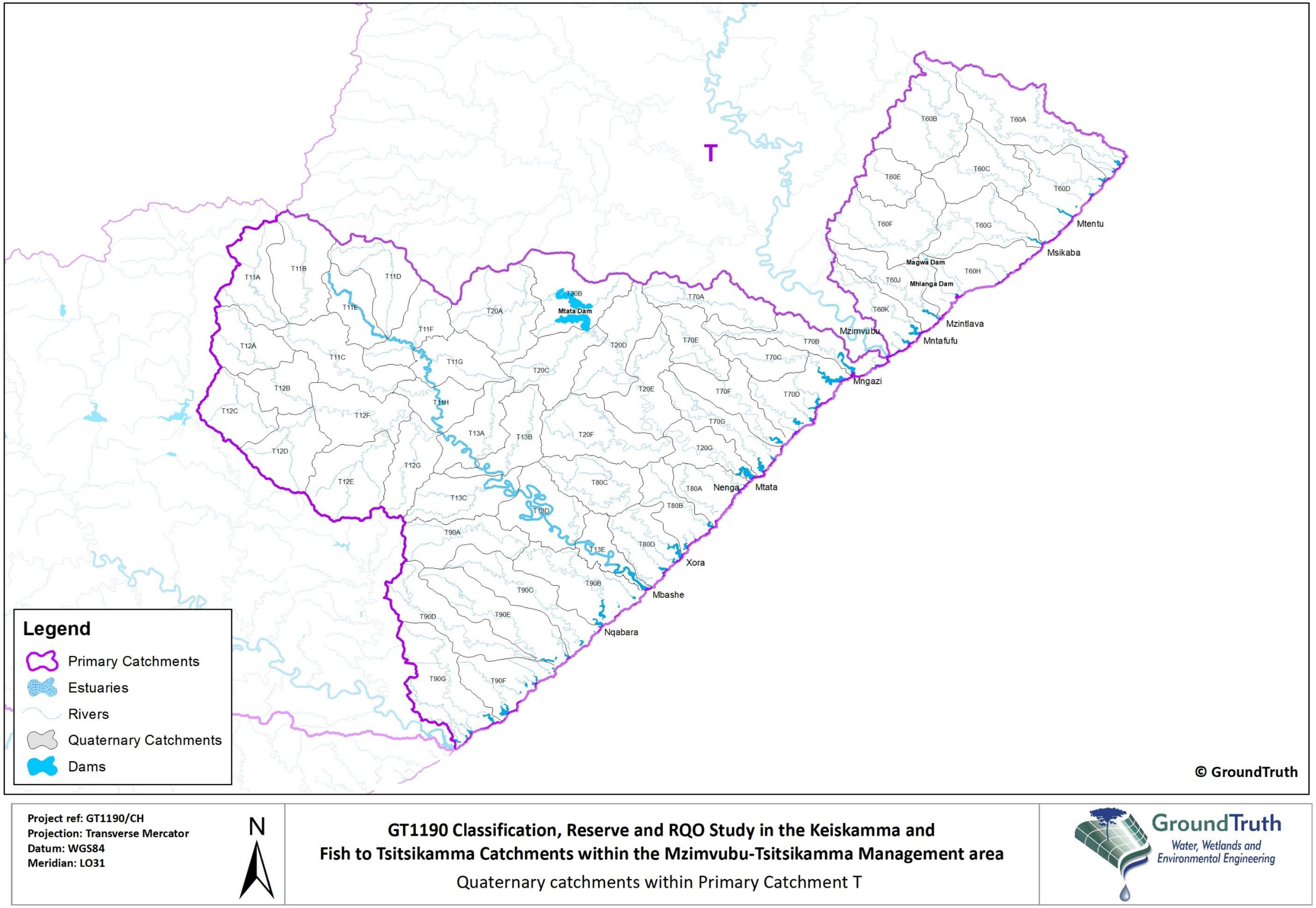

Figure 11-6: Sub-catchment areas within drainage regions T10, T20 and T60 to T90

Appendix C: Figures for Groundwater

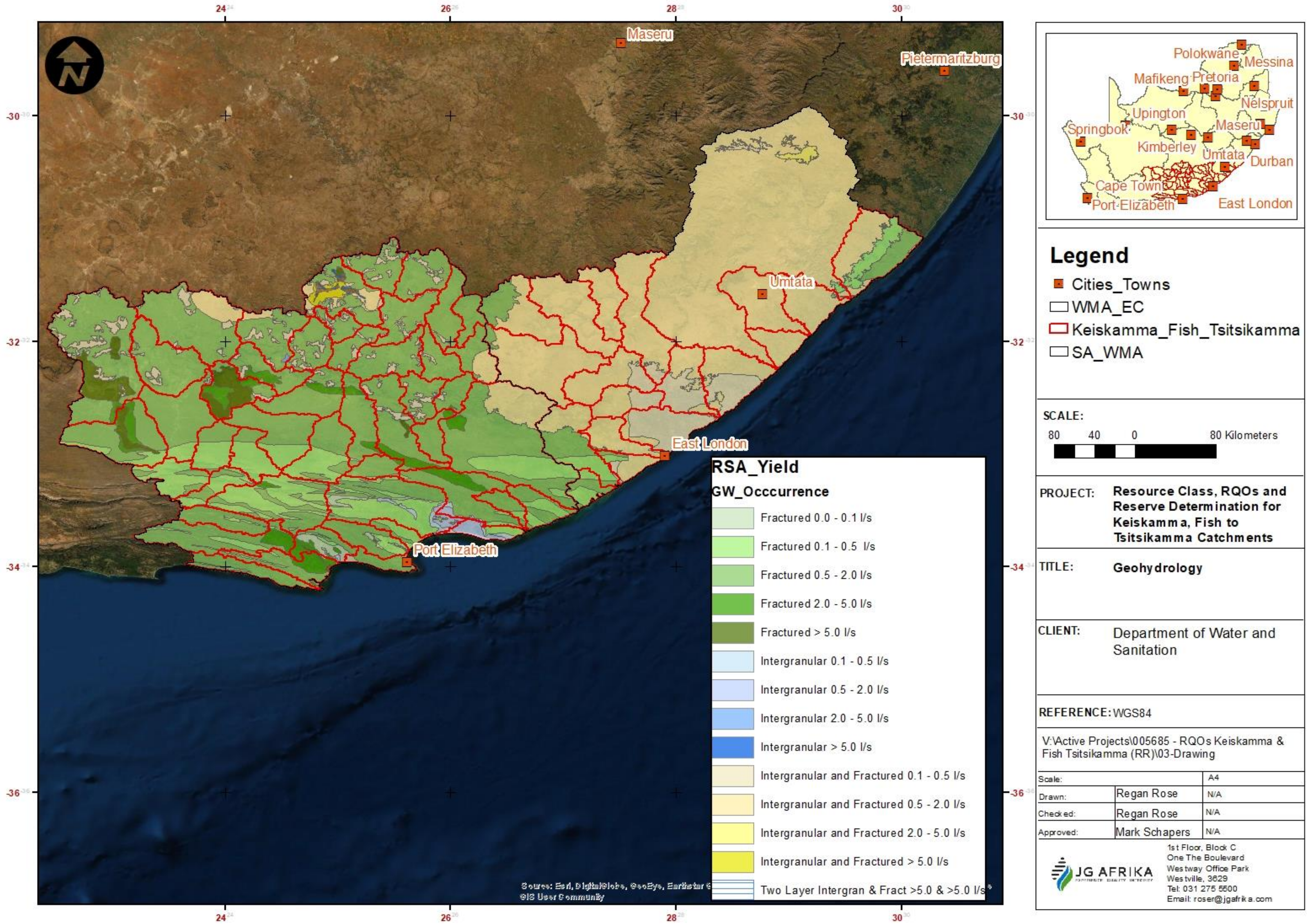

Figure 11-7: Geohydrology

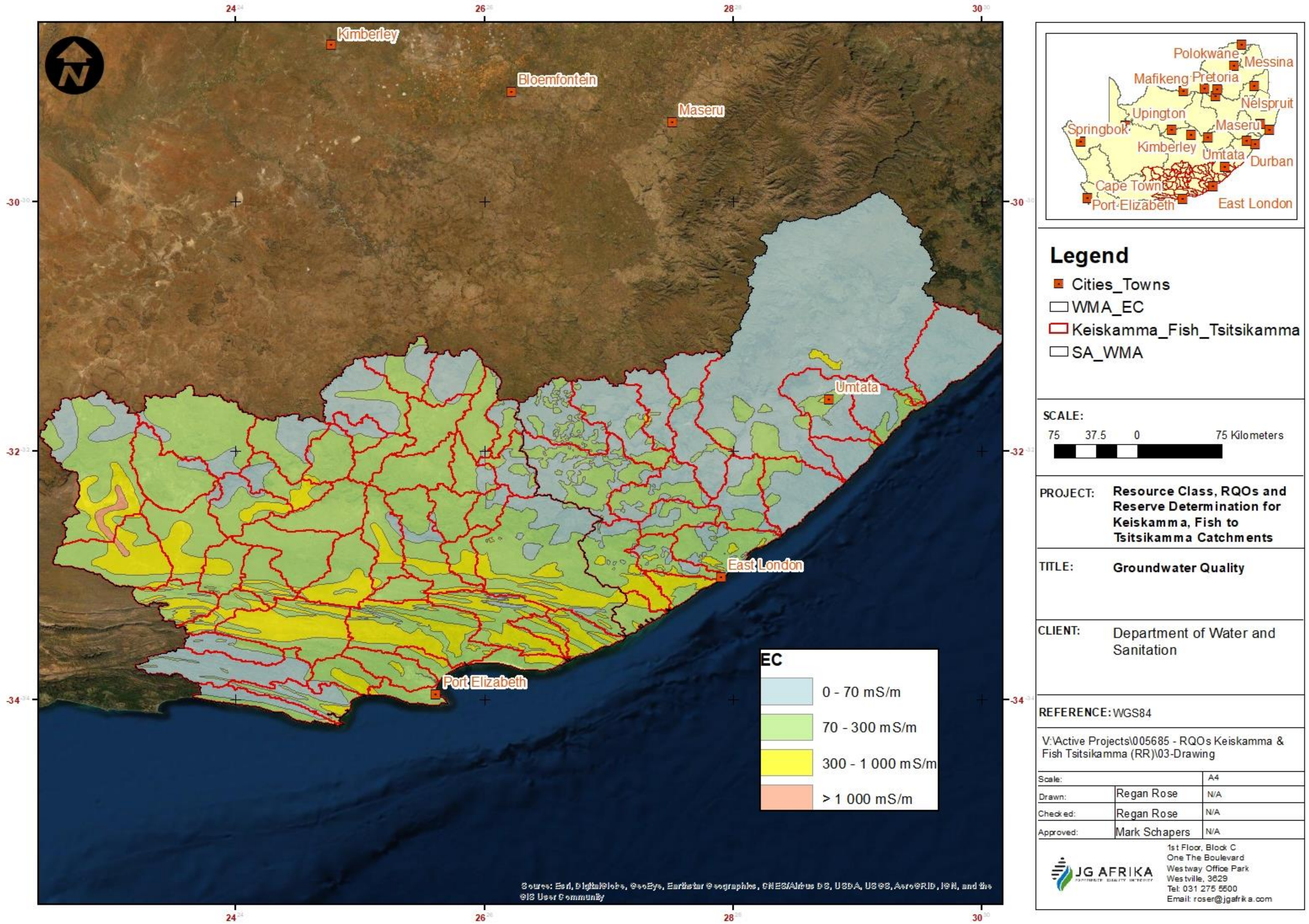

Figure 11-8: Groundwater quality

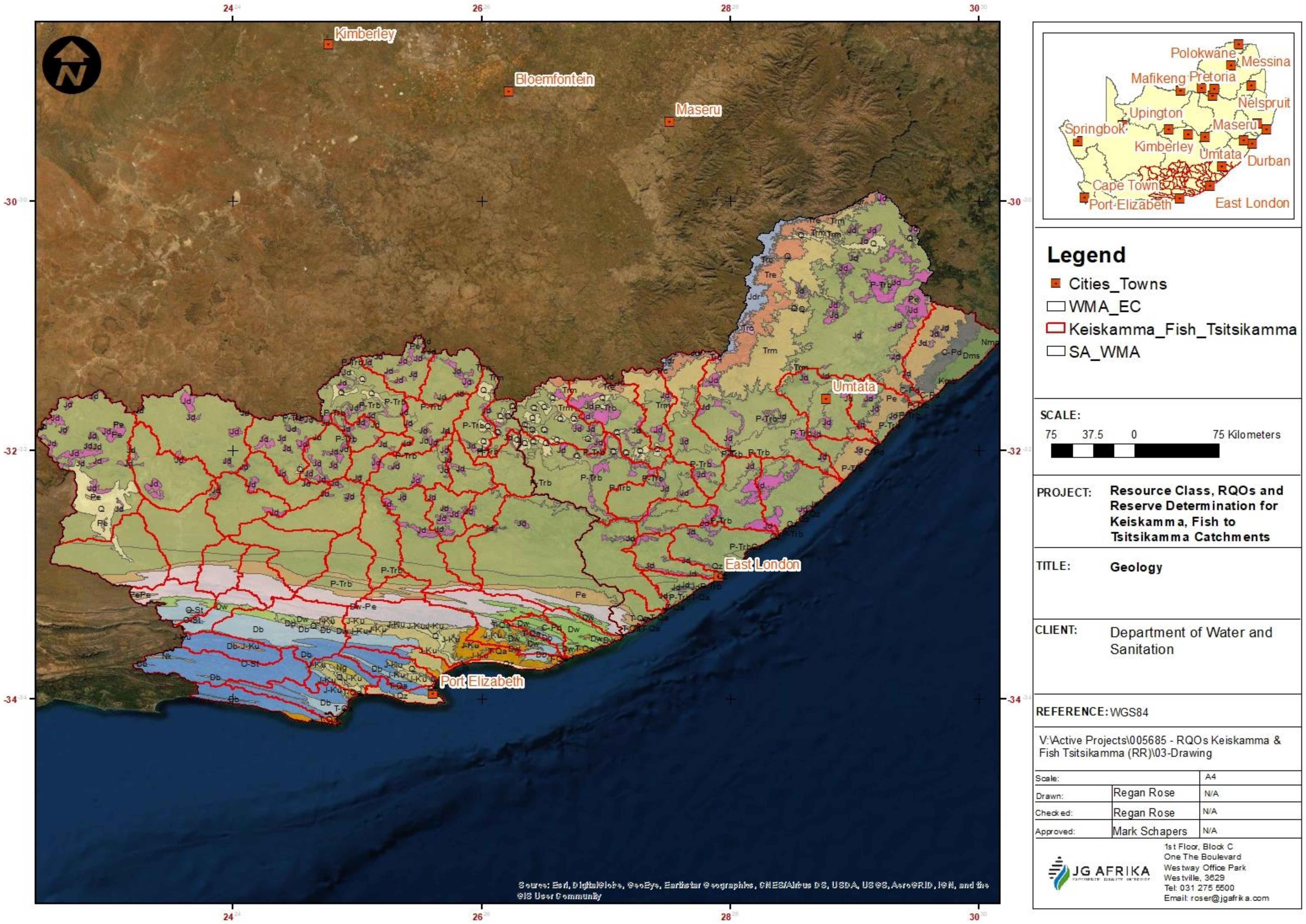

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Figure 11-9: Geology

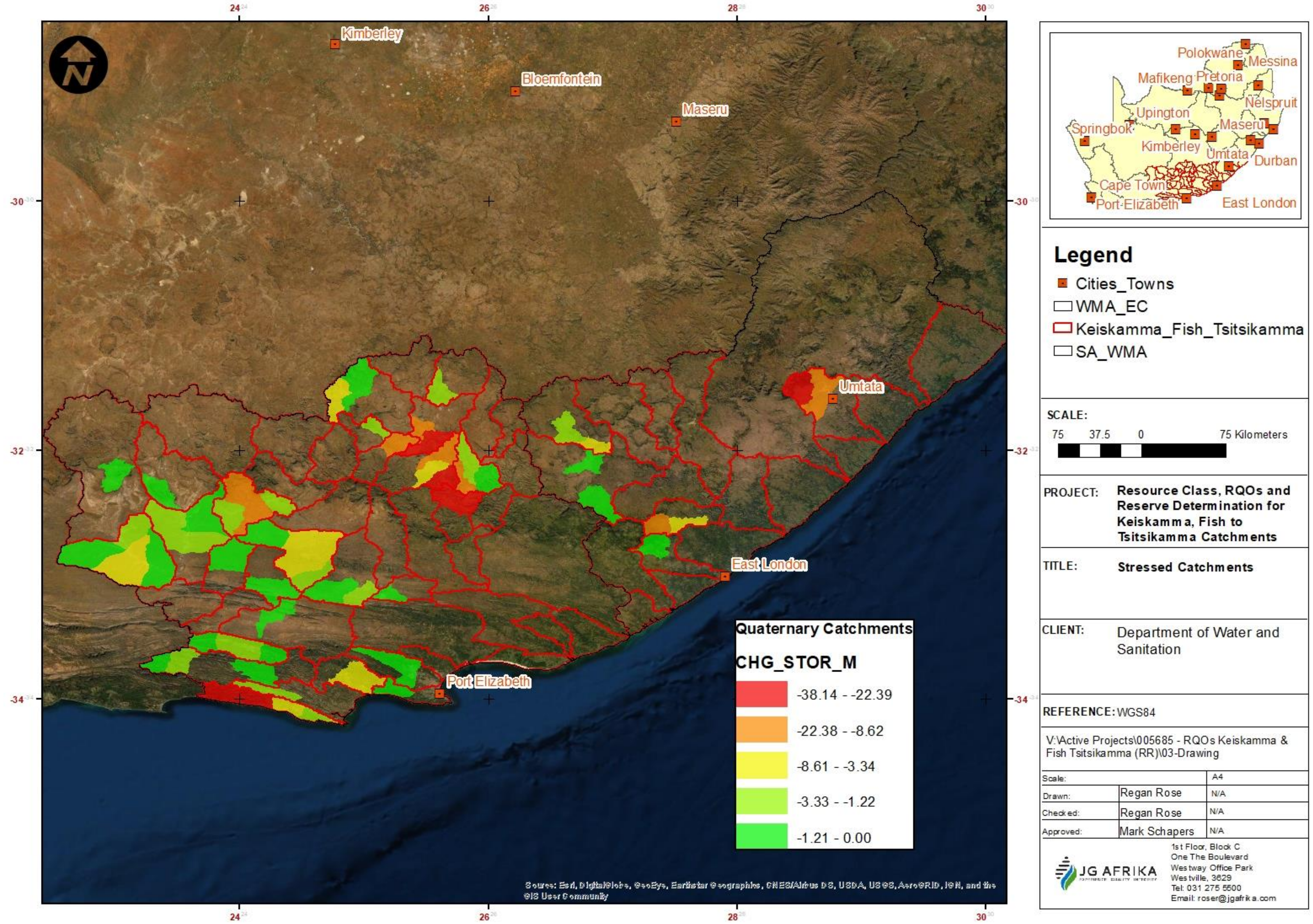


Figure 11-10: Stressed catchments (legend indicates "change in storage": a negative change in storage value reflectsa negative change in storage or deficit in the catchment, thus stressed)

Appendix D: Ecological Important Areas

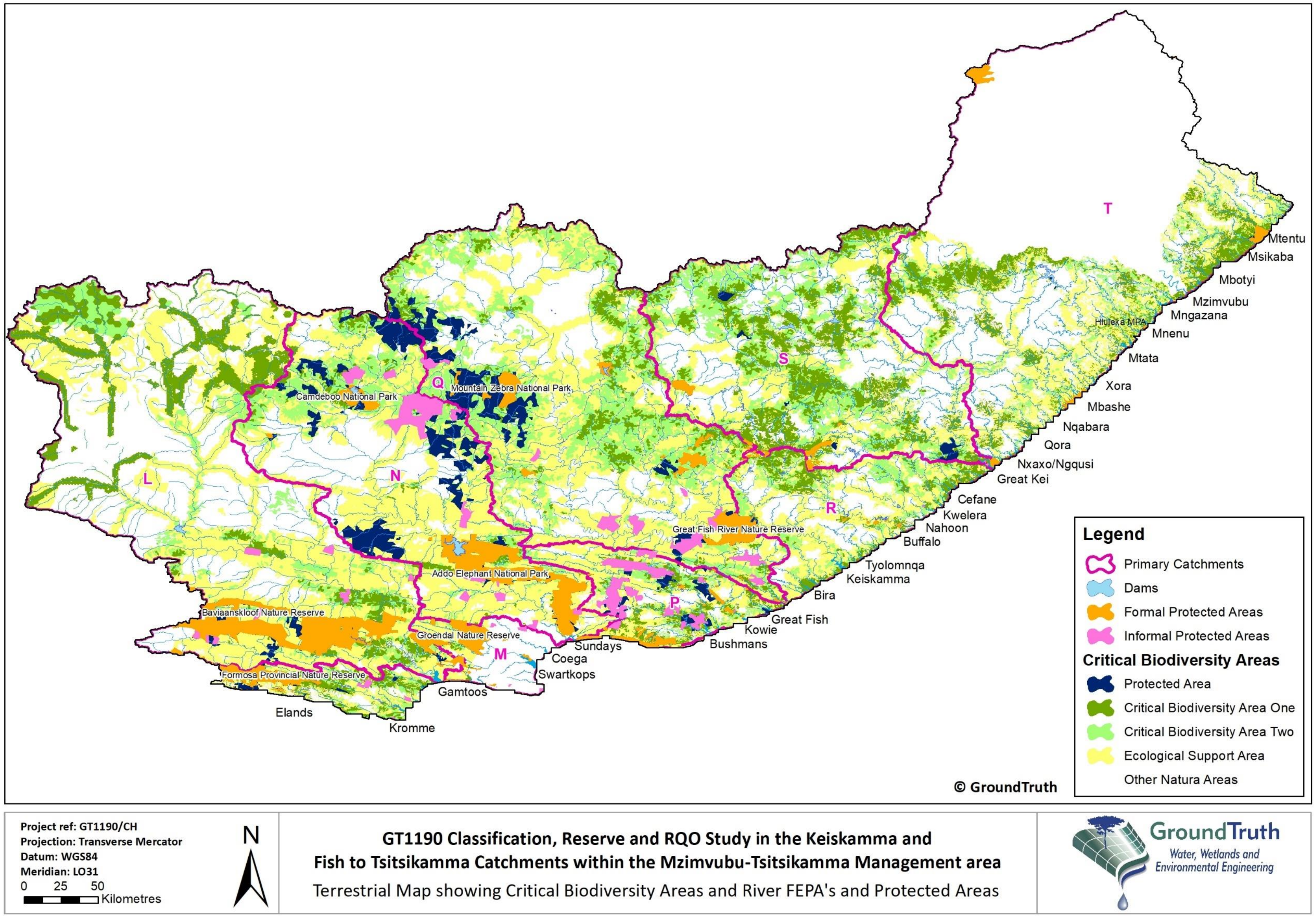


Figure 11-11: Ecosystem threat status (terrestrial)

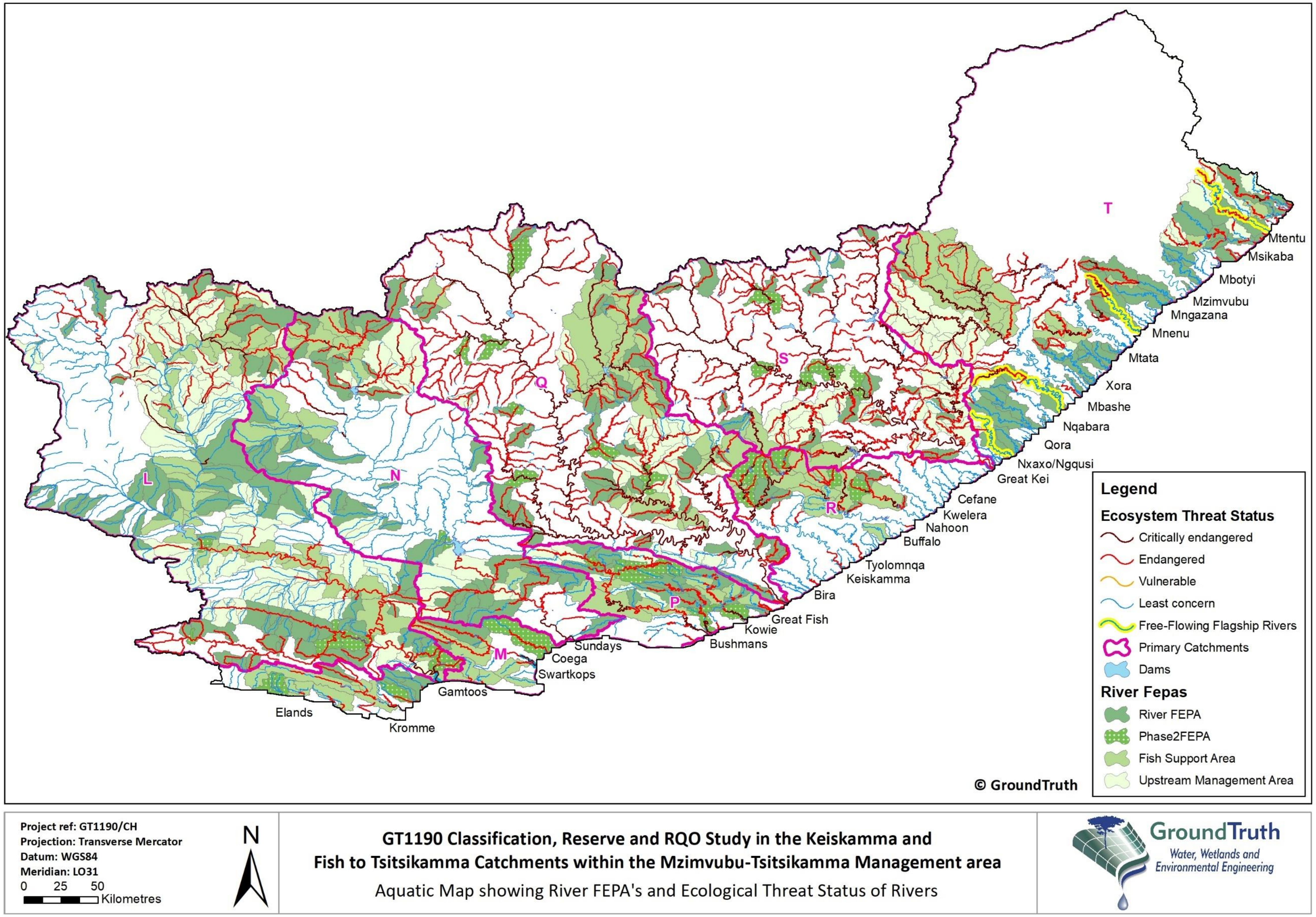


Figure 11-12: Ecosystem threat status (aquatics)

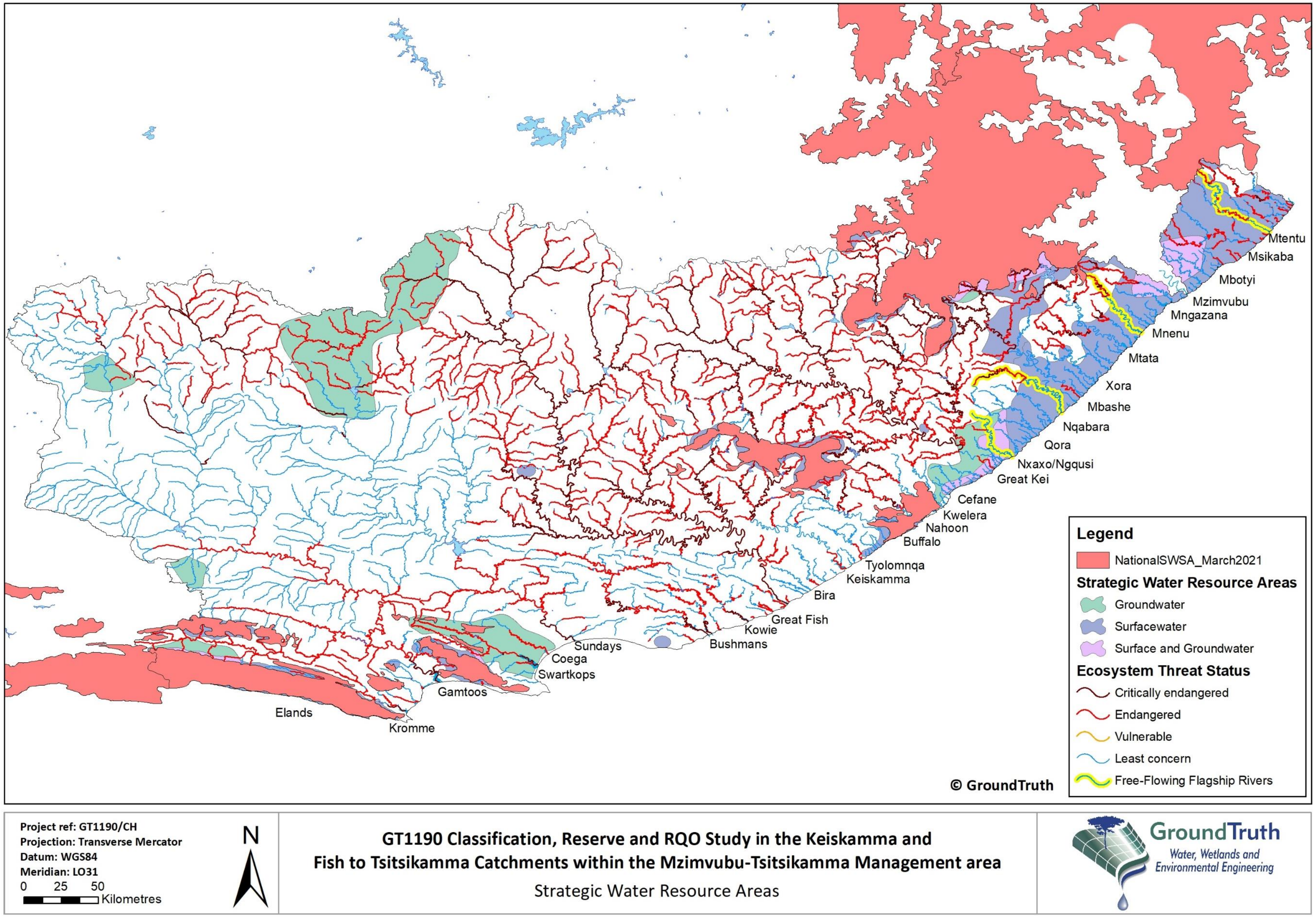


Figure 11-13: Strategic Water Source Areas within the study area - an update/ revision of the 2017 SWSA (Lötter & Maitre, 2021)

Appendix E: Initiation Meeting: 3 November 2021 agenda, meeting minutes and presentation

Appendix F: Detailed capacity building programme

CAPACITY BUILDING PROGRAMME

WP:113543 DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RESOURCE QUALITY OBJECTIVES FOR KEISKAMMA, FISH AND TSITSIKAMMA CATCHMENTS

Activities	Final Participants	Comments from trainees	2021				2022												2023												2024								
			SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1 Approach for RU delineation and level of assessment							◆																																
2 Selection of priority wetland and groundwater RUs								◆																															
3 Key gap disucssion around all components							◆																																
4 EWR site selection										◆																													
5 Wetland surveys										■																													
6 River surveys											◆									◆																			
7 Estuarine surveys											◆									◆																			
8 Socio-economic outline and Socio-Cultural Importance (SCI)															◆																								
9 River ecoclassification (ecostatus models)											◆										◆																		
10 River EWR quantification workshop (DRM, RDRM, HFSR)													◆										◆																
11 Groundwater workshop (PES, quantification and setting RQOs)																	◆																						
12 Wetlands workshop (WET-Health, functioning, EIS)																						◆																	
13 Stakeholder workshop 1 (Citizen Science)													●																										
14 Scenarios and Water Resource Modelling																													◆										
15 Ecological consequences																													◆										
16 Trade-off workshop																															◆								
17 Setting of RQOs (Rivers & Estuaries)																																◆							
18 Setting of RQOs (GW)																																◆							
19 Setting of RQOs (Wetlands)																																◆							
20 Integration between components (rivers, estuaries, wetlands & groundwater)																										◆													
21 Stakeholder workshop 2 (Citizen Science)																													●										
22 1-day Wrap-up training (all components)																																					◆		

◆ = Training workshop

▲ = Individual training

● = Awareness creation/ Citizen science

Mentorship Programme for the Fish study: Mr Henry Maluleke (HM)

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
Step 1: Delineation of RUs and select provisional study sites (Rapid Reserve)	Ecology, Hydrology, Water Quality, Delineation	▪ Hot spot identification and level assessment ▪ Delineation of RUs	▪ Use of Google Earth ▪ Sourcing of data ▪ Delineation of the Resource Units	
Step 2: Describe status quo and delineate study area into IUAs (Rapid Reserve)	Ecology, Hydrology, Water Quality, Socioeconomics, Groundwater, Delineation	▪ Establishment of a network of nodes to be used as the basis of the Classification Process ▪ Determination of the present-day status of the catchment (ecological, economic, social, ecosystem services and water quality) ▪ Delineation of IUAs	▪ Application of GIS ▪ Use of Google Earth ▪ Allocation of nodes ▪ Data collection and sourcing (what to collect and how) ▪ Delineation of the socio-economic zones ▪ Delineate groundwater resource units	
Step 3: Quantify EWRs and BHNR (Rapid Reserve)	Ecology, Hydrology, Hydrodynamics, Water Quality	▪ Reserve field survey ▪ Understanding the hydrology of the Fish to Tsitsikamma system ▪ Understanding the BHNR ▪ EWR processes ▪ Ecosystem services	▪ Sourcing of data ▪ Desktop EWR estimation for biophysical nodes ▪ Interpretation of results ▪ Understanding linkages between ecosystem services, PES and REC	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
Groundwater Modelling	Groundwater Reserve study/ SW-GW interaction	▪ Hydrocensus ▪ Understanding sampling techniques	▪ Measuring interactions ▪ Modeling and information systems ▪ Understanding of groundwater recharge mechanisms	

Mentorship Programme for the Fish study: Mr Lawrence Mulangaphuma (LM)

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
Step 1: Delineation of RUs and select provisional study sites	Ecology, Hydrology, Water Quality, Delineation	▪ Hot spot identification and level assessment ▪ Delineation of RUs	▪ Use of Google Earth ▪ Sourcing of data ▪ Delineation of the Resource Units	
Step 2: Describe status quo and delineate study area into IUAs	Ecology, Hydrology, Water Quality, Socio-economics, Groundwater, Delineation, etc	▪ Establishment of a network of nodes to be used as the basis of the Classification Process ▪ Determination of the present-day status of the catchment (ecological, economic, social, ecosystem services and water quality) ▪ Water resources rezoning and identification of important water use ▪ Delineation of IUAs	▪ Application of GIS ▪ Use of Google Earth ▪ Allocation of nodes ▪ Data collection and sourcing (what to collect and how) ▪ Delineation of the socio-economic zones ▪ Delineate groundwater resource units	
Step 3: Quantify EWRs and BHNR	Ecology, Hydrology, Hydrodynamics, Water Quality	▪ Reserve field survey (Determination of Rapid Reserve) ▪ Extrapolation and ▪ estimation processes, i.e. biophysical nodes ▪ Understanding the hydrology of the Keiskamma	▪ Sourcing of data ▪ Exposure to field data collection methods ▪ Desktop EWR estimation for biophysical nodes ▪ Interpretation of results ▪ Understanding the application of EcoStatus and estuary models	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
		and Fish to Tsitsikamma system ▪ Understanding the BHNR ▪ EWR processes ▪ Ecosystem services	▪ Setting and running the river water quality model (PAI) ▪ Understanding linkages between ecosystem services, PES and REC	
Step 4: Identification and evaluation of scenarios within Integrated Water Resource Management	Ecology, Hydrology, Water quality, macro-economics, ecosystem services, MCA	Establishment of operational scenarios, considering the relationship among social, economic and ecological trade-offs	▪ The development of the scenarios and understanding the scenario modelling process ▪ Interpretation of consequences results	
Step 5: Determine WRC and configurations for the identified scenarios	MCA	▪ Social, economic and ecological trade-offs ▪ MCA ▪ Selection of catchment configurations ▪ Allocation of WRC	▪ Understanding and use of MCA ▪ Understanding the process of defining WRC	
	Citizen science	▪ Application of citizen science in resource monitoring of RQOs.	▪ Site selection ▪ Community identification ▪ Sourcing of data ▪ Exposure to field survey methods.	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
–			▪ Knowledge on effective water resourcing monitoring	

Mentorship Programme for the Fish study: Rendani Makhwedzha

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
Step 1: Delineation of RUs and select provisional study sites (Rapid Reserve)	Ecology, Hydrology, Water Quality, Delineation	▪ Hot spot identification and level assessment ▪ Delineation of RUs	▪ Use of Google Earth ▪ Sourcing of data ▪ Delineation of the Resource Units	
Step 2: Describe status quo and delineate study area into IUAs (Rapid Reserve)	Ecology, Hydrology, Water Quality, Socio-economics, Groundwater, Delineation	▪ Establishment of a network of nodes to be used as the basis of the Classification Process ▪ Determination of the present-day status of the catchment (ecological, economic, social, ecosystem services and water quality) ▪ Water resources rezoning and identification of important water use ▪ Delineation of IUAs	▪ Application of GIS ▪ Use of Google Earth ▪ Allocation of nodes ▪ Data collection and sourcing (what to collect and how) ▪ Delineation of the socio-economic zones ▪ Delineate groundwater resource units	
Step 3: Quantify EWRs and BHNR (Rapid Reserve)	Ecology, Hydrology, Hydrodynamics, Water Quality	▪ Reserve field survey ▪ Extrapolation and ▪ estimation processes, i.e. biophysical nodes ▪ Understanding the hydrology of the Fish to Tsitsikamma system ▪ Understanding the BHNR	▪ Sourcing of data ▪ Exposure to field data collection methods ▪ Desktop EWR estimation for biophysical nodes ▪ Interpretation of results ▪ Understanding the application of EcoStatus and estuary models	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
		▪ EWR processes ▪ Ecosystem services	▪ Setting and running the river water quality model (PAI) ▪ Understanding linkages between ecosystem services, PES and REC	
Step 4: Identification and evaluation of scenarios within Integrated Water Resource Management	Ecology, Hydrology, Water quality, macro-economics, ecosystem services, MCA	Establishment of operational scenarios, considering the relationship among social, economic and ecological trade-offs	▪ The development of the scenarios and understanding the scenario modelling process ▪ Interpretation of consequences results	
Step 5: Determine WRC and configurations for the identified scenarios	MCA	▪ Social, economic and ecological trade-offs ▪ MCA ▪ Selection of catchment configurations ▪ Allocation of WRC	▪ Understanding and use of MCA ▪ Understanding the process of defining WRC	
Step 6: RQOs and implementation	Determination of the RQOs	Development of RQOs	▪ Use of the RQOs toolkit and development of numerical limits ▪ Knowledge on effective water resourcing monitoring	
Step 7: Gazette WRC and RQOs	Communication, Public participation,	▪ Stakeholder consultation ▪ Legal input to gazetting	▪ Stakeholder engagement	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
	Stakeholder engagement			

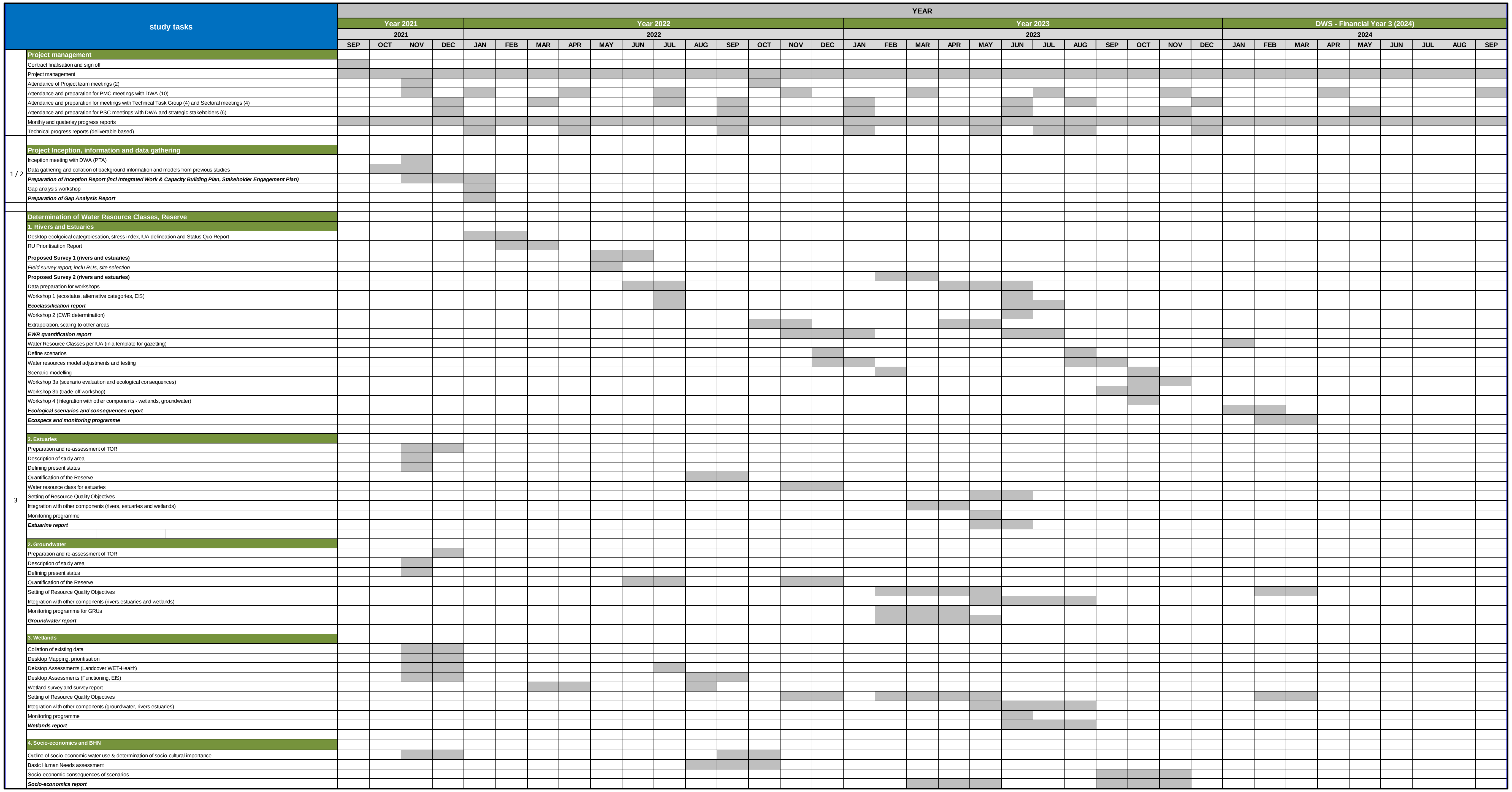
Mentorship Programme for the Fish study: Tinyiko Neswiswi

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
Step 1: Delineation of RUs and select provisional study sites (Rapid Reserve)	Ecology, Hydrology, Water Quality, Delineation	▪ Hot spot identification and level assessment ▪ Delineation of RUs	▪ Use of Google Earth ▪ Sourcing of data ▪ Delineation of the Resource Units	
Step 2: Describe status quo and delineate study area into IUAs (Rapid Reserve)	Ecology, Hydrology, Water Quality, Socio-economics, Groundwater, Delineation	▪ Establishment of a network of nodes to be used as the basis of the Classification Process ▪ Determination of the present-day status of the catchment (ecological, economic, social, ecosystem services and water quality) ▪ Water resources rezoning and identification of important water use ▪ Delineation of IUAs	▪ Application of GIS ▪ Use of Google Earth ▪ Allocation of nodes ▪ Data collection and sourcing (what to collect and how) ▪ Delineation of the socio-economic zones ▪ Delineate groundwater resource units	
Step 3: Quantify EWRs and BHNR (Rapid Reserve)	Ecology, Hydrology, Hydrodynamics, Water Quality	▪ Reserve field survey ▪ Extrapolation and ▪ estimation processes, i.e. biophysical nodes ▪ Understanding the hydrology of the Fish to Tsitsikamma system ▪ Understanding the BHNR	▪ Sourcing of data ▪ Exposure to field data collection methods ▪ Desktop EWR estimation for biophysical nodes ▪ Interpretation of results ▪ Understanding the application of EcoStatus and estuary models	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
		▪ EWR processes ▪ Ecosystem services	▪ Setting and running the river water quality model (PAI) ▪ Understanding linkages between ecosystem services, PES and REC	
Step 4: Identification and evaluation of scenarios within Integrated Water Resource Management	Ecology, Hydrology, Water quality, macro-economics, ecosystem services, MCA	Establishment of operational scenarios, considering the relationship among social, economic and ecological trade-offs	▪ The development of the scenarios and understanding the scenario modelling process ▪ Interpretation of consequences results	
Step 5: Determine WRC and configurations for the identified scenarios	MCA	▪ Social, economic and ecological trade-offs ▪ MCA ▪ Selection of catchment configurations ▪ Allocation of WRC	▪ Understanding and use of MCA ▪ Understanding the process of defining WRC	
Step 6: RQOs and implementation	Determination of the RQOs	Development of RQOs	▪ Use of the RQOs toolkit and development of numerical limits ▪ Knowledge on effective water resourcing monitoring	
Step 7: Gazette WRC and RQOs	Communication, Public participation,	▪ Stakeholder consultation ▪ Legal input to gazetting	▪ Stakeholder engagement	

Steps	Learning area	Task description	Skills required	Mentee participation / involvement
	Stakeholder engagement			

Appendix G: Study programme



	study tasks	YEAR																																				
		Year 2021				Year 2022												Year 2023												DWS - Financial Year 3 (2024)								
		2021				2022												2023												2024								
		SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	5. Determination of RQOs																																					
	Report on the prioritization and selecting of preliminary RU for RQO determination																																					
	RQO workshop																																					
4	**RQO Report**																																					
	RQO per RU within a template for gazetting																																					
	Implementation/operationalization Plan of the Water Resource Classes and the RQOs, including the monitoring programme																																					
	5. Stakeholder engagement																																					
	Develop stakeholder database and engagement plan																																					
5	General awareness creation (BID, invitations)																																					
	Stakeholder meetings x 4 (2 at start of project and 2 towards end of project)																																					
	Register of stakeholder comments and responses																																					
	Gazetting Process																																					
6	Facilitate the gazetting of recommended Water Resource Classes per IUA, Reserve and associated RQOs																																					
	Address all comments received during the 60 days public review																																					
	Capacity building																																					
7	Specialist workshop																																					
	Capacity building report																																					
	Reporting																																					
8	**Main integrated report**																																					
	Preparation of templates																																					
	Close-out report																																					