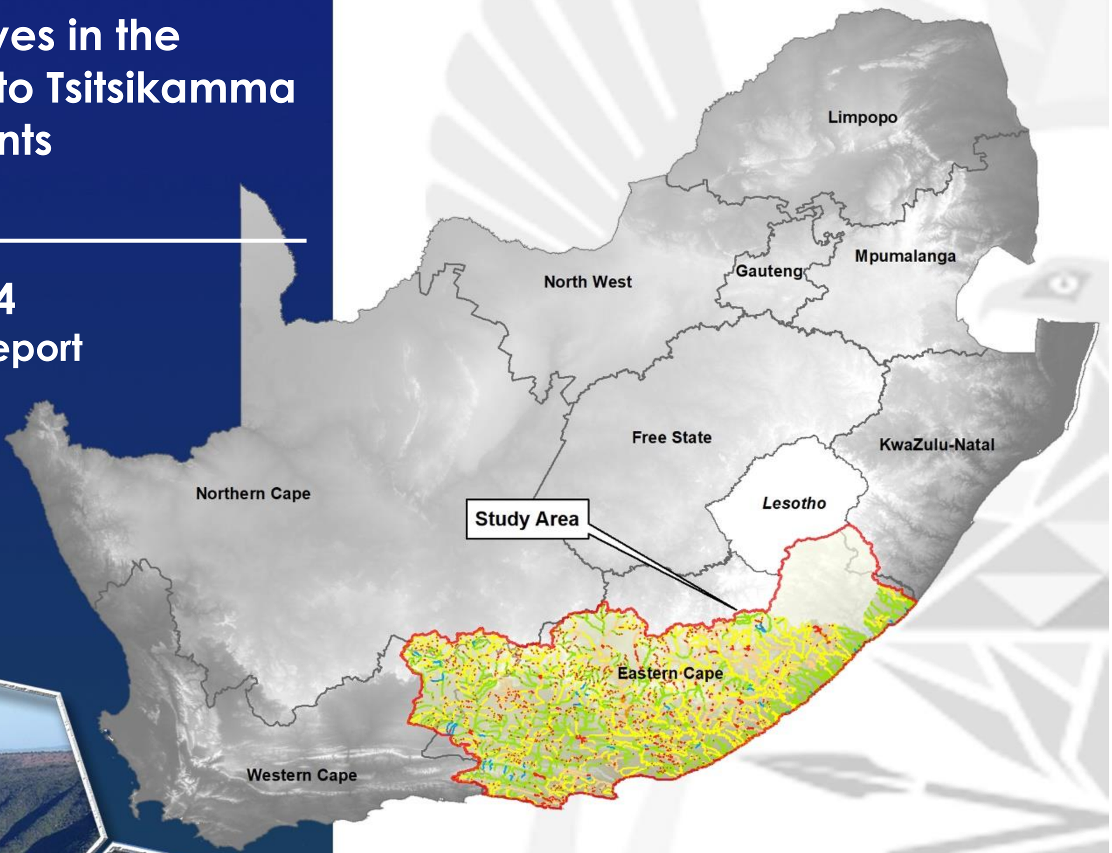
DEPARTMENT OF WATER AND SANITATION

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

WP11354
Scenario's Report



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LIST OF ACRONYMS

AOA	Annual Operating Analysis
BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EI	Ecological Importance
ES	Ecological Sensitivity
EIS	Ecological Importance and Sensitivity
ESBC	Ecological Sustainable Base Configuration
EWR	Ecological water requirements
HGM	Hydrogeomorphic Unit
IUA	Integrated Unit of Analysis
NWA	National Water Act
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
ROF	Risk of Failure
ROS	Reliability of Supply
RQO	Resource Quality Objectives
RU	Resource Units
Sc	Scenario
SWSA	Strategic Water Source Areas
WAAS	Water Availability Assessment Study
WARMS	Water use Authorisation & Registration Management System
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WR2012	Water Resources 2012
WRCS	Water Resources Classification System
WRSM2000	Water resources simulation model (also known as the Pitman model)
WRYM	Water Resource Yield Model
WSS	Water Supply System

WULA	Water Use License
WWTW	Waste Water Treatment Works

EXECUTIVE SUMMARY

Background and Purpose

This Scenario's Report forms part of Step 4 of the Classification process and aligns with Step 4 of the integrated framework, DWS (2017) as part of the study to Determine the Water Resource Classes, Reserve and Resource Quality Objectives (RQOs) in the Keiskamma and Fish to Tsitsikamma catchment.

The results from this study will guide the Department of Water and Sanitation (DWS) to meet the objectives of maintaining, and if attainable, improving the ecological state of the water resources to facilitate sustainable use of the water resources while maintaining ecological integrity. The primary deliverable will be the preparation of the templates with the final Water Resource Classes and RQOs for gazetting.

The purpose of this report will be to provide the approach taken when identifying the various operational scenarios for the study area. This was undertaken through several meetings with other tandem studies namely:

- Algoa West Water Availability Assessment Study (WAAS); and
- Reconciliation Strategies for Algoa and Amathole Systems.
- Discussions with regional and National DWS officials and planning teams.

Furthermore, the identified and detailed operational flow scenarios for both present and future are provided in this report, for the evaluation of the ecological and socio-economic consequences (subsequent deliverable). The aim being to finalise the Ecological Water Requirements (EWR) that can be met.

Study Area

The study area consists of the water resources of the Keiskamma, Fish to Tsitsikamma catchments and include large drainage areas as well as some smaller coastal systems, including:

- Mbhashe River (part of drainage region T which includes T11, T12 and T13),
- Great Kei River (drainage region S),
- Great Fish (drainage region Q),
- Sundays (drainage region N),
- Gamtoos River (drainage region L),
- Mthatha River (drainage region T20),
- Small coastal rivers in the Pondoland area (drainage regions T60 to T90),
- Keiskamma, Buffalo, Nahoon and Gqunube Rivers (drainage region R),
- Kowie, Kariega and Boesmans Rivers (drainage region P),
- Koega and Swartkops Rivers (drainage region M),

- Krom and Seekoei Rivers (drainage region K90), and
- Tsitsikamma and small coastal rivers (drainage region K80).

Priority Resource Units

Priority Resource Units (RUs) have been identified through an approach that considers both the water use, water quality impacts as well as ecological integrity and protection requirements for the water resources. See Resource Units prioritisation report (WEM/WMA7/00/CON/RDM/0422) for more detail on the approach and the final RU priorities.

Three levels of **priority RUs** were identified with associated level of detail required for the EWR assessment.

These priorities were:

i. Priority 1 – intermediate level (at least 1 survey during high and low flow conditions);
ii. Priority 2 – rapid level 3 (surveys during low flow conditions); and
iii. Priority 3 – field verification or desktop level (on site, and extrapolation from high confidence sites and expert opinion).

Scenarios

Scenarios were developed considering different variables that capture the range of uncertainty and likely conditions, now and into the future. The main variables that were drivers of the scenarios are:

- Development levels – Associated with time slices into the future. This relates primarily to socio-economic development in, and of, the catchments and associated water resources. The development levels are defined by two main factors namely:
  - The projected water requirements for current and future water users, and
  - The development of additional water resources (surface water, groundwater, of water reuse and desalination) to meet the growing water requirements.
  - A baseline (the present day) and future time slices were utilised for this purpose.
- Level of ecological protection targeted – In this case the inclusion or exclusion of ecological water requirements (EWRs) were taken as scenarios.
- Climate change – Climate variability is captured in the long records of hydrology and climate data used. Climate change from the baseline was considered as an additional possible impact.

These main variables were varied and captured in the scenarios as defined below:

- **Scenario 1** – Present Day Demands
  - Scenario 1a (without EWR) – “modelling flows in rivers/ estuaries and supply to users without EWR”
  - Scenario 1b (with EWR - rivers) – “the EWR for REC for rivers were included into the models and prioritised to ensure the flows are provided to meet the ecological needs

- **Scenario 2** – Medium Term (2030)

  - Scenario 2a (without EWR)
  - Scenario 2b (with EWR - rivers)

- **Scenario 3 –** Long Term (2050) *(some IUAs will have iterations, some wont - limited clarity from parallel studies to which is the preferred intervention for required growth. The growth used for this study will be clearly stated for later use by the parallel studies if necessary)*
  - Sc3a (without EWR)
    - Sc3a.1 (<u>intervention alternative</u> scenario without EWR)
  - Sc3b (with EWR - rivers)
    - Sc3b.1 (<u>intervention alternative</u> scenario with EWR for rivers)

- **Scenario 4 –** Water quality (predictions, expert opinion) **–** only for selected IUAs (please refer to the Consequences Report (Report No. WEM/WMA7/00/CON/RDM/2624 to be submitted in February 2025).

- **Scenario 5 –** Climate Change
  - Work is currently being executed by the Reconciliation team in collaboration with the WAAS team, to develop an updated climate change impacted flow series for use in the water resources models. This would be for one or two most likely scenario(s), and will be included in the final version of this report, if available in time.
  - While waiting for this data to finalise the Report, a literature review was conducted and included in an appendix of this report. Previous studies and the latest information on climate change of key metrics, e.g. rainfall suggest that the impacts will be most significant on the western parts of the study area i.e. the Algoa WSS, and that the impacts for this area are in the order of around 5 to 10% reduction in average annual streamflow depending on the future time slice considered. The climate change impacts of the remainder of the study area are deemed inconclusive, or of insufficient confidence to develop a specific scenario. The flow and climate data utilised to evaluate the scenarios, already capture significant climate variability.

Scenarios Analysis

The results of the scenario analyses are provided in this Report. The goal of the scenarios with the EWRs included is to capture the impacts of prioritising the ecological protection, and what the corresponding impacts on socio-economic (consumptive) water supply are. The scenarios without EWRs included show the impacts of prioritising the socio-economic water supply and what the corresponding impacts on the ecology and environment. This provides important information for the trade-off process.

As part of the consequences assessment and trade-off process, some additional scenarios might be identified with the aim of finding balanced solutions. These will be documented in the associated reporting. The results of the scenarios analysed in this report are thus preliminary and there might be some further refinement as part of the trade-off process.

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1. INTRODUCTION

1.1 Background

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 for 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 Department of Water and Sanitation, through 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 and Fish to Tsitsikamma catchments. The water resource components included for this study are surface water (rivers, wetlands and estuaries) and groundwater. The Reserve determination includes both the water quantity and quality of the Ecological Water Requirements (EWR) and BHN. This will assist the process of ensuring the availability of water required to protect aquatic systems and to secure water that is essential for the needs of individuals that are directly dependent on these water resources for their daily livelihood.

1.2 Purpose of this study

The Keiskamma and Fish to Tsitsikamma catchments are within the Mzimvubu to Tsitsikamma Water Management Area (WMA 7) are amongst many water stressed catchments in South Africa. These areas are important for conservation and have recognisable protected areas, natural heritage, cultural and historical sites that require protection. However, water use from surface as well as groundwater for agricultural and domestic purposes is 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 WMAs (i.e. transfer from Gariep Dam on Orange River to the Great Fish River) and within the study area as well as numerous storage dams change the flow patterns, impacting the aquatic biota.

Thus, the main purpose of the study is to determine the Water Resource Classes, the Reserve and associated RQOs for all significant water resources in the study area to facilitate sustainable use of the water resources while maintaining ecological integrity.

The aim is to:

- Implement the Water Resource Classification System (WRCS) (Regulation 810, 2010) to determine the Water Resource Classes;
- Follow the integrated framework steps (DWS, 2017);
- Undertake the 7-step process within the integrated framework context to determine and set RQOs; and
- Determine the Reserve (EWR and BHN) for the selected water resources in the study area.

The above mentioned will ultimately assist the DWS in the management of the water resources in the study area from source to sea as far as practicably possible, to allow for the making of informed decisions regarding the authorisation of future water use and the magnitude of the impacts of current and proposed developments in the study area.

1.3 Purpose of this report

The purpose of this report is to provide the details of the final assessment and the results of the scenario analysis for the Keiskamma, Fish to Tsitsikamma catchment areas. This is related to the following:

- Description of the catchment scenarios assessed as part of the scenario analysis;
- Presentation of the water availability analyses per scenario (results of the water balance per IUA per scenario); and
- Summary of the scenario analysis results.

Furthermore, the identified and detailed operational flow scenarios for both present and future are provided in this report, for the evaluation of the ecological and socio-economic consequences (subsequent deliverable). The aim being to finalise the Ecological Water Requirements (EWR) that can be met. Therefore, this report focuses on the approach to identifying the various operational scenarios for this proposed study and the description thereof. The results of the analyses are also provided (primarily flows and supply volumes). The ecological and socio-economic consequences of these are determined and presented as part of Step 5, and captured in a separate deliverable (Report No. WEM/WMA7/00/CON/RDM/2624 to be submitted in February 2025)

This forms part of Step 4 of the Classification process and aligns with Step 4 of the integrated framework, DWS (2017) (see **Figure 1-1**).

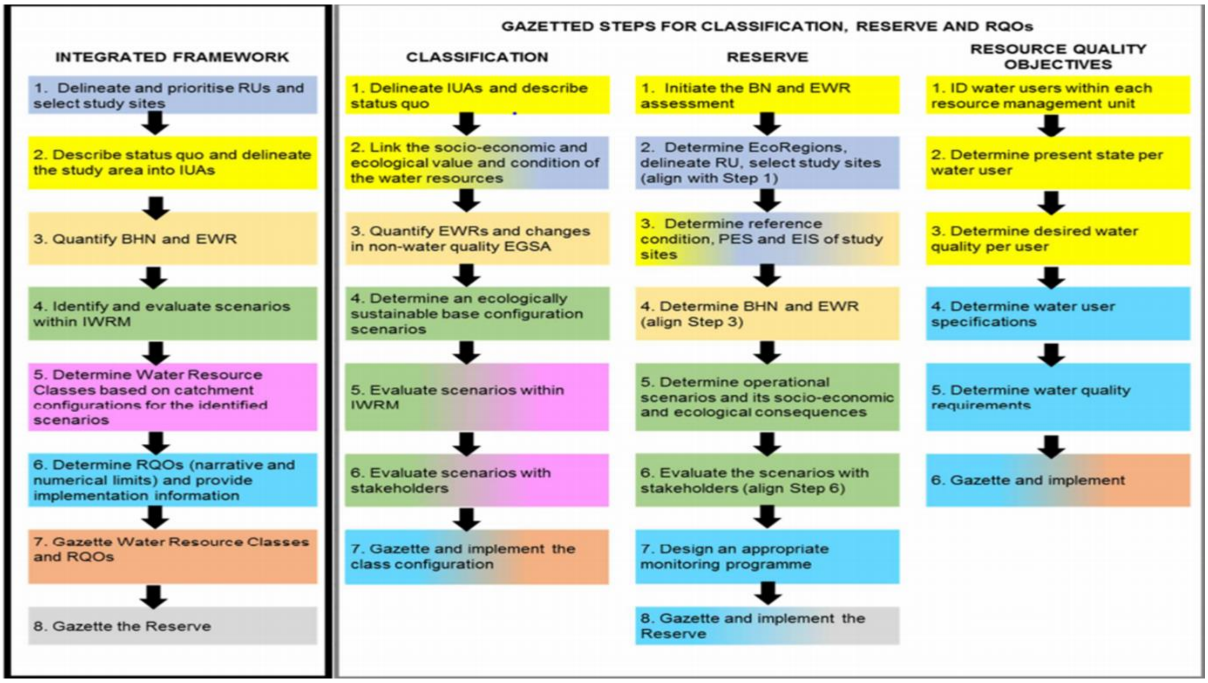

Figure 1-1: Integrated framework for the determination of Water Resource Classes, Reserve and RQOs.

2. OVERVIEW OF STUDY AREA

The study area forms part of the Mzimvubu to Tsitsikamma Water Management Area (WMA 7) with the main catchments and rivers indicated in **Table 2-1** and **Figure 2-1**. The water resources of the Mzimvubu River (T31 – T36) are not included as part of the study area as the resources have already been classified, RQOs determined and gazetted. Furthermore, Secondary catchments T40 (Mtamvuna) and T50 (Mzimkhulu) form part of WMA 4 and are not included in this study. A detailed overview and status quo of the study area in terms of the rivers, wetlands, estuaries and groundwater, water resource infrastructure and socio-economics has been presented in the delineation of IUAs report (Report Number: WEM/WMA7/00/CON/RDM/0322).

The rivers in the study area ranges from large perennial to semi-ephemeral systems and there are also small coastal rivers that all drains towards the Indian Ocean. The study area consists of five large drainage basins with several smaller rivers in-between. The larger drainage basins are the:

- Mbhashe River (part of drainage region T which includes T11, T12 and T13),
- Great Kei River (drainage region S),
- Great Fish (drainage region Q),
- Sundays (drainage region N), and
- Gamtoos River (drainage region L).

The small drainage regions include the:

- Mthatha River (drainage region T20),
- Small coastal rivers in the Pondoland area (drainage regions T60 to T90),
- Keiskamma, Buffalo, Nahoon and Gqunube Rivers (drainage region R),
- Kowie, Kariega and Boesmans Rivers (drainage region P),
- Koega and Swartkops Rivers (drainage region M),
- Krom and Seekoei Rivers (drainage region K90), and
- Tsitsikamma and small coastal rivers in drainage region K80.

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

Catchment	Major Rivers
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	Mbhashe
T20	Mthatha
T60	Small coastal rivers (Mtentu, Msikaba, Mzintlava)
T70	Small coastal rivers (Mtakatye, Mngazi)
T80 & T90	Small coastal rivers

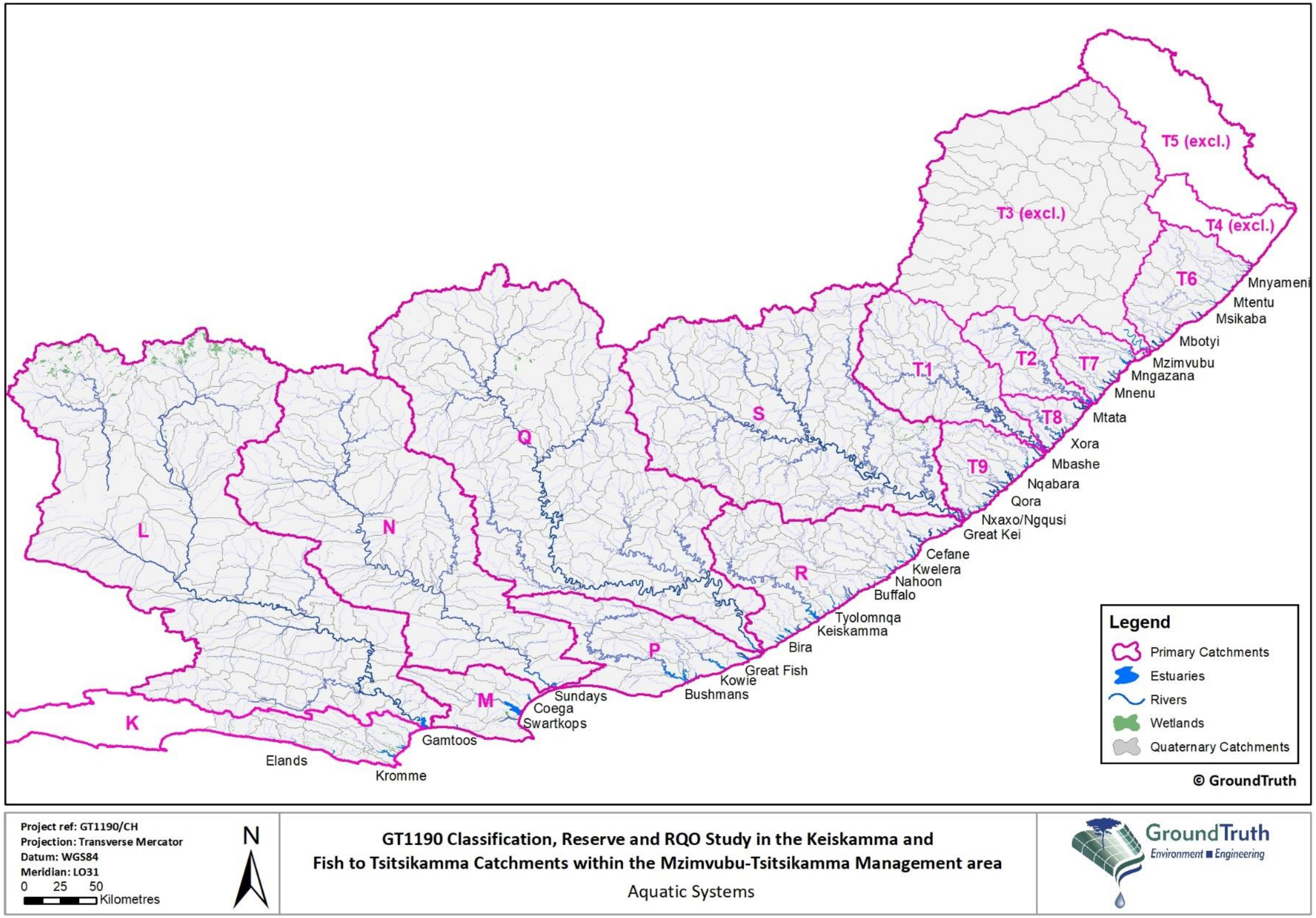

Figure 2-1: Map illustrating the study area for the Keiskamma, Fish to Tsitsikamma.

3. THE EVALUATION OF SCENARIOS WITHIN THE WATER RESOURCE MANAGEMENT PROCESS

An integral component of the water resource classification process is the scenario configuration and evaluation, which is an iterative process that assesses the resulting water supply potential of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible for the study area being classified, to support the recommended water resource management class options.

This task has been undertaken in compliance with the requirements of the study terms of reference that specifies that the classification process is required to build from existing and current initiatives within the framework of the integrated water resource management processes in the Keiskamma, Fish to Tsitsikamma catchment areas and is illustrated in **Figure 1-1.** The study process is now in the final stages of the water resources classification process that will inform the setting of Resource Quality Objectives.

The scenario evaluation has been finalised and recommended scenarios are proposed.

3.1 Objectives of the scenario evaluation Step 4 of the Integrated Framework for Classification, Reserve and RQOs

The objective of Step 4 of the Integrated framework is to evaluate scenarios configured. Scenario evaluation has been incorporated into the integrated water resource management process so that a subset of catchment scenarios can be recommended. Within the Classification steps, this falls under Step 5 of the WRCS process which includes:

- Inclusion of the various identified scenarios; and
- Water Resources Planning and Water Resource Yield Model configurations, analysis and adjustment.

The process followed is that described in the WRCS Guidelines, Volumes 1, 2, 3 and 4 (Overview and the 7-step classification procedure; Ecological, hydrological and water quality guidelines for the 7-step classification procedure; Socio-economic guidelines for the 7-step classification procedure, and Decision analysis (including the stakeholder engagement process for 7–step Classification Procedure) (DWA, 2007a, 2007b, 2007c and 2007d).

4. SUPPORING INPUTS TO SCENARIO DEVELOPMENT

In terms of the components of the study process, the following outputs have been defined/ determined to date or used as key input as support to the evaluation of scenarios for this study:

- Visioning exercise for purposes of the classification process;
- Water resource information and data gathering;
- Determination of the integrated units of analysis;
- Socio-economic evaluation and the decision-analysis framework and method summary;
- Present ecological state and recommended ecological category at selected EWR sites and for the estuaries;
- Ecological Water Requirements quantification;
- Ecological Base Scenario Configuration determination (please refer to Report No. WEM/WMA7/00/CON/RDM/2024); and
- Alternate Catchment Configuration Scenarios definition (This report).

All the above are detailed in the subsequence sub-headings.

4.1 Visioning exercise for purposes of the Classification Process

The following activities have been conducted that relate to visioning for the study area and associated catchments:

4.1.1 *Activities with stakeholders:*

The study team met with the study team and client for the Reconciliation Strategy for the Southern Planning Area which included the Algoa, Amathole and All Towns systems. A discussion was held on what the respective studies were required to achieve, what the challenges were, and where the studies might overlap or be able to support each other. At these meetings the study team and client for the Water Availability Assessment (WAAS) for the Algo area (more focused in extent) were also in attendance. The meetings held were:

- An initial session to introduce and share approaches (8 December 2021).
- A follow up engagement to discuss timeframes and information needs and sharing (20 January 2023).
- A meeting to discuss the EWRs and how the information from the classification can be integrated with the Reconciliation Strategy and WAAS (3 June 2024).

Further to these structured engagements, ad hoc engagements with the two teams were held over the course of December 2023 to November 2024 to align the models and approaches for assessing scenarios the Algoa and Amathola systems across the studies.

These two parallel studies have quite rigorous stakeholder engagement as they advance. Through the classification study teams interactions with the two parallel study teams, the views and perspectives of the stakeholders they were engaging with were brought into attention.

4.1.2 *Internation team activities:*

Prior to the commencement of the classification study and evolving through the earlier phases of this project, the following have been some key thoughts and ideas regarding the study area, as deliberated internally by the team and captured through the proposal, and early study reports. These have provided some insights and vision into the dynamics and scenarios.

Several separate catchments and systems make up the study area, with an accompanying range of climates, environments, development levels and even studies and associated levels of planning. More so than any other classification completed to date, this is a process covering a diverse area of connected and discrete parts.

Some of the catchments are water stressed. While there are some areas that are relatively undeveloped, there are several catchments and water supply systems that are both heavily developed, e.g. the Algoa and Amathole systems, and have recently been through a protracted drought. This drought has made stakeholders more aware of water scarcity and has also likely increased competition for water resources. As such, the process and team have been aware and sensitive to the water scarcity in some regions when approaching the scenarios development and analyses. There are even some areas where the existing allocations are known tobe in excess of the current water requirements.

Due to the multiple different catchments, different studies and different levels of information available, there has been an anticipation of the need for different approaches and possibly even levels of confidence being a reality for completing the process. These different approaches will require some degree of creativity and flexibility by the team and stakeholders in finding solutions, but also some effort in trying to standardise the messaging and presentation of results to avoid unnecessary complication with stakeholders.

4.2 Water resource information and data gathering assessment

During the inception phase, a literature review was conducted to assess the information, data and existing studies available. It became evident that there is a range of data and information already available across the catchments, but also several parallel studies that are developing more relevant information and data in parallel to the classification process.

The existing studies and key information databases used in both developing the models and scenarios are described in **Section 5.1**

4.3 Determination of the integrated units of analysis

Integrated Units of Analysis (IUAs) are spatial units consisting of significant water resources for which Water Resource Classes will be determined. The delineation of the various catchment areas was done primarily according to several socio-economic criteria and the boundaries of water resource components or catchments, taking into consideration ecological information and biophysical characteristics. These IUAs for this study will be used for the assessment of the ecological and socio-economic implications and/ or consequences of the different scenarios with the ultimate objective to determine Water Resource Classes.

Due to the large number of catchments and the diversity in the water resources (aquatic ecosystems, groundwater systems, estuaries, wetlands, water infrastructure) and socio-economic aspects, 19 IUAs were identified for the study area. These are listed in **Table 4-1** with detailed descriptions and status quo per water resource component provided in DWS, 2022 and further illustrated in **Figure 4-1**.

Table 4-1: Integrated Units of Assessment for the study area

IUA	IUA code	Description	Main rivers	Quaternary Catchments
1	IUA_K01	Tsitsikamma and headwaters of Kromme to Kromme Dam (Churchill)	Tsitsikamma, upper Kromme	K80A-F, K90A-B
2	IUA_KL01	Kromme from Kromme Dam (Churchill) to estuary and Gamtoos	Kromme, Gamtoos	K90C-G, L90A-C
3	IUA_L01	Kouga to Kouga Dam, Baviaanskloof	Kouga, Baviaanskloof	L81A-D, L82A-J
4	IUA_M01	M primary catchment	Swartkops, Coega	M10A-D, M20A-B, M30A-B
5	IUA_LN01	Groot to Kouga confluence, Upper Sundays to Darlington Dam	Sout, Kariega, Groot, Upper Sundays	L11A-G, L12A-D , L21A-F, L22A-D, L23A-D, L30A-D, L40A-B, L50A-B, L60A-B, L70A-G, N11A-B, N12A-C, N13A-C, N14A-D, N21A-D, N22A-E, N23A-B, N24A-D, N30A-C
6	IUA_N01	Sundays downstream Darlington Dam	Lower Sundays	N40A-F
7	IUA_P01	P primary catchment	Boesmans, Kowie, Kariega	P10A-G, P20A-B, P30A-C, P40A-D
8	IUA_Q01	Upper Fish	Little Brak, Upper Great Fish, Upper Little Fish	Q11A-D, Q14A-E, Q21A-B, Q22A-B, Q30A-B, Q80A-C
9	IUA_Q02	Great Fish	Great Fish, Tarka, Baviaans, Lower Little Fish	Q12A-C, Q13A-C, Q30C-E, Q41A-D, Q42A-B, Q43A-B, Q44A-C, Q50A-C, Q60A-C, Q70A-C, Q80D-G, Q91A-C, Q93A-D
10	IUA_Q03	Koonap and Kat	Koonap, Kat	Q92A-G, Q94A-F

IUA	IUA code	Description	Main rivers	Quaternary Catchments
11	IUA_R01	Keiskamma	Keiskamma, Tylomnqa	R10A-M, R40A-C, R50A-B
12	IUA_R02	Buffalo/ Nahoon	Baffalo, Nahoon, Kwelera, Gqunube	R20A-G , R30A-F
13	IUA_S01	Upper Great Kei	Indwe, White Kei, Tsomo, Great Kei	S10A-J, S20A-D, S40A-F, S50A-J
14	IUA_S02	Black Kei	Klipplaat, Klaas Smits, Black Kei	S31A-G, S32A-M
15	IUA_S03	Lower Great Kei	Kubusi, Great Kei	S60A-E , S70A-F
16	IUA_T01	Upper Mbashe, Upper Mthatha	Xuka, Mgwali, Upper Mbashe, Upper Mthatha	T11A-H, T12A-G, T20A
17	IUA_T02	Lower Mbashe	Lower Mbashe	T13A-E
18	IUA_T03	Lower Mthatha	Lower Mthatha	T20B-G
19	IUA_T04	Pondoland coastal	Mtentu, Msikaba, Mngazi, Mtakatye, Xora, Nqabara, Qhorha	T60A-K, T70A-G, T80A-D, T90A-G

The detailed descriptions and rationale for these IUAs are provided in Report No. WEM/WMA7/00/CON/RDM/0322.

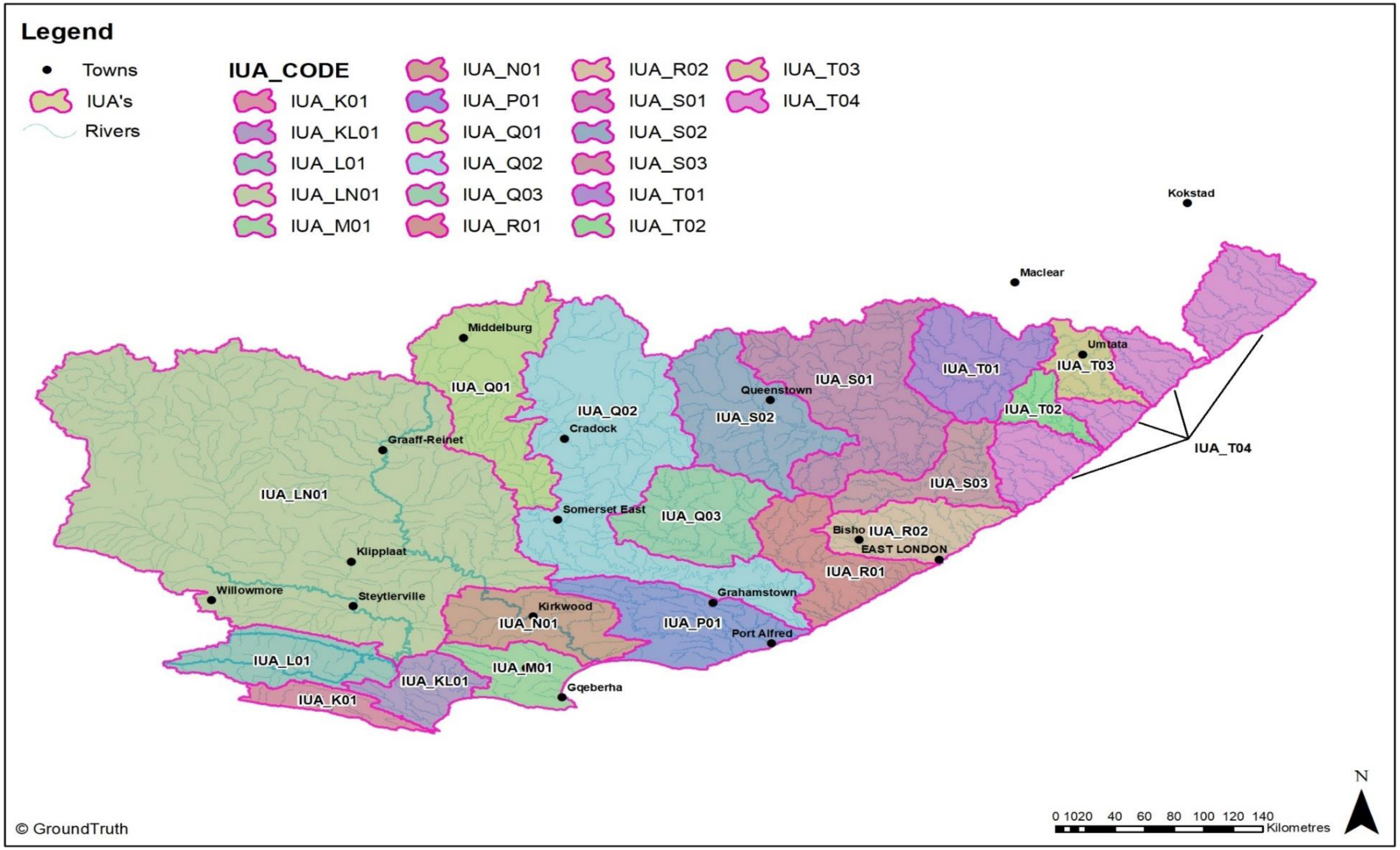

Figure 4-1: Integrated Units of Analysis

4.4 Present Ecological State

The PES, including the Recommended Ecological Category (REC), Ecological Importance (EI) and Ecological Sensitivity (ES) for the selected EWR sites on rivers and priority estuaries were determined during the Reserve determination phase of the study. For further detail, please refer to the following reports:

- Rivers Eco-categorisation and EWR Reports (Report No. WEM/WMA7/00/CON/RDM/1723 and WEM/WMA7/00/CON/RDM/1923 respectively);
- Estuary Eco-categorisation and EWR Reports (Report No. WEM/WMA7/00/CON/RDM/2024 and WEM/WMA7/00/CON/RDM/2124 respectively); and
- Final Estuary Report (Report No. WEM/WMA7/00/CON/RDM/2224).

A summary of the priority wetlands per IUA and their identified PES, EIS and REC is provided in **Table 4-2** and further detail is within Report No. WEM/WMA7/00/CON/RDM/1223.

A summary of the results for both rivers and estuaries is included in **Table 4-3.**

Table 4-2: Summary of the priority wetlands per IUA and their PES, EIS and REC

IUA	Wetland Name	HGM Type	SWSA (Y/N)	PES	EIS	Key ecosystem services provided	REC
K01	Lottering	Valley-bottom/Seep	Y	C	High	Carbon (C) storage, Biodiversity, Streamflow regulation	C
	Slang	Valley-bottom/Seep	Y	B	Very High	Biodiversity, Carbon storage, Streamflow regulation	B
	Kromme	Unchannelled valley-bottom	Y	A	Very High	Biodiversity, C storage, Streamflow regulation, flood attenuation	A
L01	Krakeel	Valley-bottom	Y	D	Very High	Water quality enhancement, Biodiversity, Water supply	C/D
M01	Longmore	Valley-bottom	Y	C	Very High	Biodiversity, Streamflow regulation, Sediment trapping	B/C
	Chatty River	Floodplain	Y	D	Very High	Biodiversity, water quality enhancement, sediment trapping	C
		Channelled valley-bottom	Y	D	Very High	Biodiversity, water quality enhancement, sediment trapping	C
LN01	Sneeuberg West	Seep	N	B	High	Grazing, Water supply, Biodiversity	B

IUA	Wetland Name	HGM Type	SWSA (Y/N)	PES	EIS	Key ecosystem services provided	REC
		Valley-bottom	N	C	High	Grazing, Water supply, Biodiversity	C
LN01	Loodsberg	Hillslope Seep	Y	B	High	Grazing, Water supply, Biodiversity	B
		Valley-bottom	Y	C	High	Grazing, Water supply, Flood attenuation, Biodiversity	C
Q02	Dagbreek	Valley-bottom	N	B	Very High	Sediment trapping, Erosion control, Biodiversity,	A/B
R02	eDrayini	Floodplain	N	C	High	Grazing, Flood attenuation, Biodiversity	C
	KwaMasele	Valley-bottom/Seep	N	C	High	Biodiversity, Grazing, Flood attenuation	C
S01	Cala	Valley-bottom	Y	C	High	Streamflow regulation, Water supply, Sediment trapping	B
		Hillslope Seep	Y	C	High	Streamflow regulation, Sediment trapping, Harvestable resources	B
	Mbokotwa	Floodplain	N	D	Very High	Water quality enhancement, Water supply, Biodiversity	C/D
S02	Cairns	Unchannelled valley-bottom /Seep	Y	B	Very High	Biodiversity, Grazing, Streamflow regulation	B
	Hogsback	Hillslope Seep	Y	C	Very High	Biodiversity, Streamflow regulation, Grazing, Erosion control	B/C
		Hillslope Seep (degraded)	Y	D	High	Grazing, Erosion control, Water quality enhancement	D
		Channelled valley-bottom	Y	C	High	Biodiversity, Flood attenuation, Grazing, Erosion control	B/C
		Floodplain	Y	C	High	Biodiversity, Erosion control, Sediment trapping, Grazing	B/C
T01	Elliot/Khowa	Hillslope Seep (Tributaries))	N	D	Moderate	Streamflow regulation, Grazing	C/D
		Floodplain (east)	N	D	Very High	Flood attenuation, Streamflow	C/D

IUA	Wetland Name	HGM Type	SWSA (Y/N)	PES	EIS	Key ecosystem services provided	REC
						regulation, Biodiversity	
		Channelled valley-bottom (west)	N	D	Very High	Water quality enhancement, Grazing, Flood attenuation	C
		Floodplain (upper)	N	E	Very High	Biodiversity, Water quality enhancement, flood attenuation	D
		Floodplain (lower)	N	C	Very High	Biodiversity, Flood attenuation, Water quality enhancement	B
T04	Sikombe	Channelled valley-bottom	Y	B	High	Biodiversity, C storage, Streamflow regulation	B
	Xolobeni	Channelled valley-bottom	Y	C	High	Water supply, C storage, Streamflow regulation	B
	Ludeke Halt	Seep/Valley-bottom	Y	D	High	Subsistence use, Grazing, Streamflow regulation	C/D

Table 4-3: A summary of the rivers and estuaries REC per EWR site per IUA, along with a summary of where the Ecological Water Requirements are not met (red and orange highlights)

IUA	EWR site code	River Name	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)	Percentage Supplied		Estuary System	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)
							EWR OFF	EWR ON					
	RIVERS								ESTUARIES				
IUA_T01	MBHA02_R	Mbhashe (Upper)	T11H	B/C	22.05	373.4	99%	99%	-				
	MTHA02_D	Mthatha (Upper)	T20A	C	21.49	122.5	92%	100%					
IUA_T02	MBAS01_I	Mbhashe (Middle)	T13C	C/D	38.02	673.8	100%	100%	Mbashe	T13E	B	108.5[1]	786.9
IUA_T03	MTHA01_I	Mthatha (Lower)	T20G	B/C	37.81	389.2	98%	100%					
IUA_T04	MNGA01_R	Mngazi	T70B	B/C	25.94	78.2	96%	100%%	Xora	T80D	B	77.3 + 5%	52.4
	NQAB01_R	Nqabarha	T90A	C	34.51	9.8	77%	*n/a*	Msikaba	T60G	A	93.8	212.4
	MTEN01_R	Mtentu	T60C	B/C	44.33	89.6	94%	*n/a*	Mngazi	T70B	B	95	87.3
	XORA01_D	Xora	T80D	B	30.53	83.0	67%	*n/a*					
IUA_S01	TSOM01_I	Tsomo	S50G	C/D	37.48	196.7	15%	78%	-				
	INDW01_R	Indwe	S20D	C/D	24.69	61.9	37%	100%					
	WKEI01_R	White Kei	S10J	C	26.16	155.7	64%	100%					
IUA_S02	BKEI01_I	Black Kei	S32K	D	32.03	187.9	53%	100%	-				

IUA	EWR site code	River Name	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR ($10^6 m^3$)	Percentage Supplied		Estuary System	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR ($10^6 m^3$)
							EWR OFF	EWR ON					
	RIVERS								ESTUARIES				
IUA_S03	GKEI01_I	Great Kei	S70A	C	24.97	897.2	84%	100%	Great Kei	S70F	B/C	74.1	1040.7
	GCUW01_R	Gcuwa	S70D	D	14.86	67.6	42%	100%					
	KUBU03_R	Kubusi (Lower)	S60B	B/C	20.38	98.1	40%	53%					
IUA_R01	KEIS01_I	Keiskamma (Upper)	R10E	D	34.31	58.8	22%	99%	Keiskamma	R10M	B	76.8	128.7
	KEIS02_R	Keiskamma (Lower)	R10L	B/C	27.85	107.8	28%	100%					
	TYUM01_R	Tyume	R10H	B/C	34.15	32.6	31%	98%					
IUA_R02	BUFF01_I	Buffalo (Middle)	R20F	D	34.46	83.8	46%	98%	Nahoon	R30F	C	62.8 + 5%	32.5
	BUFF02_FV	Buffalo (Lower)	R20G	D	32.83	91.9	6%	99%	Qinera	R30F	B	98.3	8.4
IUA_Q01	FISH01_FV	Great Fish (Upper)	Q21B	D	12.35	18.0	34%	96%	-				
	LFIS01_FV	Little Fish (Upper)	Q80B	B/C	23.72	24.3	85%	99%					
IUA_Q02	FISH03_I	Great Fish (Lower)	Q91B	C	29.73	331.8	90%	99%	Great Fish	Q93D	B/C	90.3	496.3
	LFIS02_FV	Little Fish (Lower)	Q80G	C	18.88	88.9	100%	100%					
	TARK01_FV	Tarka	Q44C	D	12.21	63.3	9%	12%					

IUA	EWR site code	River Name	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)	Percentage Supplied		Estuary System	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)
							EWR OFF	EWR ON					
	RIVERS								ESTUARIES				
	FISH02_FV	Great Fish (Middle)	Q50B	D	12.50	201.9	93%	100%					
IUA_Q03	KOON01_R	Koonap	Q92G	D	17.14	76.9	40%	100%					
	KAT02_R	Kat (Lower)	Q94F	C/D	15.16	61.8	38%	100%					
	KAT01_I	Kat (Upper)	Q94B	B/C	43.53	23.9	27%	100%					
IUA_N01	SUND02_R	Sundays (Lower)	N40C	D	5.42	214.0	86%	100%	Sundays	N40F	B	95	263.1
IUA_M01	SWAR01_I	KwaZungu/ Swartkops	M10C	B/C	39.97	27.3	46%	100%	Swartkops	M10D	C	123.9[2]	56.9
IUA_P01	BOES01_FV	Bushmans	P10G	B	27.44	32.7	1%	82%	Kariega	P30C	C	60	21.9
									Bushmans	P20A	B	75.8 + 3%	43.1
									Kowie	P40C	B/C	89.1	31.4
IUA_KL01	GAMT01_I	Gamtoos	L90A	D	10.80	427.0	31%	97%	Gamtoos	L90C	C	51.8	404.2
									Kabeljous	K90G	B	89.3	5.3
									Kromme[3]	K90E	C	51	72.2
IUA_K01	KROM01_R	Kromme	K90A	C	36.66	27.6	85%	97%		K80B	B	66.9 + 5%	19.9

IUA	RIVERS								ESTUARIES				
	EWR site code	River Name	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)	Percentage Supplied: EWR OFF	Percentage Supplied: EWR ON	Estuary System	Quaternary catchment	REC	Total EWR as %nMAR for REC	nMAR (10^6m^3)
	GROO01_FV	Groot (K80D)	K80D	B/C	29.09	47.6	57%	58%	Tsitsikamma				
IUA_L01	KOUG01_R	Kouga	L82D	B/C	15.78	155.1	84%	100%	-				
IUA_L01	BAVI01_D	Baviaanskloof	L81D	B	28.58	48.1	79%	80%	-				
IUA_LN01	SUND01_FV	Sundays (Upper)	N22E	C	18.25	148.0	44%	83%	-				
IUA_LN01	GRT01_D	Groot (L70G)	L70G	B	29.91	185.7	21%	42%	-				

**Following the assessment of the critical users per IUA, these columns illustrates where the RoS for the EWR, are not met (RoS is <75% i.e. it fails more than 25% of the time). This will aid the team to also focus on these during the trade-off assessment in the next phase of the study. The % achieved of the Ecological Water Requirements in relation to the Total EWR as %nMAR for REC for rivers and estuaries*

- *Red: 0 – 40% achievement of the ecological water requirements*
- *Orange: 40% - 70% achievement of the ecological water requirements*
- *Green: 70% - 100% achievement of the ecological water requirements*

[1]Mbashe is above natural due to transfer scheme.

[2]The REC MAR of Swartkops is above Natural due to the Motherwell Channel and the Chatty River stormwater input. The scenario is down from present as it requested all 3 WWTW to rese water and not discharge into or just above the estuary.

[3]Kromme: 51% of 97 x 106

4.5 Ecological Water Requirements Quantification

The classification process requires the quantification of EWRs that is used during the evaluation of the various water resource scenarios to assist with the determination of the water resource classes. This step has been completed for this study, for the purpose of classification. The EWR Quantification Report formed part of Step 4 of the Reserve determination process and aligns with Step 3 of the integrated framework, DWS (2017) as part of the study to determine the Water Resource Classes, Reserve and RQOs in the Keiskamma and Fish to Tsitsikamma catchment.

The results from this step will guide the Department to meet the objectives of maintaining, and if attainable, improving the ecological state of the water resources to facilitate sustainable use of the water resources while maintaining ecological integrity. This scenario report drew on the results of the EWR quantification that was undertaken for all selected EWR sites (see Report No. WEM/WMA7/00/CON/RDM/1723, Volume 1 and Volume 2). Thus, the focus of the EWR report was to quantify the EWRs using various approaches depending on the specific conditions and impacts at the EWR sites.

Additional to the above, the hydraulic information that was obtained during both river surveys (September 2022 and May 2023) at the selected intermediate and rapid 3 sites will be used for the interpretation and evaluation of the ecological consequences (fish and macroinvertebrates) of the various selected water use scenarios. These included the selection and surveying of an appropriate cross-sectional profile of the river and longitudinal water slope and to measure the discharge. This data was used to develop the depth/discharge relationships for each EWR site. In addition, the hydraulics was further modelled using the HABFLO (HABitat FLOw) program to predict statistical distributions of hydraulic habitats for fish and macroinvertebrates.

Natural and present-day hydrology was obtained from several sources, including the data in the water resources yield planning models, WR2012 hydrology, and dam operating rules studies, reconciliation strategies for the Algoa and Amathole systems and the Algoa Water Assessment and Allocation Study for the Kouga, Baviaans, Gamtoos and Krom Rivers. The flow time series obtained from these studies were used and adjusted by catchment area to obtain the flows at the EWR sites.

The final EWR quantification results for all Intermediate and Rapid 3 EWR sites for the Recommended Ecological Category (REC) is presented in **Table 4-3** below (which also includes the PES for each EWR site). These EWR results will be used in the next steps during the evaluation of ecological consequences of management scenarios (this report), trade-offs with socio-economic considerations to determine the Water Resource Classes per IUA and for the setting of RQOs.

The flows at the estuaries have been assessed based on the upstream EWR's water cascading down to the estuaries and upstream catchment developments and impacts. If more defined estuary flow requirements are developed, these will be assessed as part of the trade-off's refinement process.

Quantification of the Changes in Ecosystem Goods, Services and Goods, Services and Attributes (EGSAs)

Based on the above established EWR sites, the changes in relevant ecosystem aspects as they related to identified EGSAs for the Keiskamma, Fish to Tsitsikamma catchment areas will be assessed.

This will be addressed and presented in the Consequences Report (Report No. WEM/WMA7/00/CON/RDM/2624).

4.6 Development Level Considerations

The following high level scenario concepts have been applied and developed, and relate to:

- The catchment development levels (socio-economic growth), and
- Different ecological status targets.

4.6.1 ***Catchment development levels:***

- Present day
- Intermediate future
- Long term future:
    - Most likely options
    - Alternative options

Present Day:

The present-day scenario uses the latest available hydrological data and records, together with the best estimates of present-day water use and water resources development levels. In some instances, this may be reliant on a study that is not from 2023, but typically is from the last few years.

This scenario was utilised to develop the present-day flows and provide input to the Ecological Sustainable Base Configuration (ESBC) to provide the baseline for the evaluation of the other identified scenarios, as captured in the Report No. WEM/WMA7/00/CON/RDM/2024 of this study. The EBSC forms part of Step 4 of the Classification process and aligns with Step 4 of the integrated framework, DWS (2017) as part of the study to Determine the Water Resource Classes, Reserve and Resource Quality Objectives (RQOs) in the Keiskamma and Fish to Tsitsikamma catchment.

More detailed information per IUA is provided in Section 5. Where actual water supply has been curtailed in the short term due to drought impacts, some practical refinements have been made, where necessary and where possible, to better capture the realities of water use outside of the immediate drought impacts.

Intermediate future:

This scenario represents development levels and water requirements anticipated in approximately 10 years time, i.e., around 2030 to 2035. In several water supply system and catchment development cases, the current water resources have been exceeded, and some level of supply intervention has been required. It is also assumed that in most cases, that higher than reasonable water losses have been resolved through WC/WDM measures.

Long term future:

While not necessarily the ultimate development level, this scenario(s) represents the development levels anticipated in around 25 years' time, i.e., around 2045 to 2050. Multiple water resources developments are likely needed to meet growing water requirements in the growth nodes and water is anticipated to be used more efficiently. Growth beyond this time frame is uncertain and outside of the current planning horizons. Where necessary, an alternative long-term scenario has been provided for, in the case that there is not yet confidence in the selection of the future developments or interventions to meet growing water requirements and there are multiple options as part of the strategy. The alternative option will be assessed and based on the preliminary assessments (from both a socio-economic and ecological perspective), a preferred scenario will be utilised for the final scenario. This will be done in collaboration with the DWS, and key stakeholders.

4.6.2 *Ecological Protection scenarios*

Different ecological protection scenarios through specified Ecological water requirements (EWRs) were then applied to the three main development levels. These EWRs are described in Report No. WEM/WMA7/00/CON/RDM/1923 (for rivers) and Report No. WEM/WMA7/00/CON/RDM/1923 (for estuaries).

4.7 Towards scenario evaluation

When assessing or evaluating the scenarios, there are various ways in simulating the scenarios and interpreting the results and impacts. These relate in part to how the water uses are prioritised in the water resources models. The two approaches are:

- Simulate the water abstractions and socio-economic needs as priority and see what flows remain in the rivers for ecological functioning. This is typically done to assess the ecological impacts of supplying the future projected water requirements, as well as confirming the ability of these future water requirements to be supplied by the catchments and associated water resources developments. The impacts of this scenario are typically on the ecological functioning and associated goods and services.

- Simulate the impacts of targeting specific ecological categories (in this study REC) and the water requirements for maintenance or improvement of the river and estuary systems. This is done by prioritising the ecological water requirements (EWRs) at the designated sites, over and above the water abstractions and supply for socio-economic purposes. This entails making releases from dams, where necessary, and having water not supply (bypass) existing or future water users. The impacts of this scenario are typically on the socio-economic growth potential.

Both approaches to evaluating the scenario impacts are needed, often together with some level of iteration, to enable the impacts to be contextualised, and ultimately, to work towards trade-offs and the greatest net benefit (with compromises) scenario.

5. SCENARIOS AND WATER RESOURCE PLANNING ANALYSIS

5.1 Hydrological Data and Modelling

The hydrological data and modelling utilised are the base information onto which the water requirements and development levels were layered. Four main hydrological models and sources of data were utilised. These were:

- The Water Resources 2012 (WR2012) study and hydrology by the Water Research Commission (WRC). Hydrological data records were typically: 1920 – 2009
- The hydrology as utilised by the Algoa Reconciliation strategy and associated Annual Operating Analyses (AOA): 1927 – 2004
- The hydrology as utilised by the Amathole Reconciliation Strategy Study and annual operating analyses (AOA): 1920 – 2020
- The updated hydrology as developed by the Water Availability Assessment Study (WAAS) for the Western catchments of the Algoa Water Supply System (WSS). This information only became available late in 2023, as the parallel WAAS study completed the hydrological extension and full recalibration exercise.

The WR2012 is the broadest of the four datasets and covers the entire study area. This comes at the cost of the level of detail contained within the models. Conversely, the Algoa and Amathole Studies are limited to the catchments as listed in **Table 5-1**; however, it is believed that greater detail is captured for these areas and the information is thus of higher confidence and was used in preference over the WR2012 information.

Where no catchment specific study and hydrology was available, the natural flows were determined using the WR2012 natural incremental flow datasets. In some cases, gauges that were not included in the WR2012 study (and showed stationary data) were used to calibrate runoff from quaternaries upstream of the gauge.

A summary of the hydrology utilised per EWR site is provided in **Section 6.**

Table 5-1: Catchments included in Hydrological Datasets.

Study Area	Catchments (Quaternaries)
Algoa	K90A-D, L81A-D, L82A-H, M10
Amathole	R10A-C, R10K, R20A-G, R30B-F, S60A-B
WAAS	K90A-G, L81A-D, L82A-H, L90

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

The hydrological data and models utilised for this sub-area are based on the latest work done by the DWS for the Algoa Water Supply System (WSS) Reconciliation Strategy (DWS, 2024b). 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 as utilised by that iteration of the Reconciliation Strategy was last updated to September 1999 (Kouga below Kouga Dam and Gamtoos), September 1992 (Swartkops), and the remainder (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 of the Southern Planning region. This covers the study area to be addressed by this classification study. To date, the water requirements have been updated, and a status Report developed (October 2023) to review progress with the implementation and update of the strategy interventions. A formal revised and updated strategy has not yet been completed.

The Study team is aware that the DWS is busy with a new Water Availability Assessment Study (WAAS) for parts of this area, as recommended by the 2012 Strategy. This WAAS study is focusing on the Krom, Kouga, Baviaanspoort and Gamtoos catchments and has updated the hydrology, together with a full recalibration of the rainfall runoff response, to the end of the 2020 hydrological year.

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 is 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. This study captured realities of low-level abstraction from dam storage as an example.

It is 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. 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 configuration has been sourced from the WAAS study, incorporating the new hydrology.

The new hydrology is believed to be an improvement on the previous work done, and through capturing greater details and simulating at a more refined spatial resolution (including rainfall variability), is of higher confidence and more representative of reality. The resultant hydrological runoff estimates (including natural runoff) have changed from the previous studies (the bridging study used by the Reconciliation Strategy, and the WR2012 study), and in the most part have reduced. This aligns with expectations, where the previous hydrology was believed to be overestimated.

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 A,** above. A key concern was the transfer from the Orange River via the Fish River to the Sundays River. This was 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 be linked in a model, thus the appropriate transfer volume as per the Orange River Reconciliation Strategy was included as a support to the Sundays River.

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

- 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 provided a good platform to use for the classification study;
- Engage with the DWS 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.
- 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), were developed into WRYM configurations due to system complexity and operating rules associated with dam storage utilisation. This allowed the catchments to be analysed for different scenarios; and
- While the Sundays (and Fish) catchments are included in the current Integrated Orange-Vaal WRPM model, these catchments were added several years ago, and do not drive the volumes of water transferred from the Orange River, nor are they used for any decision making. A check by the study team, showed that these model catchment definitions, and associated hydrology, are dated and of low confidence, and as such, the use of the WR2012 information updated with new information and studies as listed above was applied.

Where the quaternary level catchments have multiple small rivers that are included within a tributary, these were 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 water is transferred to the Little Fish River and then to the Sundays River in the adjacent catchment, as shown in **Figure 5-1**. The classification process will assess the catchments considering both the transfers and impacts on water availability, but also the remainder of the users in the catchments.

The modelling of the Fish took into account the transfer into and out of the catchment, but also considered and modelled the resources in an integrated manner. The main concern was 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.

This catchment has been simulated together with the Sundays in an integrated WRYM configuration. This configuration was based on the WR2012 results, but updated with the following localised information:

- A transfer from Gariep Dam to the Teebus River (Q91A) of 697 million m^3/a.

- A transfer from De Mistraal Dam (Little Fish) to Darlington Dam (N23A) of 218 million m^3/a.
- A transfer from the Great Fish River (Q91C) to Glen Melville Dam with a capacity of 7.6 million m^3/a.

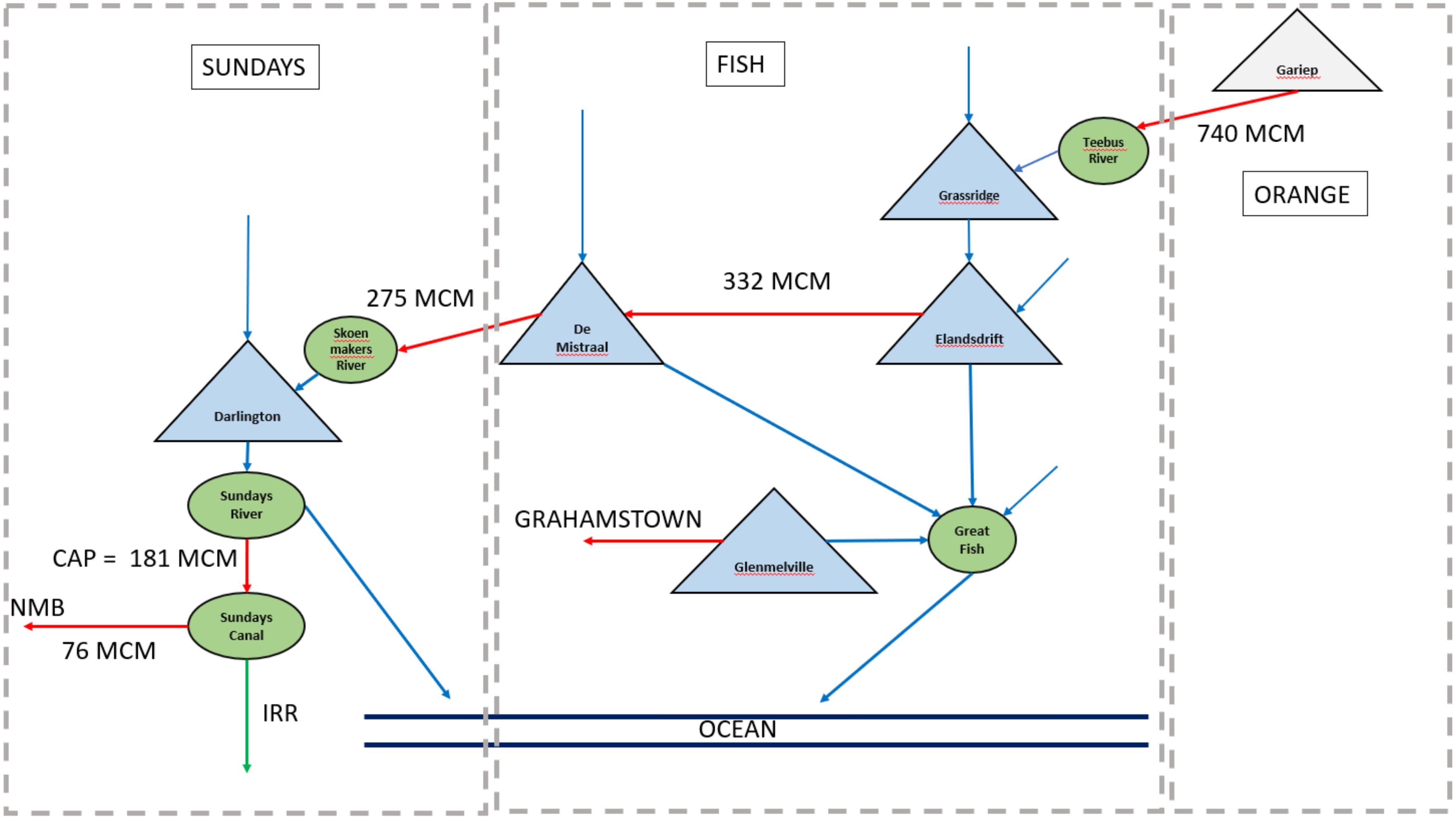

Figure 5-1: Schematic of Orange-Fish-Sundays transfer

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 Amathole Water Supply System Reconciliation Strategy. A draft status Report (DWS, 2022) was utilised as the base information, together with the 2022/23 annual operating analysis (DWS, 2023d) process and models. 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 in recent history. Thus, the Operating Rules study was 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.

A new WRYM with hydrology updated to 2020 was developed by the Reconciliation Strategy team, and has been utilised, where applicable.

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

There are several smaller catchments in this area, and the same hierarchical approach for the hydrological data and models will be used for the smaller catchments in this area, as per the P catchments described in point B.

However, the Mbashe River has been integrated into the Great Kei WRYM configuration to better model the hydropower transfer from Ncora Dam (T31B) using a combination of WR2012, DWS gauge data and the operational analysis report (DWS, 2017). The dam was assumed to serve irrigation and hydropower equally until the dam reaches 40%, below which only domestic supply can be abstracted. The hydropower transfer was assumed to amount to 85 million m^3/a according to the operational analysis report, with the monthly distribution modelled according to the WR2012 configuration. The irrigation transfer was modelled such that the irrigation blocks in T12C and T12D can pull water from Ncora Dam, through the transfer canal with a capacity of 4.5 million m^3 per month, which was the maximum recorded volume in gauge T1H012. Finally, a transfer loss of 15% was assumed.

However, WR2012 set the irrigation areas in T12C and T12D as 1.06 and 2.38 km^2, respectively. This is vastly different to the satellite imagery of 6.4 km^2 in T12C and 0.00 km^2 in T12D, although some dry-land agriculture did appear over the history of satellite imagery. This was highlighted in the operational analysis report, which states the allocation for irrigation from Ncora Dam was 21.9 million m^3/a for 28.96 km^2, however, only 3 km^2 was currently utilised yet gauge T1H012 recorded irrigation supply between 15 – 39 million m^3/a during this period.

The Mthatha catchment and dam are examples of a system with existing hydrological data and models 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 5-11.

5.2 Present day and future water requirements

Closely linked to the hydrological studies and sources of information, the records of historic use and the most recent use for that hydrological record, were obtained from the associated hydrological study. This included abstractions for domestic, industrial and irrigation users, as well as diffuse water uses associated with land-use such as commercial afforestation and alien invasive plants.

Model connectivity was adjusted to better reflect the nature of the river system. The irrigation areas from WR2012 were retained in most cases and compared to WARMS data and satellite imagery where significant differences were found.

Monthly abstraction volumes were taken as per the associated hydrological study or adjusted to the monthly averages over the last 10 years, where monthly values were relatively similar. This needed to be done for systems where the present day set-ups where not available and only dynamic set-ups, for calibration purposes, were available.

The projected water use by abstractions and consumptive water users has been adopted from the following main sources of information:

- Key planning documents including the Reconciliation strategies of:
    - The Algoa Water Supply System (Nelson Mandela Bay Municipality and surrounds). Here the latest October 2023 Status Report (Draft) on monitoring and implementation of the Algoa Strategy (DWS, 2024c) has been used with support from preceding reports and documents.
    - The Amathole Water Supply System (Buffalo City Metropolitan Municipality). Similarly, the latest June 2022 Status Report on monitoring and implementation of the Amathole Strategy (DWS, 2022) has been used with support from preceding reports and documents.
    - The All Towns for the Southern Planning Cluster (covering smaller stand along schemes in the Eastern and Southern Cape). Some of these All-Towns Strategies have not been updated yet (as part of the current study to update the Reconciliation Strategies in the Southern Cluster), and older reports have needed to be utilised. (DWA, 2011)
- The existing lawful water use in the study area, as per the DWS database (WARMS).
- Ad hoc plans and reports on potential developments as provided by the DWS and stakeholders in the study area.
- New water use licence applications (WULAs) provided in summary by the DWS, that show potential new water use.
- A generic provision for water-use growth. This has been considered in catchments where little information is available on possible development and/or associated planned water-use growth. Here a nominal provision has been recommended, as described further in Section 5.2.

5.2.1 *Domestic and commercial water use*

The water use per supply centre is captured in **Table 5-2** to **Table 5-9**, together with the future water requirement projections for the main development centres, i.e., cities, towns and water supply systems. Irrigation has been included here when it is part of an integrated water supply system. The total irrigation requirements are available in Section 5.2.2.

A. K80, K90, L80 to L90 and M10 to M30 (Krom, Tsitsikamma, Gamtoos, Kouga and Swartkops)

The water requirements for the domestic and commercial water users as supplied through the formal water supply system by the water boards and water authorities are based on the latest projections by the Reconciliation Strategy (DWS, 2024b). These are summarised, together with other key water use sectors in **Table 5-2**.

Table 5-2: Summary of main water requirements of the Algoa WSS

Water user	IUA	Allocation	Current use (2021/22) [3]	2035			2050		
				Unconstrained	High	Medium	Unconstrained	High	Medium
NMBM	KL01 **M01** N01	148.9	126.38 [1]	148.5	126.2	108.85	178.3	151.6	133
Kouga LM	KL01	0.93	7.9	7.9			7.9		
Kareedouw	KL01	-	0.26	0.301			0.301		
Irrigation		63.3	13.6 [2]	63.4			63.4		
Total Algoa WSS		213.15	132.25	220.1	197.8	180.45	249.9	223.2	204.6

Notes:

[1] – This amount includes 1.9 million m^3/a potable supply to the Special economic Zone (SEZ). Future growth and development in the SEZ is reportedly planned to be supplied by reuse of treated effluent.

[2] – This amount includes 5.45 million m^3/a for canal losses and unaccounted for water. This has been added to the irrigation use, but other users also make use of the canal for conveyance of their water.

[3] – the 2021/2022 use is impacted by drought and short-term water restrictions. Use is expected to increase once the drought impacts pass.

The projection of the water requirements together with a comparison of the water availability of the system as a whole are provided in **Figure 5-2**. The availability is summarised in **Table 5-11**, as part of **Section 5.3**. The projection shows the high growth scenario, with drought impacts ending and WC/WDM savings being implemented.

The Reconciliation Strategy (DWS, 2024b) appears to target the high growth scenario for the purpose of water balances and strategy development. Recent actual use appears volatile as drought constraints are lifted. As such, the high growth was adopted for the classification process to align with the Reconciliation Strategy.

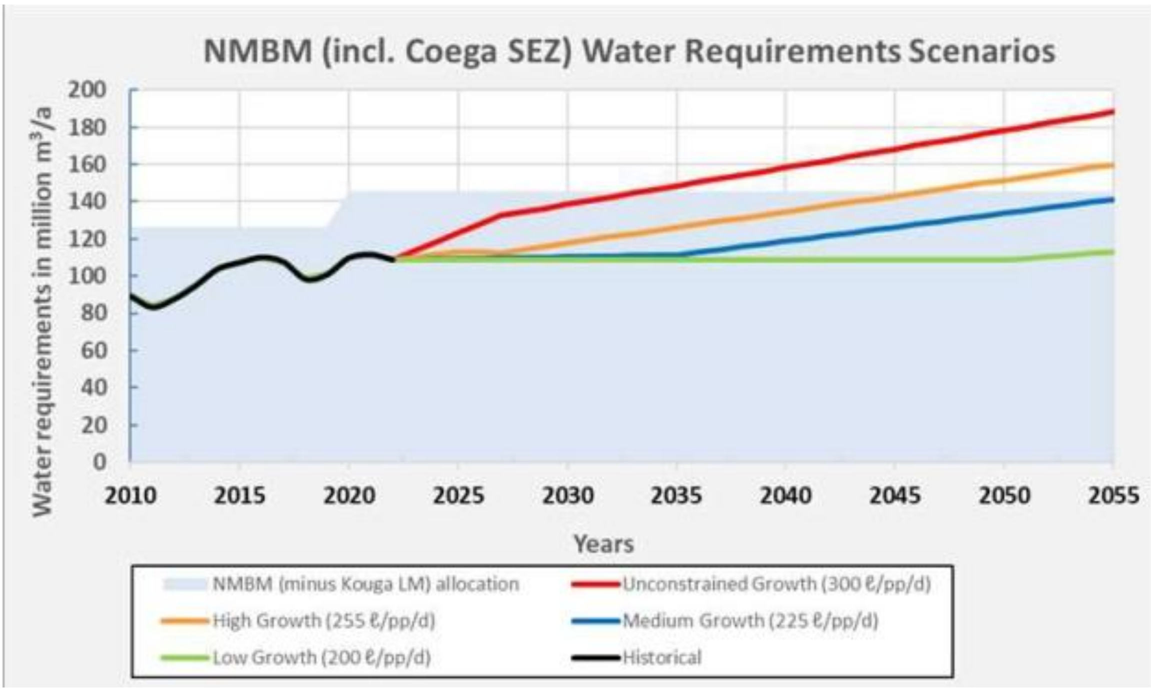

Figure 5-2: Water requirements projected for the Algoa WSS (high growth scenario)

B. L10 to L70 (Kariega, Sout and Groot)

The key water requirement is domestic supply to Klipplaat as shown in **Table 5-3**, which receives water from Klipfontein Dam (DWA, 2011).

Table 5-3: Summary of main water requirements (Groot)

Water user	IUA	Current use as of reporting (2010)	Medium Growth		
			2020	2035	2050
Kliplaat	IUA_LN01	0.678	0.779	0.960	0.96

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

The key water requirements are domestic supply to Robert Sobukwe (Graaff Reinet) and Makhanda (Grahamstown) as shown in **Table 5-4**. Robert Sobukwe receives its water from a mix of groundwater and surface water supplied by Nqweba Dam. Makhanda receives its water from the Settlers, Howieson, Jameson and Milner Dams in catchment P, as well as from Glen Melville Dam in catchment Q. In the model, Howieson and Settlers dams have been lumped as well as Jameson and Milner Dams. The demands for Makhanda are split between the Glen Melville Dam and the other small dams, with the Settlers system contributing 90% of the small dams allocation and the Jameson system contributing 10%. This was based on the dams' relative capacities with allowance for farm dams and irrigation. It is expected that the future growth will be catered for by Glen Melville Dam with support from the Orange Fish Transfer.

Port Alfred receives its water from an off-channel dam on the Kariega River (Sarel Haywood), Groundwater and Desalination (DWA, 2011).

Table 5-4: Summary of main water requirements (Sundays, Bushmans)

Water user	IUA	Current use as of reporting (2010)	Medium Growth		
			2020	2035	2050
Robert Sobukwe (Graaff Reinet)	IUA_LN01	5.2	5.802	6.836	6.836
Makhanda (Grahamstown)	**IUA_P01** IUA_Q02	3.591	8.87	9.92	10.33
Kirkwood, Addo, Enon and Bersheba	**IUA N01**	4.0025	4.0025	4.8799	5.947
Port Alfred	**IUA_P01**	2.233	2.233	2.005	2.506
Total		15.02	20.9	23.64	25.62

C. Q10 to Q90 (Great Fish)

The key water requirements are domestic and irrigation supply to the Kat River Valley, as shown in **Table 5-5**. KwaMagoma (Fort Beaufort), Seymour and Balfour rely on water from the Kat River Dam.

Table 5-5: Summary of main water requirements (Great Fish)

Water user	IUA	Current use as of reporting (2010)	Medium Growth		
			2020	2035	2050
KwaMagoma (Fort Beaufort), Seymour, Balfour	IUA_Q03	3.113	3.113	3.113	3.113
Adelaide	IUA_Q03	0.78	0.78	0.78	0.78
Bedford	IUA_Q03	0.526	0.526	0.526	0.526
Cookhouse/ Sommerset East	IUA_Q02	2.447	2.447	2.824	2.824

Inxuba (Cradock)	IUA_Q01	1.715	1.9335	2.124	2.124
Total		8.581	8.799	9.367	9.367

D. R20 to R30 and S60 (Buffalo, Nahoon, Keiskamma, Kubusi)

The current water requirements were sourced from the 2023 Annual Operating Analysis (AOA) (DWS, 2023d) and associated reporting by the DWS (DWS, 2024a). The future projected water requirements for the Amathole WSS are sourced from the latest Status Report of the Reconciliation strategy for this area. The water requirements of the key water users are summarised in **Table 5-6.**

Table 5-6: Water requirements of the key users in the Amathole WSS

Water user	**IUA**	**Allocation**	**Current use (2022/23)** [1]	**2035**			**2050**		
				High	**Med**	**Low**	**High**	**Med**	**Low**
BCMM	**R02** S03	70.43	80.73 [2]	102.92	90.27	77.14	138.51	111.11	91.48
Amatola Water	R02	35.69							
ADM (Keiskamahoek, Dimbaza and Gubu)	**R01** S03	2.83	4.00 [3]	5.82	4.83	3.96	8.74	5.78	4.71
Qonce (King Williams)	R02			34.5	29.93	24.18	53.26	40.13	28.28
Irrigation		12.75	6.16 [4]	8.46	8.46	8.46	8.46	8.46	8.46
Total Amathole		121.70	90.89	151.7	133.49	113.74	208.97	165.48	132.93

Notes:

[1] – The 2022/23 actual were obtained from the 2023 Annual Operating Analysis WRPM configuration.

[2] – This amount includes the water supplied by Amatola Water to the BCMM.

[3] – The Amathole District Municipality is using more than their allocated volume and also potentially getting water via BCMM that is included in their use volume.

[4] – It is not confirmed if this amount includes all the irrigation listed as part of the allocation or just some of the key users on shared water resources.

The water requirements are shown graphically in **Figure 5-3.**

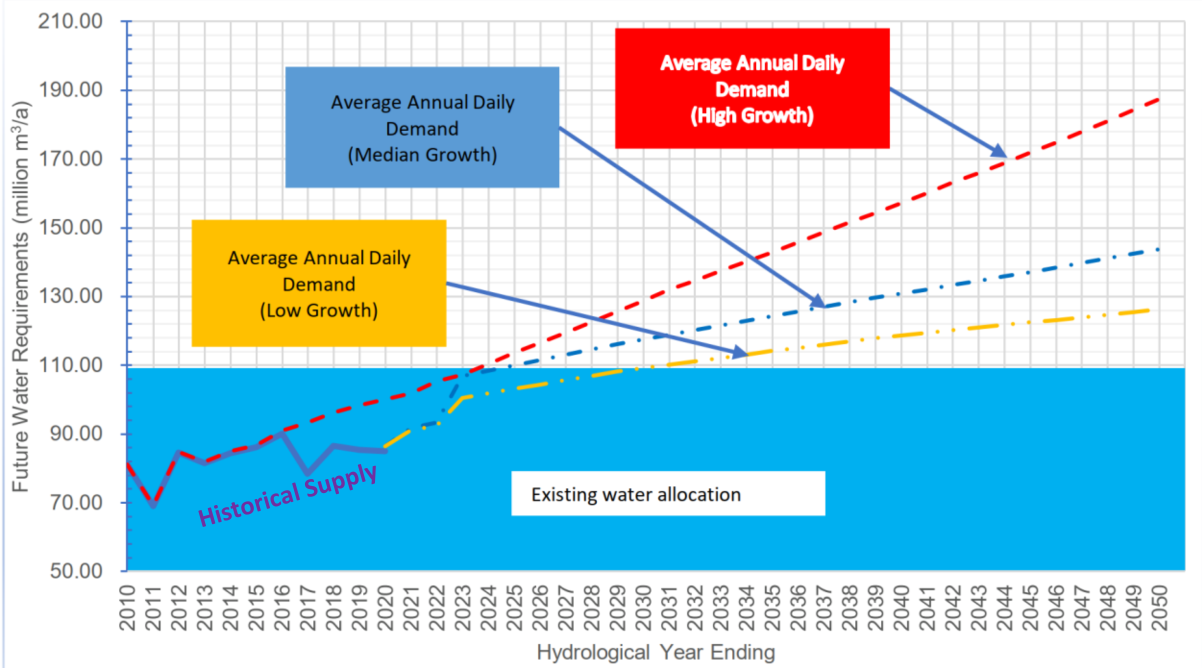

Figure 5-3: Projected water requirements of the Amathole WSS

Water requirements of the key users in the Amathole WSS adapted from the Water Allocations, Requirements and Return Flows Report (DWS, 2023b), as a part of the latest Reconciliation Strategy Update.

	Growth	Requirements (million m^3/a)		
		2020	2035	2050
Middle Buffalo (Qonce/King Williams Town)	High	19.79	34.51	53.26
	Med	17.39	29.93	40.13
	Low	17.39	24.18	28.28
Buffalo City	High	71.07	102.92	138.51
	Med	58.24	90.27	111.11
	Low	58.24	77.14	91.48
Kwelera	High	0.55	1	1.5
	Med	0.55	0.87	1.12
	Low	0.55	0.73	0.9
Kubusi (Stutterheim)	High	1.02	1.63	2.53
	Med	0.83	1.37	1.67
	Low	0.83	1.13	1.32

Sandile (Keiskammahoek and Dimbaza)	High	2.33	4.19	6.21
	Med	2.05	3.46	4.11
	Low	2.05	2.83	3.39

E. R10 (Keiskamma)

The key water requirements are domestic supply to Peddie, Dimbaza and Debe as shown in **Table 5-7**. Dimbaza is supplied by Sandile Dam while Debe is supplied by Debe Dam.

Table 5-7: Summary of main water requirements (Keiskamma)

Water user	IUA	Allocation	Current use (2013/14)	Medium Growth		
				2018	2035	2050
Peddie	IUA_R01	2.4	2.68	2.68	3.72	3.72
Sandile/Dimbaza	IUA_R01	7.4	7.29	7.29	10.39	10.39
Debe	IUA_R01	0.35	0.78	0.78	1.37	1.37
Total		10.15	10.75	10.75	15.48	15.48

F. S10 to 70 (Great Kei)

The key water requirements are domestic supply to Komani (Queenstown) and Butterworth with smaller schemes in the Emalahleni and Intsika local municipalities as shown in **Table 5-7.** Komani (Queenstown) is supplied by Waterdown and Bongolo Dams with an emergency supply from Xonxa Dam. Butterworth is supplied from Gcuwa Dam.

Table 5-8: Summary of main water requirements (Mbashe, Mthatha, and Coastal Systems)

Water user	IUA	Current use as of reporting (2016)	Medium Growth		
			2020	2035	2050
Queenstown	IUA_S02	13.8	13.8	13.2[1]	14.67[1]
Butterworth system	IUA_S03	8.54	8.54	8.22	9.08
Emalahleni LM	IUA_S01	2.42	2.42	2.51	2.61
Intsika LM	IUA_S01	4.83	4.84	4.86	4.86
Total		29.6	29.6	28.8	31.2

[1] – Projected using Butterworth's projected growth rate

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

The key water requirements are domestic supply to Mthatha, Lusikisiki and Port Saint Johns, as shown in **Table 5-9.** Mthatha is supplied by Mthatha Dam, Lusikisiki through abstractions from the Xura River. Port Saint Johns is supplied from the Bulolo Dams and Mngazi off-channel storage dam as well as resources on the Mzimvubu River.

Table 5-9: Summary of main water requirements (Mbashe, Mthatha, and Coastal Systems)

Water user	IUA	Allocation	Current use as of reporting (2010)	Medium Growth		
				2020	2035	2050
Mthatha	IUA_T03		22.332	22.3	23.126	24.393[1]
Lusikisiki	IUA_T04		5.837	5.901	5.901	5.901
Port Saint Johns	IUA_T04		7.95	(3.025)	(3.025) [2]	(3.025)[2]
Elliot	IUA_T01		0.305	0.305	0.3335	0.3555
Total			36.42	31.53	32.38	33.67

Notes:

[1] – Alternative scenario includes growth to 55.08 million m^3/a with Hydropower requirement reduced to 90 million m^3/a.

[2] – Modelled Port Saint Johns as supplied by the Mngazi system (3.025). Assumed all new growth to be supplied from outside the system.

5.2.2 *Irrigation and Stream flow reduction activities*

The present day water requirements of irrigation and stream flow reduction activities, such as alien invasive plants and forestation are included in **Table 5-10.**

Table 5-10: Requriements of Irrigation and Stream Flow Reduction Acitivities

IUA	Requirement (million m^3/a)	
	Irrigation	Stream Flow Reduction
IUA_K01	11.2	35.3
IUA_KL01	77.9	6.8
IUA_L01	43.5	0.0
IUA_LN01	367.7	1.5
IUA_M01	8.0	32.5
IUA_N01	180.4	0.3
IUA_P01	17.7	10.3

IUA	Requirement (million m^3/a)	
	Irrigation	Stream Flow Reduction
IUA_Q01	15.1	0.0
IUA_Q02	506.7	1.4
IUA_Q03	31.7	1.3
IUA_R01	16.3	15.6
IUA_R02	2.9	9.7
IUA_S01	19.8	7.2
IUA_S02	23.1	2.1
IUA_S03	8.1	29.6
IUA_T01	5.4	40.6
IUA_T02	0.0	0.3
IUA_T03	0.0	5.0
IUA_T04	0.0	13.1

5.3 Present Day Water Resources

The key present day water resources in the Keiskamma, Fish to Tsitsikamma catchment areas are highlighted in **Table 5-11** and include the main dams that have been developed in the catchment. It further includes which dams have operating rules within the Water Resource Yield Model (WRYM) model. This list excludes the various local water supply schemes for potable water, industry and irrigation within the catchment developed by the municipalities and farmers.

There are also some significant water transfers in the study area. These are summarised in **Table 5-12.**

Table 5-11: Main dams in the catchment with operating rules within WRYM models

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Water yield (million m^3/a) *	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	30.0 [1]	Yes, based on the models for the annual operating analyses (AoA's) and the Water Availability Assessment Study (WAAS)
Kromriver (Churchill)	Krom	K90	32	Domestic water supply		
Beervlei	Groot	L30	90	Irrigation water supply		
Kouga	Kouga	L82	128	Domestic water supply	75.0 [1]	
Haarlem	Haarlemspruit	L82	4.7	Domestic water supply		
Loerie	Loerie	L90	3.17	Domestic water supply	Part of Kouga yield	
Groendal	Swartkops	M10	12.3	Domestic water supply	6.8 [1]	
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: Robert Sobukwe (Graaff Reinet)	2.4 [3]	Yes
Darlington	Sundays	N20	187	Irrigation		N/A
Settlers	Kariega	P30	5.57	Makana LM: Mkhanda & Irrigation (Grahamstown System)	9.1 [3] (Grouped with 4 other dams)	Yes
Sarel Hayward	Kowie	P40	2.5	SBDM: Port Alfred	1.55 [3]	Yes
Klipfontein	N/A	L60	1.8	SBDM: Klipplaat	0.83 [3]	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	8.8 [4]	Yes
De Mistkraal	Little Fish	Q80	3.1	Transfer of water		N/A

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Water yield (million m^3/a) *	Dam with operation rules
Katrivier	Kat	Q90	24.8	ADM: KwaMagoma (Fort Beaufort RoR, Seymour, Irrigation	20.22 [3]	Yes
Andrew Turpin	eNyara	Q90	N/A	ADM: Bedford	0.27 [3]	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	18 [3]	Yes
Cata	Cata	R10	12.1	Irrigation	6.2 [3]	N/A
Binfield Park	Tyume	R10	36.8	ADM: Alice & rural & Irrigation	16.5 [3]	Yes
Pleasant View	Tyume	R10	2.0	ADM: Alice & rural & Irrigation	1.5 [3]	Yes
Debe	Debe	R10	6.0	ADM: Rural	2.15 [3]	Yes
Laing	Buffalo	R20	21	Domestic water supply	18.3 [2]	N/A
Rooikrantz	Buffalo	R20	4.9	Domestic water supply	3.7 [2]	N/A
Bridle Drift	Buffalo	R20	101.7	Domestic water supply to East London	29.4 [2]	N/A
Nahoon	Nahoon	N30	20.7	Domestic water supply	8.4 [2]	N/A
Xonxa	White-Kei	S10	126	Irrigation	27 [3]	N/A
Lubisi	Indwe	S20	135	CHDM: Irrigation & rural	28.5 [3]	Yes
Doringrivier	Doring	S20	17.84	CHDM: Indwe & rural	3.38 [3]	Yes
Waterdown	Klipplaat	S30	36.6	Queenstown System	16.5 [3]	Yes
Bonkolo	Komani	S30	6.95	CHDM LM: Komani, Sada, Whittlesea, rural & Irrigation	0.65 [3]	Yes
Oxkraal	Oskraal	S30	17.8	Queenstown System	6.18 [3]	Yes
Bushmankrantz	Oskraal	S30	4.62	Queenstown System	2.07 [3]	Yes

Dam	Associated River	Catchment	Volume (MCM)	Main purpose	Water yield (million m^3/a) *	Dam with operation rules
Sam Meyer	Thorn	S40	0.5	ADM: Cathcart	1.00 [3]	Yes
Ncora	Tsomo	S50	120	CHDM: Rural & Irrigation & hydroelectric & ADM: rural, Tsomo	13.0 [3]	Yes
Tsojana	Tsojana	S50	9.35	CHDM: Cofimvaba Rural	3.16 [3]	Yes
Gubu	Gubu	S60	8.8	Domestic water supply	2.9 [2]	N/A
Wriggleswade	Kubusi	S60	91.2	Transfer of water to R2 catchment for domestic use	31.8 [2]	N/A
Xilinxa	Xilinxa	S70	14.5	ADM: Butterworth, rural & augmentation to Dutywa & Kentane	7.3 [3]	Yes
Toleni	Toleni	S70	N/A	ANDM: Rural	0.16 [1]	Yes
E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems)						
Macubeni	Mgwali	T10	1.85	CHDM: Ngcobo	2.2 [3]	Yes
Mthatha	Mthatha	T20	228.0	ORTDM: Mthatha & Rural & Hydropower	145 [3]	Yes
Mabeleni	Mhlahlane	T20	2.0	ORTDM: Mthatha peri-urban & rural	1.73 [3]	Yes
Corana	Corana	T20	0.71	ORTDM: Rural	0.34 [3]	Yes
Bulolo	Bulolo	T70	0.255	ORTM: Port St Johns & rural	0.337 [3]	Yes
Mhlanga	Mngazi	T70	1.96	ORTDM: Libode & rural	0.78 [3]	Yes
Nzwakazi	Mtakatye	T70	N/A	ORTDM: Ngeleni & rural	0.103 [3]	Yes
Nqadu Weir	Nqadu	T90	N/A	ORTDM: Rural		Yes

** Yields are often calculated and reported at different risk levels and through different calculation methods. The following relates:*

[1] – Algoa Reoconciliation Strategy (1:50 yr recurrence - 98% assurance yield excl. EWR impacts)

[2] – Amathole Reconciliation strategy (1:50 yr recurrence - 98% assurance yield excl. EWR impacts)

[3] –All towns Reconciliation strategy (1:50 yr recurrence - 98% assurance yield)

[4] –All towns Reconciliation strategy (1:20 yr recurrence - 95% assurance yield)

Table 5-12: Water transfers in the study area

Transfer	Associated source River	Source Catchment	Associated receiving River / point	Receiving Catchment	Volume (MCM)	Main purpose
Gqeberha Transfer	Krom (Kromriver Dam)	K90B	Coastal Towns & Gqeberha	K90 & M	8.0	
Gqeberha Transfer	Krom (Impofu Dam)	K90D	Coastal Towns & Gqeberha	K90 & M		
B. N10 to N40 and P10 to P40 (Sundays, Kowie, Kariega and Boesmans)						
Fish-Sundays	Little Fish (De Mistkraal)	Q80E	Skoenmakers River (Darlington Dam)	N23A	275.54	
Orange-Fish	Orange (Gariep Dam)	D35H (K)	Teebus River	Q12B	740.7	
D. R10 to R50 and S10 to S70 (Buffalo, Nahoon, Keiskamma, Great Kei)						
Amathole	Kubusi (Wriggleswade Dam)	S60B	Yellowwoods River	R20E	15.0	Amathole Domestic
Amathole	Kubusi (Wriggleswade Dam)	S60B	Nahoon River	R30E	10.6	Amathole Domestic
Ncora	Tsomo (Ncora Dam)	S50E	Qumanco	T12C	106.86	Hydropower and Irrigation
E. T10, T20 and T60 to T90 (Mbashe, Mthatha, coastal systems)						
Macubeni	Tsomo	S50E	CHDM: Ngcobo		1.85	Domestic

Table 5-13: Summary of main waste water return flows

WWTW Name	Capacity (Ml/d)	Quartenary	Associated receiving River / point	Volume (MCM/month 2020)	Re-use
Cape Recife	9.00	M20A	*Evaporation ponds*		Irrigation 3 Ml/d
Despatch	8.86	M10D	Swartkops River	0.27	Construction 1.9 Ml/d
Driftsands	22.00	M20A	*Evaporation ponds*		
Fishwater Flats	132.00	M20A	To sea		Construction 2 Ml/d
Kelvin Jones	24.00	M10D	Swartkops River	0.73	Irrigation 0.7 Ml/d
Kwanobuhle	9.00	M10C	Brak River (Swartkops River)	0.27	
Rocklands SBR	0.18	M10C	*No*		
Brickfield			*No data*		

5.4 Future surface water resource development options

To meet growing water requirements, projected to exceed the current water availability of existing river systems and associated water resources infrastructure, new interventions have typically been proposed and planned. These physical infrastructure options have been included in scenarios and are summarised in **Table 5-14.**

These were guided by the same Reconciliation Strategies that are projecting the water requirements, plans for individual scheme developments by local authorities where available, the various tandem project technical meetings had in December 2021 and December 2023, the Study Team's experience and knowledge of the catchment, as well as through the engagements with the DWS (National and Regional), and the consulting teams involved with the Reconciliation Strategy for the Southern Cluster, as well as the WAAS study.

While the development of new water resources and associated infrastructure is a key long-standing approach to meeting development and water requirement growth, the efficient use of water is also a key approach within the strategies and has been carried through to this classification approach. Considering the competition for water this is important, and as such, all future scenarios assume reasonable water losses with the implementation of water conservation and water demand management (WC/WDM) as part of the future scenarios. These are WC/WDM scenarios as provided in the appropriate plans and strategies.

The anticipated commissioning dates noted in **Table 5-14** are often from dated plans and strategies, and in some cases are in the past. However, it is not certain that these planned interventions have been implemented, especially where the interventions are not surface water developments that would be captured in the models that have been obtained. Furthermore, some surface developments listed in the table were considered but not formally modelled.

For example, Coerney Dam was considered but not modelled for the following reasons:

- The dam is planned as an operational storage dam, to provide some operational buffer to allow water supply to the Algoa Water supply system (WSS) to be maintained should there be any infrastructure issues or downtime, as well as to manage the operational complexity and risk associated with the multiple transfers to get the water from the Orange River through to the Sundays and ultimately the Algoa WSS.

- The water from the Orange River transfer provides a significant portion of the total volume of water in the Sundays at the point of abstraction for the Scheepersvlakte scheme that supplies water through a canal system to the Irrigators in the Lower Sundays, as well as the Algoa WSS.

- The planned Coerney Dam will be filled primarily through from the transfer Canal and is anticipated to be maintained full to provide the operational buffer storage when needed. Thus, it is anticipated that any flows that do sporadically occur in the stream on which the dam is proposed, will likely spill and continue downstream.

- The dam has a catchment of around 37 km^2, which is only around 5% of the N40D quaternary in which it is positioned. It thus has a very limited flow impact within the already dry and heavily modified Sundays River.

- Since the dam is to provide operational storage for a short period (for around 21 days), we are not able to simulate this within the monthly time step model, and the impacts would be relatively negligible within the larger system context.

- Outside of what can be simulated within the models, from a practical perspective, the inclusion of the operational storage dam in the system will provide some flexibility, and a greater ability to comply with any downstream ecological water requirements in the Sundays River due to the buffer storage created. This is relevant given the complexity of the cascading operations of the Fish-Sundays system.

Table 5-14: Possible major water resources developments in the Keiskamma, Fish to Tsitsikamma catchment areas

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
	Algoa Reconciliation area (K90, L, M)				
IUA_M01	Nooitgedagt / Coega Low Level Scheme	All Scenarios	2022. Included here, as not yet completed when the Recon Strategy was previously updated, but a completed scheme for the scenarios.	Up to 76.52 million m^3/a	Reconciliation Strategy
IUA_N01	Coerney Balancing Dam	Not modelled	Operational storage dam supplied by the Sundays Canal to aid maintaining supply to NMBM. 21 days of storage	4.6 million m^3/a	DWS Regional Office (Eastern Cape)
IUA_M01	Re-use for Industrial users in Coega IDZ	Scenarios 2 and 3	Dependant on growth of Industrial development zone and associated need for additional water. Assume phase 1 in intermediate and phase 2 in long term future.	30 ML/d (phase 1) to to 60 ML/d) for phase 2.	Algoa Recon Strat (2023 status Report)
IUA_KL01	Removal of illegal dams	Scenarios 2 and 3	An investigation has flagged illegal dams (and associated irrigation). These could be removed for a specific scenario. May need to be coupled with the WAAS reallocation process, if the kabeljous or associated catchments are part of the scope.	Estimated at least 10% of dams built after qualifying period (unlawful). Reduce by 10% - ± 100 000 m^3.	Data provided by region (shape files) & commentary on legality.
IUA_M01	Groundwater development	Scenarios 2 and 3	Coega-kop aquifer and other ad hoc groundwater. Groundwater exploitation near Kromme Dam (Churchill).	Coegakop: 0.4 million m^3/a Churchill: 2.2 million m^3/a	Algoa Schemes Report (2023)
IUA_M01	Desalination of seawater	Scenario 3.1	Schoenmakerskop or Marina desalination options.	Either 60 ML/d or 25 ML/d dependant on scheme option	Algoa Recon Strat (2023 status Report)
IUA_KL01	Kouga Dam	Scenario 3.2	Either a new dam at Guernakop or the raising of the Kouga dam wall.	Guernakop: 200 million m^3 Kouga: +19.8 m	Algoa Recon Strat – 2015 report
IUA_KL01	Removal of Alien Invasives	Scenarios 2 and 3	Removal of alien invasive plants in upper Kouga Catchments (L82)	± 14.8 million m^3/a	Algoa Schemes Report - 2024

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
	Groot River Catchment (L10 – L70)				
IUA_ LN01	Groundwater development	Scenarios 2 and 3	2030. Two test holes drilled with a potential combined supply of up to 190 kl/d. However, the water quality was poor.	0.2 MCM/a	All Towns (2011) (DWA, 2011).
IUA_ LN01	Re-use of water in Klipplaat	Scenarios 2 and 3		0.475 MCM/a in 2010	All Towns (2011)
	Sundays and Bushman's Catchments (N and P)				
IUA_ LN01	Groundwater development (N13C)	Scenarios 2 and 3	2015	0.82 MCM/a	All Towns (2011)
IUA_ LN01	Raising of Nqweba Dam	Scenarios 2 and 3	Unlikely due to dam safety considerations	0.4 MCM/a	All Towns (2011)
IUA_ LN01	Transfer from De Hoop Dam		Unlikely.		All Towns (2011)
IUA_ LN01	Re-use of water in Graaf-Reinet	Scenarios 2 and 3		3.64 MCM/a in 2010	All Towns (2011)
IUA_ P01	Increased allocation from Glen Melville Dam	Scenarios 2 and 3		6.57-8.03 MCM/a	DWS Regional Office (Eastern Cape)
IUA_ P01	Groundwater development (P40A)	Scenarios 2 and 3	2027	0.5 MCM/a	All Towns (2011)
IUA_ P01	Re-use of water in Makhanda (Grahamstown)	Scenarios 2 and 3	Not Included. Assumption is for future requirements to be met by Glen Melville	2.514 MCM/a in 2010	All Towns (2011)
	Fish Catchment (Q)				
IUA_ Q01, 2,3	Groundwater development	Scenarios 2 and 3	2010 (as per old documentation). Continue to confirm with the region if any development has already occurred.	0.7 MCM/a	All Towns (2011)
	Amathole Recon Area				

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
IUA_ R02	AIP removal	Future scenarios	TBC – approximate areas of AIPs flagged by Region. Total use appears uncertain. 2015 estimates by be of AIP impacts of around 8.4 million m^3/a. Location needs to be confirmed. possibility of being combined to allow new commercial forestry application	8.4 million m^3/a.	Status Report
IUA_ R02	Water reuse / Aquifer storage Recovery (ARS) seems to be an or.	Intermediate and Ultimate future	TBC (water balance suggests that the first intervention would be needed in around 2027). Dependant on effectiveness of WC/WDM and AIP removal, this could be around 2030. This recommend for both future time slices. Buffalo City MM looking at the Reeston WWTWs.	10 million m^3/a by 2028 and 20 million m^3/a by 2035	2016 status Report and 2023 status report
IUA_ R02	New surface water	Ultimate future option. Intermediate option	Dependant of reuse of water and WC/WDM success. 2023 status report suggests Wesselshoek on the Kwelera is preferred option. Ravenswood (keiskamma) for larger volume. Stone Island (nahoon) but might have negative environmental impacts. 2016 Status report suggests 2035 or beyond. 2023 focuses only on Wesselshoek.	11 million m^3/a additional yield	2016 status Report and 2023 status report
IUA_ R02	Desalination of seawater	Ultimate future alternative	Long term back-up option. Not focused on for the 2022 status report.	TBC	2016 status Report.
	Great Kei Catchment (S10-S70)				
IUA_ S02	Additional abstractions from Xonxa and Lubisi Dams		2015	2 MCM/a	All Towns (2011)
IUA_ S01	Groundwater development (S10G)		2015	1 MCM/a	All Towns (2011)
IUA_ S01	Increased allocation from Doringrivier Dam				All Towns (2011)

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
IUA_S01	Groundwater Development (S20A)			10.18 MCM/a	All Towns (2011)
IUA_S02	Groundwater Development (S31F)		2011	1 MCM/a	All Towns (2011)
IUA_S02	Re-use of water in Komani (Queenstown)			4.391 MCM/a in 2010	All Towns (2011)
IUA_S01	New allocation on Ncora Dam				All Towns (2011)
IUA_S01	New allocation on Lubisi Dam				All Towns (2011)
IUA_S01	Groundwater development (S50D)		2012	0.5 MCM/a	All Towns (2011)
IUA_S01	Extension of the Tsojana Scheme		2015	0.12 MCM/a	All Towns (2011)
IUA_S01	Groundwater development (S50G-H)		2015-2030	0.507 MCM/a	All Towns (2011)
IUA_S03	Groundwater development (S60A)			13.02 MCM/a	All Towns (2011)
IUA_S03	Re-use of water in Stutterheim			0.926 MCM/a in 2010	All Towns (2011)
IUA_S03	Groundwater development (S70A and E)		2015	1.2 MCM/a	All Towns (2011)
IUA_S03	Extension of Qolora Scheme		2015	0.5 MCM/a	All Towns (2011)
IUA_S03	Extension of Butterworth scheme		2015	0.5 MCM/a	All Towns (2011)

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
IUA_ S03	Additional allocation from Xilinxa Dam		2015	2.9 MCM/a	All Towns (2011)
IUA_ S03	Groundwater development		2015	1 MCM/a	All Towns (2011)
IUA_ S03	Re-use of water in Butterworth			3.877 MCM/a in 2010	All Towns (2011)
IUA_ S03	Raising of Gcuwa dam		For domestic water supply	1.2 m raising of Gcuwa Dam	Gcuwa Weir Design report (2022)
	Coastal Catchments (T)				
IUA_ T03	Groundwater development (T20A)		2035		All Towns (2011)
IUA_ T03	Re-use of water in Mthatha			2.795 MCM/a in 2010	All Towns (2011)
IUA_ T03	Reallocation of water in Mthatha		Reduction of Hydropower releases from Mthatha dam (132 to 90) to allow for larger domestic supply (55.08)		DWS Regional Office (Eastern Cape)
IUA_ T04	Construction of Zalu Dam		TBC	5.84 MCM/a	All Towns (2011)
IUA_ T04	Additional abstractions from Magwa Dam		2011	1 MCM/a	All Towns (2011)
IUA_ T04	Groundwater development (T32)		2012	2 MCM/a	All Towns (2011)
IUA_ T04	Development of the Mngazana RWSS		2015	1 MCM/a	All Towns (2011)
IUA_ T04	Groundwater development (T36A)		2015	2 MCM/a	All Towns (2011)
IUA_ T04	Abstraction from the Mzimvubu/Mzintlava River		2015	1 MCM/a	All Towns (2011)

No.	Development	Scenario inclusion	Details and estimated commissioning date*	Scheme Dimensions	Literature
IUA_T01	Full utilisation of irrigation allocation from Ncora Dam			21.9 MCM/a	Operational Analysis (2016) (DWS, 2017).

** The estimated completion dates are often outdated and based on previous studies and plans. Original dates are reported.*

5.5 Present and future groundwater resource development options

Table 5-15 summarises the groundwater status for each IUA, highlighting areas where groundwater is the primary source of water use and overall stress. Refer to **Figure 5-4** for a visual of the overall stress of the IUA for groundwater. These IUAs mostly include small towns reliant on groundwater to supplement surface water resources. Additionally, parts of certain IUAs are designated for future development (Scenario 2 and/or Scenario 3) to reduce pressure on surface water supplies. The table also presents where groundwater-stressed areas are identified where usage exceeds recharge.

Table 5-15: Groundwater status and overall stress for each IUA

IUA No.		GW Aquifer types	SWSA[1]	Current GW use	Planned GW developments (Sc 2 and/or 3)	AREA (km^2)	GW Available (m^3/a)	GW Surplus[2] (m3/a)[3] (GRA)[4]	UGEP DRY	% Area Stressed (GRA) by Quaternary Catchment	% Area Stressed (UGEP)[5] by Quaternary Catchment	Overall stress of the IUA for GW	
1	IUA_K01	The aquifer is of a fractured type, mainly associated with the fractured Table Mountain Group Aquifer.	Yes	9.4Mm³/annum. Large percentage of total groundwater use is for irrigation (78%)	-	1565.70	54045340.00	44379322.00	44851940.00	14.11	0.00	Localised stressed area in 1 quaternary catchment. Remainder of IUA is not currently stressed	Under allocated
2	IUA_KL01	The aquifer is of a fractured type, mainly associated with the fractured Table Mountain Group Aquifer.	Yes	Large percentage of total groundwater use is for irrigation (57%) and 26% for municipal use. Groundwater qualities are good to marginal.	Groundwater development for Kouga LM There will be potentially short-term groundwater development, medium term de-salination and further groundwater development to provide domestic demands for Algoa area. Coega-kop aquifer and other ad hoc groundwater exploitation near Kromme Dam (Churchill).	2396.00	9840275.00	74882.00	5869318.00	40.91	0.00	Widespread stressed areas in 4 quaternary catchments. Localised areas in 1 quaternary catchments are near stressed but currently under allocated	Under allocated
3	IUA_L01	The aquifer is of a fractured type, mainly associated with the fractured Table Mountain Group Aquifer.	Yes	6.0Mm³/annum, of which 90% is for irrigation.	Kouga LM additional groundwater development to augment and supplement existing surface water allocations from Churchill & Kouga Dams. (2.2 million m³/a)	4052.60	14905772.00	9981729.00	13290148.10	6.44	0.00	Localised stressed area in 1 quaternary catchment. Widespread areas in 6 quaternary catchments are near stressed but currently under allocated	Under allocated
4	IUA_M01	The aquifer is of a fractured type, mainly associated with the fractured Table Mountain Group and Uitenhage Group. A small part of the IUA is also of an intergranular type, associated with Quaternary sands.	Yes	8.4Mm³/annum, of which 51% is for irrigation, 29% is for municipal use and 12% is for industrial use.	Groundwater development Groundwater development at Swartkops (0.4 million m³/a)	2627.00	6460714.00	-12421975.00	2974244.00	51.61	16.36	Widespread stressed areas in 4 quaternary catchments. Remainder of IUA in 3 quaternary catchments is near stressed but currently under allocated	Over allocated
5	IUA_LN01	The aquifer is of a fractured type, mainly associated with the fractured Upper Cape Supergroup (Bokkeveld and Witteberg Groups) and Lower Karoo Supergroup.	Yes	65% of groundwater use is for irrigation and, 31% for domestic. A number of towns in this area is solely dependant	Groundwater development (Groot) (0.2 MCM/a)	46305.50	138253407.00	91941344.00	81887937.80	24.02	12.84	Widespread stressed areas in 19 quaternary catchments. Widespread areas in 9 quaternary catchments are	Under allocated

IUA No.		GW Aquifer types	SWSA[1]	Current GW use	Planned GW developments (Sc 2 and/or 3)	AREA (km²)	GW Available (m³/a)	GW Surplus[2] (m3/a)[3] (GRA)[4]	UGEP DRY	% Area Stressed (GRA) by Quaternary Catchment	% Area Stressed (UGEP)[5] by Quaternary Catchment	Overall stress of the IUA for GW	
				on groundwater with no other sources available.	Groundwater development (Sundays) (0.82 MCM/a)							near stressed but currently under allocated	
6	IUA_N01	The aquifer is mainly of a fractured type associated with the fractured Lower Karoo Supergroup and Uitenhage Group. A smaller part of the area is also of an intergranular type associated with Quaternary sand and alluvium.	No	Minimal groundwater use for irrigation, industrial and domestic.	-	4398.10	6824455.00	6164744.00	1822445.90	0.00	0.00	Localised area in 1 quaternary catchment is near stressed but currently under allocated. Remainder of IUA is not currently stressed	Under allocated
7	IUA_P01	The aquifer is mainly of a fractured type associated with the upper Cape Supergroup (Bokkeveld and Witteberg Groups) and Lower Karoo Supergroup. A smaller part of the area is also of an intergranular type associated with Quaternary sand and alluvium.	Yes	70% of the total groundwater use is for municipal and 15% for irrigation.	-	5320.30	23761098.00	20545207.00	8320162.25	0.00	0.00	Widespread areas in 4 quaternary catchments are near stressed but currently under allocated	Under allocated
8	IUA_Q01	The aquifer is mainly of a fractured type associated with the Karoo Supergroup. Intergranular and fractured aquifers, owing to the presence of dolerite sills and dykes also exist, as well as localised intergranular aquifers associated with alluvial deposits.	No	57% of the total groundwater use is for irrigation purposes and 30% for domestic	Groundwater development (Fish) (0.7 MCM/a)	8079.60	32168102.00	14688002.00	20085866.00	22.03	0.00	Localised stressed area in 1 quaternary catchment. Widespread areas in 2 quaternary catchments are near stressed but currently under allocated	Under allocated
9	IUA_Q02	The aquifer is mainly of a fractured type associated with the Karoo Supergroup. Intergranular and fractured aquifers, owing to the presence of dolerite sills and dykes also exist.	Yes	Water use, mainly for irrigation in those areas not linked to the transfer scheme.	Groundwater development (Fish) (0.7 MCM/a)	17098.90	80560612.00	70492857.00	45646838.50	2.50	0.00	Localised stressed areas in 3 quaternary catchments. Remainder of IUA is not currently stressed	Under allocated
10	IUA_Q03	The aquifer is mainly of a fractured type associated with the Karoo Supergroup. Intergranular and fractured aquifers, owing to the presence of dolerite sills and dykes also exist.	Yes	GW use limited	Groundwater development (Kat) (0.7 MCM/a)	5049.70	38999280.00	36796467.00	17036222.80	0.00	0.00	Whole IUA is not currently stressed	Under allocated
11	IUA_R01	The aquifer is mainly of a fractured type associated with the Karoo Supergroup. Intergranular and fractured aquifers, owing to the presence of dolerite sills and dykes also exist.	No	GW use limited	-	4357.40	34114052.00	32098056.00	16748823.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated

IUA No.		GW Aquifer types	SWSA[1]	Current GW use	Planned GW developments (Sc 2 and/or 3)	AREA (km^2)	GW Available (m^3/a)	GW Surplus[2] (m3/a)[3] (GRA)[4]	UGEP DRY	% Area Stressed (GRA) by Quaternary Catchment	% Area Stressed (UGEP)[5] by Quaternary Catchment	Overall stress of the IUA for GW	
12	IUA_R02	The aquifer is mainly of a fractured type associated with the Karoo Supergroup. Intergranular and fractured aquifers, owing to the presence of dolerite sills and dykes also exist.	No	GW use limited	Groundwater (Amathola) (3.3 million m^3/a Water reuse / Aquifer storage Recovery (ARS). This is TBC (water balance suggests that the first intervention would be needed in around 2027). Dependant on effectiveness of WC/WDM and AIP removal, this could be around 2030. This recommends for both future scenarios (medium and long term) AIP removal – TBC, approximate areas of AIPs flagged by Region. Total use appears uncertain. 2015 estimates of AIP impacts around 8.4 million m^3/a. Location needs to be confirmed.	3577.30	36770460.00	34531285.00	22420095.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated
13	IUA_S01	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	Yes	Mostly for domestic/ rural water supply.	Groundwater development (0.1 MCM/a)	10134.60	84280591.00	78122277.00	63664129.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated
14	IUA_S02	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	No	GW use limited	-	6904.50	37935960.00	35132958.00	23191494.00	0.00	6.38	Localised areas in 2 quaternary catchments are near stressed but currently under allocated. Remainder of IUA is not stressed	Under allocated
15	IUA_S03	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes. The IUA is	Yes	GW use limited	Groundwater development (2 MCM/a) Groundwater development in Butterworth & Idutwa	3444.10	41831320.00	41405152.00	24489062.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated
16	IUA_T01	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	Yes	GW use limited	-	5115.30	84053530.00	82648153.00	67027140.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated
17	IUA_T02	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	No	GW use limited	-	1415.90	26753230.00	26207146.00	10729730.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated

IUA No.		GW Aquifer types	SWSA[1]	Current GW use	Planned GW developments (Sc 2 and/or 3)	AREA (km²)	GW Available (m³/a)	GW Surplus[2] (m3/a)[3] (GRA)[4]	UGEP DRY	% Area Stressed (GRA) by Quaternary Catchment	% Area Stressed (UGEP)[5] by Quaternary Catchment	Overall stress of the IUA for GW	
18	IUA_T03	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	No	GW use limited	Groundwater development proposed in Mthatha to alleviate stress on surface water resources	2117.80	43002700.00	42120476.00	32271350.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated
19	IUA_T04	The aquifer is of an intergranular and fractured type associated with the Karoo Supergroup, as well as the presence of dolerite sills and dykes.	Yes	GW use limited	-	9273.90	284081530.00	282105876.00	172544760.00	0.00	0.00	Whole IUA is not currently stressed	Under allocated

[1] *Strategic Water Source Area*

[2]*Surplus: Likely refers to water surplus, which in groundwater terms could indicate the amount of water available beyond the immediate usage or demand. It may also pertain to specific tools or models assessing water availability.*

[3] *As of December 2024 based on NIWIS (National Integrated Water Information System)*

[4]*GRA: Groundwater Resource Assessment - refers to evaluations conducted to determine the quantity, quality, and sustainability of groundwater resources.*

[5]*UGEP: Utilisable Groundwater Exploitation Potential (This provides for a management restriction on the volumes that may be abstracted based on a defined "maximum" allowable water level drawdown)*

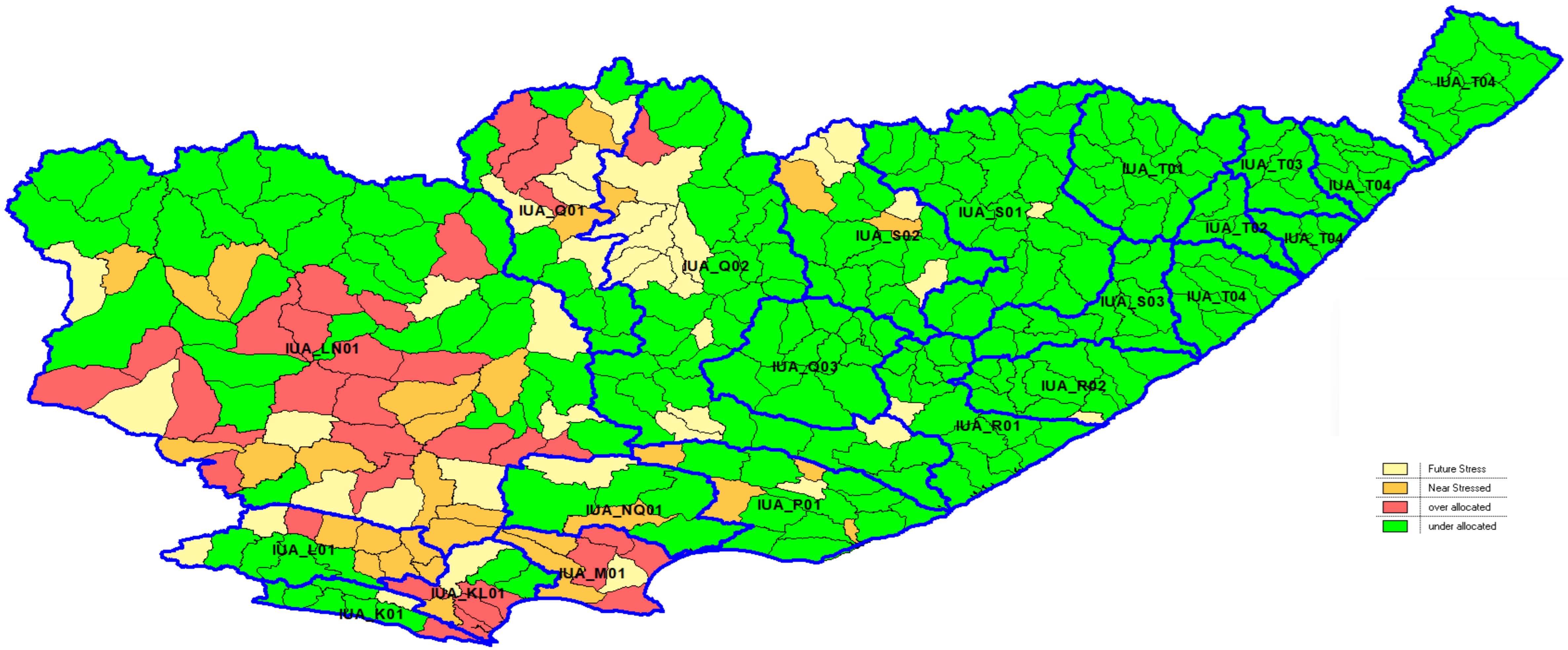

Figure 5-4: Level of groundwater stress through the study area per IUA

5.6 Overall Summary of the Planning Scenarios

The scenarios as described in **Sections 5.1 to Section 5.4**, have been summarised in the matrix in **Table 5-16**.

Table 5-16: Summary of scenarios proposed for analysis

Scenarios		Development Level			EWRs		Comment
No.	**Name**	**2022 / 2023**	**2035**	**2050**	**Incl.**	**Excl.**	
1a	Present day – With EWRs	Yes			Yes		
1b	Present day – No EWRs	Yes				Yes	
2a	Intermediate future – With EWRs		Yes		Yes		
2b	Intermediate future – No EWRs		Yes			Yes	
3.1a	Long-term future (option 1) – Without EWRs			Yes		Yes	
3.1b	Long-term future (option 1) – with EWRs			Yes	Yes		
3.2a	Long-term future (option 2) – Without EWRs			Yes		Yes	Alternative long-term scheme *
3.2b	Long-term future (option 2) – With EWRs			Yes	Yes		Alternative long-term scheme *

** Where applicable. For example, the Reconciliation Strategies have not yet selected / resolved which is the preferred scheme for long term water supply security, e.g., a new dam development vs desalination.*

To avoid too many scenarios and "analysis paralysis", a selection will be made between the option 1 and option 2 alternatives for the long-term development level to be used for the final scenario. This will be done in collaboration with the Reconciliation Strategy Team (DWS and consultants), as well as based on how each of the alternative scenarios performs from both a socio-economic and ecological perspective.

Regarding the scenarios with ecological water requirements included, it is anticipated that there might be some iteration on the EWRs included. This could entail the following:

- An inclusion of exclusion of the peak flows (or a portion of the flow regime) in the EWRs, e.g. total EWRs versus maintenance low flows only.
- A change in the targeted category.
- An iteration in operations to improve the flows reaching the estuary (where the flows are assessed as a result of a scenario, rather than with a specific full flow regime being included as a target).

The scenarios modelled are presented in **Table 5-17**.

Table 5-17: Scenarios

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
IUA_T01	Upper Mbashe, Upper Mthatha	Linked to: IUA_T02, IUA_S01, S02, S03	MBHA02_R: Mbhashe (Upper) MTHA02_D: Mthatha XUKA01_D: Xuka	N/A	None	No	Sc1	Forestry & Invasives (40.6) Irrigation (5.4) **<u>Mbashe:</u>** Elliot (0.305) Collywobbles Hydropower (84.88)		WRYM**
							Sc2	**<u>Mbashe:</u>** Elliot (0.333) 50%irrigation allocation from Ncora Dam (11 MCM/a) Collywobbles Hydropower (84.88)	Sc2.1 hydropower transfer was removed as a scenario to check impact on water availability and EWR on downstream IUAT02	
							Sc3	**<u>Mbashe:</u>** Elliot (0.355)	**Same as Sc2.**	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
								Full irrigation allocation from Ncora Dam (21.9 MCM/a) Collywobbles Hydropower (84.88)		
IUA_T02	Lower Mbashe	Linked to: IUA_T01, IUA_S01, S02, S03 Upstream water transfer from Ncora Dam (Tsomo River in S5) to Collywobbles hydropower Thus, impact on Great Kei, will have an	MBAS01_I: Mbhashe (Middle)	Mbashe (Intermediate)		No	Sc1	Forestry & Invasives (0.3) Irrigation (0)		WRYM
							Sc2	Hydropower transfer in IUA_T01 included for full impact on this downstream IUA.	Sc2.1 hydropower transfer was removed as a scenario to check impact on water availability and EWR on downstream IUAT02	
							Sc3		**Same as Sc2.**	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m³/year)	Augmentation Interventions	Model Used for Assessment
		impact on Mbashe								
IUA_T 03	Lower Mthatha	Linked to IUA_T01 (upper Mthatha) Hydropower (modified flows) Growth scenario for Mthatha Re-use included/excluded	MTHA01_I: Mthatha (Lower)	Mthatha (although will rely on rivers as the EWR site is approximately 1km upstream from the estuary)	Mthatha (T2R001)	No	Sc1	Forestry & Invasives (5) Irrigation (0) **Mthatha:** Mthatha (22.332)		WRYM
							Sc2	**Mthatha:** Mthatha (23.126)	**Mthatha:** Groundwater development Re-use of water (2.795 MCM/a)	
							Sc3	**Mthatha:** Mthatha (55.08) Hydropower (90)	**Same as Sc2.**	
							Sc3.1	**Mthatha:** Mthatha (24.393) Hydropower (132)	**Same as Sc2.**	
IUA_T 04	Pondoland coastal	Mngazi (off-channel dam - increased demands)	MNGA01_R: Mngazi NQAB01_R: Nqabarha	Mngazi (Rapid) Xora (Desktop)		No	Sc1	Forestry & Invasives (13.1) Irrigation (0)	Identifying and addressing unlawful irrigation	WRYM (Mngazi)

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
		Will use existing info for Msikaba River – JS: check you have 2 EWR sites within model Zalu Dam development in Xura River No development on Mngazana,	MTEN01_R: Mtentu MTAK01_FV: Mtakatye BULO01_D: Bulolo MNTA01_D: Mntafufu MZIN01_D: Mzizangwa XURA01_D: Xura MSIK01_D: Msikaba	Msikaba (Desktop) *Mngazana (Lara to advise owing to ecological importance/ mangroves)*				**<u>Msikaba:</u>** Lusikisiki (5.837) **<u>Mngazi:</u>** Port St. Johns (7.95)		WRSM 2000 (Remainder)
							Sc2	Irrigation (1.45) **<u>Msikaba:</u>** Lusikisiki (5.901) **<u>Mngazi:</u>** Port St. Johns to be supplied from sources outside the Mngazi.	**<u>Msikaba:</u>** Construction of Zalu Dam (on Xura River) (5.84 MCM/a) Additional abstractions from Magwa Dam and to meet the growing water requirements (1 MCM/a) **<u>Mngazi:</u>** Abstraction from the Mzimvubu/Mzintlava River (1 MCM/a) Identifying and addressing unlawful irrigation	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m³/year)	Augmentation Interventions	Model Used for Assessment
							Sc3	Irrigation (1.45) **<u>Msikaba:</u>** Lusikisiki (5.901) **<u>Mngazi:</u>** Port St. Johns to be supplied from sources outside the Mngazi.	**Same as Sc2.**	
IUA_R01	Keiskamma	Consider scenario (demand as a medium term, alternative scenario – abstractions – greater/less domestic growth).	CATA01_D: Cata KEIS01_I: Keiskamma (Upper) KEIS02_R: Keiskamma (Lower) TYUM01_R: Tyume	Keiskamma (Rapid) Gxulu *(potentially re-look at flows from scenarios) This was identified as possible groundwater-estuary integration. If no additional information*	Sandile (R1R002) Binfield (R1R003)	Yes	Sc1	Forestry & Invasives (15.6) Irrigation (16.4) **<u>Keiskamma:</u>** Peddie (2.68) Dimbaza (7.29) Debe (0.78) ADM (2.33)	Identifying and addressing unlawful irrigation, especially on Keiskamma (Not modelled)	WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
				available from estuary we can exclude						
							Sc2	**Keiskamma:** Peddie (3.72) Dimbaza (10.39) Debe (1.37) ADM (2.83)		
							Sc3	**Keiskamma:** Peddie (-) Dimbaza (-) Debe (-) ADM (3.39)		
IUA_R 02	Buffalo / Nahoon	Linked to IUA_S03 Intervention scenarios Growth scenarios	BUFF03_FV: Buffalo YELL01_D: Yellowwoods BUFF01_I: Buffalo (Middle) BUFF02_R: Buffalo NAHO01_FV: Nahoon KWEN01_FV: Kwenxura	Nahoon (Desktop) Qinera (Desktop) Kwelera *(potentially re-look at flows from scenarios)* Bulura *(potentially re-look at flows from scenarios)* Cintsa *(potentially re-look at*	Laing (R2R001) Bridledrift (R2R003) Nahoon (R3R001)	Yes	Sc1	Forestry & Invasives (9.7) Irrigation (2.9) **Amathole:** Buffalo City (91.41) Amathole District (3.35)		WRYM
							Sc2	**Amathole:** Buffalo City (102.05)	**Buffalo City:** Water Reuse (20 million m^3/a)	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
				flows from scenarios)				Amathole District (3.96)	**Amathole:** Groundwater (3.3 million m^3/a	
							Sc3	**Amathole:** Buffalo City (120.66) Amathole District (4.71)	**Buffalo City:** Water Reuse (26 million m^3/a) Wesselshoek Dam (10.9 million m^3/a) **Amathole:** Groundwater (3.3 million m^3/a	
IUA_Q01	Fish	Run as one model Linked to: IUA_Q02, Q03, LN01, N01 Major transfer from Gariep Dam (Upper Orange catchment) to Grassridge Dam to	FISH01_R: Great Fish PAUL01_D: Pauls LFIH01_FV: Klein Fish	N/A		No	Sc1	Forestry & Invasives (0) Irrigation (15.1) **Fish:** Inxuba (Cradock) (1.715)		WRYM
							Sc2	**Fish:** Inxuba (Cradock) (1.9335)	**Fish:** Groundwater development (0.7 MCM/a)	
IUA_Q02	Great Fish		GBRA01_FV: Groot Brak FISH04_FV: Great Fish	Great Fish (Desktop)		Provisionally Yes (downstream of	Sc1	Forestry & Invasives (1.4)	**Fish:** Partial supply to Makhanda (Grahamstown) (6.57)	WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
		Elandsdrift Dam to the Great Fish (Fish catchment), then transfer to Sundays system to Gqeberha (see **Figure 1** below).	TARK01_R: Tarka FISH02_R: Great Fish FISH05_D: Great Fish LFIS02_FV: Klein Fish FISH03_I: Great Fish (Lower)			Nxuba (Craddock) – WWTW, irrigation, agriculture)		Irrigation (506.7) **<u>Fish:</u>** Cookhouse & Sommerset East (2.447)		
							Sc2	**<u>Fish:</u>** Cookhouse & Sommerset East (2.824)	**<u>Fish:</u>** Groundwater development (0.7 MCM/a) Partial supply to Makhanda (Grahamstown) (7.62)	
							Sc3		**<u>Fish:</u>** Groundwater development (0.7 MCM/a) Partial supply to Makhanda (Grahamstown) (8.03)	
IUA_Q 03	Koonap and Kat		KAT01_I: Kat (Upper) KAT03_D: Kat KAT02_R: Kat (Lower) KOON01_R: Koonap	N/A	Katriver (Q9R001)	No	Sc1	Forestry & Invasives (1.3) Irrigation (31.7) **<u>Kat:</u>**		WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
								KwaMaqoma (Fort Beaufort), Seymour, Balfour (3.113) **Koonap:** Adelaide, Bedford (1.306)		
							Sc2	**Kat:** KwaMaqoma (Fort Beaufort), Seymour, Balfour (3.113) **Koonap:** Adelaide, Bedford (1.306)	**Kat:** Groundwater development (0.7 MCM/a)	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
							Sc3	**Kat:** KwaMaqoma (Fort Beaufort), Seymour, Balfour (3.113) **Koonap:** Adelaide, Bedford (1.306)	**Same as Sc2.** **Sc3.1 Koonap:** Foxwood Dam	
IUA_M01	M primary catchment	Linked to: IUA_KL01, LN01	SWAR01_I: Swartkops SAND01_D: Sand ELAN01_D: Elands CHAT01_D: Chatty	Swartkops (Desktop)	Groendal (M1R001)	Estuary only (Swartkop estuary)	Sc1	Forestry & Invasives (32.5) Irrigation (8) **Swartkops:** Nelson Mandela Bay Metro (110.75 MCM)	**Coega:** Nooitgedagt / Coega Low Level Scheme (Up to 160 Ml/d)	WRYM
							Sc2	**Swartkops:** Nelson Mandela Bay Metro (126.2)	**Swartkops:** Groundwater development (0.4 million m^3/a)	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
									<u>Coega:</u> Nooitgedagt / Coega Low Level Scheme (Up to 76.52 million m^3/a) Schoenmakerskop Desalination (60 Ml/d)	
							Sc3	**<u>Swartkops:</u>** Nelson Mandela Bay Metro (151.6)	**Same as Sc2.**	
IUA_S01	Upper Great Kei	Run as one model Linked to: IUA_T01, T02, R02 (Kubusi in S03) Ncora Dam (on Tsomo River – irrigation and	TSOM01_I: Tsomo INDW01_R: Indwe WKEI01_R: White Kei	N/A	Xonxo (S1R001) Lubisi (S2R001) Ncora (S5R001)	Yes (rivers only)	Sc1	Forestry & Invasives (7.2) Irrigation (19.8) **<u>White Kei:</u>** Emalahleni LM (2.42) **<u>Tsomo:</u>** Intsika LM (4.833)		WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
		license allocation update)					Sc2	**White Kei:** Emalahleni LM (2.51) **Tsomo:** Intsika LM (4.84)	**Tsomo:** Additional abstraction to ADM Eskom 80 million m^3/a Irrigators 22 million m^3/a (80% AOS) Domestic 10 million m^3/a (98% AOS) Groundwater development (0.1 MCM/a) Extension of the Tsojana Scheme (0.12 MCM/a)	
							Sc3	**White Kei:** Emalahleni LM (2.61) **Tsomo:** Intsika LM (4.86)	**Same as Sc2.**	
IUA_S 02	Black Kei		KOMA01_D: Komani	N/A	Waterdown (S3R001)	Yes (rivers only)	Sc1	Forestry & Invasives (2.1)		

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
			KSIM01_FV: Klaas Smits KLIP01_FV: Klipplaat BKEI01_I: Black Kei					Irrigation (23.1) **Black Kei:** Komani (Queenstown) (13.8)		
							Sc2	**Black Kei:** Komani (Queenstown) (13.282)	**Black Kei:** Additional abstractions from Xonxa and Lubisi Dams (2 MCM/a) Re-use of water in Komani Queenstown (4.391 MCM/a)	
							Sc3	**Black Kei:** Komani (Queenstown) (14.67)	**Same as Sc2.**	
IUA_S 03	Lower Great Kei		GKEI01_I: Great Kei GCUW01_R: Gcuwa KUBU01_R: Kubusi	Great Kei (Intermediate)	Gcuwa (S7R001) Wriggleswade (S6R002)	Yes (Rivers and Great Kei estuary – WWTW located on	Sc1	Forestry & Invasives (29.6) Irrigation (8.1) **Gubu:**		

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
			KUBU02_FV: Kubusi KUBU03_R: Kubusi (Lower)			estuary system)		Stutterheim (1.02) **Gcuwa:** Butterworth (8.54)		
							Sc2	**Gubu:** Stutterheim (1.13) **Gcuwa:** Butterworth (8.22)	**Kubu:** Groundwater development (2 MCM/) **Gcuwa:** Extension of Qolora Scheme (0.5 MCM/a) Groundwater development in Butterworth & Idutwa Additional allocation from Xilinxa Dam (2.9 MCM/a) Re-use of water in Butterworth (3.877 MCM/a) Raising of Gcuwa dam	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
							Sc3	**Gubu:** Stutterheim (1.32) **Gcuwa:** Butterworth (9.08)	**Same as Sc2 with:** **Gubu:** Groundwater development (2 million m^3/a)	
IUA_P01	P primary catchment	Driven by estuary requirements - rivers dry	BLOU01_D: Bloukrans KARI01_D: Kariega (Dry) BOES01_FV: Bushmans (Dry)	Kariega (Rapid) Bushmans (Desktop) Kowie (Desktop) East-Kleinemode		Yes rivers and estuaries (Kariega and Kowie estuary - WWTW located on estuary system)	Sc1	Forestry & Invasives (10.3) Irrigation (17.7) **Kariega:** Makhanda (Grahamstown) (8.87) Port Alfred (2.23)	**Fish:** Allocation from Glen Melville Dam (6.57 MCM/a)	WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
							Sc2	**Kariega:** Makhanda (Grahamstown) (9.92) Port Alfred (2.0)	**Fish:** Increased allocation from Glen Melville Dam (7.62 MCM/a)	
							Sc3	**Kariega:** Makhanda Grahamstown (10.33) Port Alfred (2.506)	**Fish:** Increased allocation from Glen Melville Dam (8.03 MCM/a)	
IUA_N01	Sundays downstream of Darlington Dam	Linked to: IUA_LN01, Q01, Q02, Q03	SUND02_R: Sundays (lower) COER01_D: Coerney	Sundays (Desktop)	Darlington (N2R001)	No	Sc1	Forestry & Invasives (0.3) Irrigation (180.4) **Sundays:** Kirkwood, Addo, Enon (4.0025)	Supply to Nelson Mandela Bay (76.55)	WRYM
							Sc2	**Sundays:**	Supply to Nelson Mandela Bay (76.55)	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m³/year)	Augmentation Interventions	Model Used for Assessment
								Kirkwood, Addo, Enon (4.88)		
							Sc3	**Sundays:** Kirkwood, Addo, Enon (5.947)	Supply to Nelson Mandela Bay (76.55)	
IUA_L01	Kouga to Kouga Dam and Baviaanskloof	Linked to: IUA_K01, KL01, LN01, M01	KOUG01_R: Kouga LOUT01_D: Louterwater TWEE01_FV: Twee Riviere NABO01_D: Nabooms BAVI01_D: Bavianskloof	N/A		No	Sc1	Forestry & Invasives (0) Irrigation (36.8)		WRYM
							Sc2			
							Sc3		Proposed Guernakop Dam on Kouga River to supply (33.945 million m^3/a)*	
IUA_LN01	Groot to Kouga confluence and Upper Sundays to	Groot linked to: IUA_K01, KL01, L01, M01	BFL01_D: Buffels KARI01_D: Kariega GRT01_D: Groot	N/A		No	Sc1	Forestry & Invasives (1.5) Irrigation (367.7) **Groot:**		WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
	Darlington Dam	Sundays linked to: IUA_N01 & IUA_Q01,02, 03	SUND01_FV: Sundays					Klipplaat (0.678) **Sundays:** Robert Sobukwe (Graaff-Reinet) (5.2)		
							Sc2	**Groot:** Klipplaat (0.779) **Sundays:** Robert Sobukwe Graaff-Reinet (5.802)	**Groot:** Groundwater development (0.2 MCM/a) **Sundays:** Groundwater development (0.82 MCM/a) Re-use of water in Robert Sobukwe (Graaf-Reinet) (3.64 MCM/a)	
							Sc3	**Groot:** Klipplaat (0.960) **Sundays:**	**Same as Sc2.**	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
								Robert Sobukwe (Graaf-Reinet) (6.836)		
IUA_KL01	Kromme from Kromme Dam (Churchill) to estuary and Gamtoos	Linked to: IUA_K01, LN01, L01, M01 Kromme has no further interventions and is over-utilised Reallocation (Sc2) Augmentation of this integrated system Some scenarios may have more	GAMT01_I: Gamtoos GAMT02_FV: Gamtoos KROM02_I: Kromme KROM03_R: Kromme DIEP01_D: Diep GEEL01_D: Geelhoutboom SEEK01_D: Seekoei SWRT01_D: Swart	Gamtoos (Intermediate) Kabeljous (Rapid) Seekoei *(potentially re-look at flows from scenarios)* Kromme (Desktop, use information from 2006 study where applicable)	Kromme River Dam (Churchill) (K9R001) Impofu (K9R002) Kouga (L8R001)	No	Sc1	Forestry & Invasives (6.8) Irrigation (77.9) **<u>Kromme:</u>** Kareedouw (0.26) Coastal Towns(8.08) **<u>Gamtoos</u>** Hankey/Patensie(2.01)	Kouga LM additional groundwater development to augment and supplement existing surface water allocations from Churchill & Kouga Dams. (2.2 million m^3/a) **<u>Kromme:</u>** Supply to Nelson Mandela Bay (-) **<u>Gamtoos:</u>** Supply to Nelson Mandela Bay (-)	WRYM

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
		consequences to each system (Kromme, Gamtoos, Kabeljous rivers and estuaries)					Sc2	**<u>Kromme:</u>** Kareedouw (0.301) Coastal Towns(8.08) **<u>Gamtoos</u>** Hankey/Patenise(2.01)	Groundwater development for Kouga LM **<u>Kabeljous:</u>** Removal of illegal dams (10%) and associated irrigators. Removal of IAP *Schoenmakerskop Desalination (60 Ml/d) as per IUA_M01	
							Sc3	**<u>Kromme:</u>** Kareedouw (-) Coastal Towns(8.08) **<u>Gamtoos</u>** Hankey/Patenise(2.01)	**Same as Sc2 with,** Sc3: Guernakop (*from IUA_L01) added to Desalination (*from IUA_M01) for final iteration Sc3.1: Guernakop without Desalination	

IUA	Description	IUA Linkages*/ Comments	Rivers (EWR sites)	Estuaries	Dam releases constraints	Water Quality Scenario required (Rivers / Estuaries) ***	Scenario No.	Water Requirements (million m^3/year)	Augmentation Interventions	Model Used for Assessment
									Sc3.2: Raised Kouga without Desalination	
IUA_K 01	Tsitsikamma and headwaters of Kromme to Kromme Dam (Churchill)	Linked to: IUA_KL01, LN01, L01, M01 No specific interventions, no trade-offs, run scenarios to include the river / estuary requirements to assess the effects from demands upstream	ELND01_D: Elandbos GROO01_FV: Groot (East) TSIT01_D: Tsitsikamma KROM01_R: Kromme	Elands *(potentially re-look at flows from scenarios)* Groot Oos *(potentially re-look at flows from scenarios)* Tsitsikamma (Desktop)		No	Sc1	Forestry & Invasives (35.3) Irrigation (11.2)		WRYM

5.7 Climate Change

Climate change is projected to have a potential impact on the flows in the study area. To develop a practical a climate change scenario, the possible climate change sources of data and possible impacts were assessed through a literature review. The findings are summarised in **Appendix A.** The latest work by the Water Availability Assessment Study (WAAS) and Reconciliation Strategy for the Algoa WSS is still being completed at the time of this draft report. It will be incorporated into the final report.

The approach has been to obtain rainfall and climate data for a select climate change scenario as simulated with a climate model by UCT. These data were then put into the WRSM2000 model and used to develop revised streamflow's for inclusion in the WRYM as a climate impacted future. This climate impacted future scenario will be used by the Reconciliation Strategy to determine climate change impacted yields, and by this study to assess the impacts on water supply and EWR supply potential.

As a placeholder until the completion of this latest work, the appendix summarises the climate change impacts literature review. The impacts in most of the study area are relatively limited and confidence in a specific direction (positive or negative on the mean annual volumes) is low. However, in the western parts of the study area correlating with the Algoa WSS, the climate change models and data are in greater agreement on an impact on average, of around 5% reduction in streamflow by around 2050.

This is driven primarily by rainfall impacts, as can be seen in an example in Figure 5-5. Increases in evaporation also contribute towards streamflow impacts but are more consistent across the study area. The trends observed in the spatial variations of rainfall impact in Figure 5-5, align with other sources as shown in the literature review in **Appendix A**.

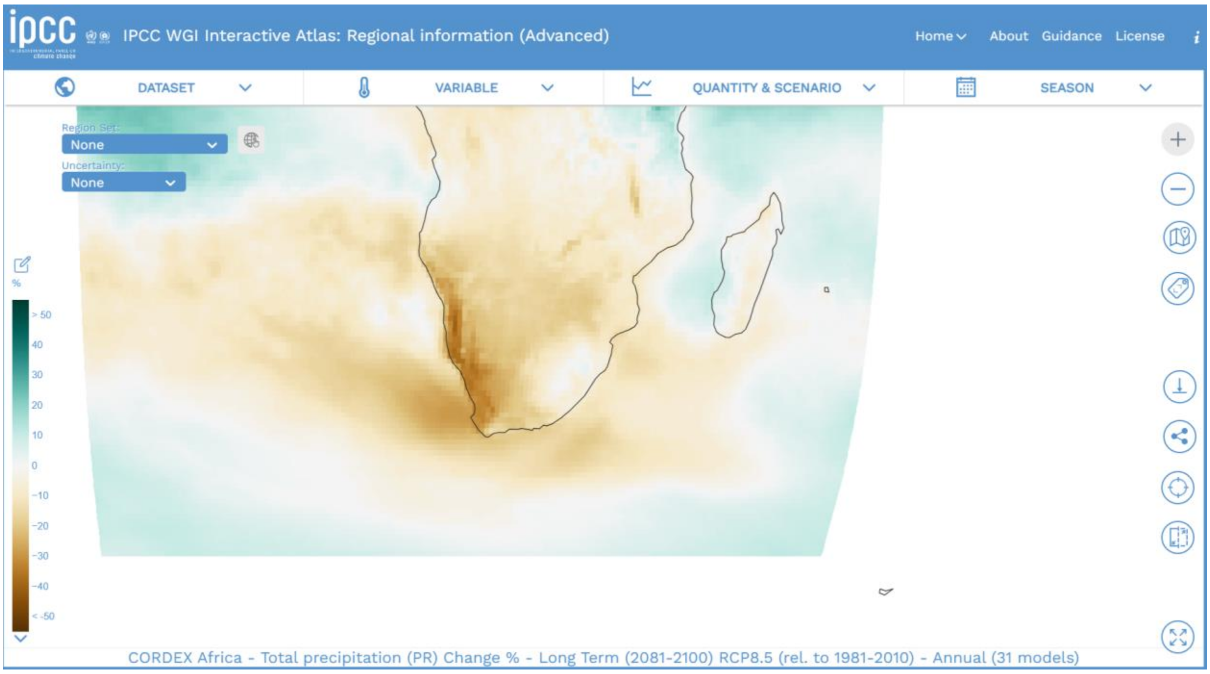

Figure 5-5: Example of changes in rainfall data as part of the IPCC Interactive Atlas

6. SCENARIO EVALUATION

The scenarios were evaluated by comparing the monthly supply to the monthly requirement for each individual user. This was done as the models used were monthly time step models and thus the monthly flows are the smallest time steps. This allows a Reliability of Supply (RoS) to be estimated for each user, as follows:

- Count the number of months the supply is less than water requirements with an allowable margin of 0.002 million cubic metres. This is known as a failure.
- The Risk of Failure (RoF) was then calculated as the number of failures plus 1 divided by the total number of months in the sequence. The number of failures was increased by 1 to account for uncertainties as the risk of failure is never 0.
- The RoS was then taken as 1-RoF.

The RoS was used to measure the performance of the users rather than the mean annual averages as these can mask failures and can give an inaccurate indication of the performance of a user. A summary of the results of the scenarios for each IUA is included in **Error! Reference source not found.**. The detailed results per individually modelled water user or group of water users, are available in APPENDIX B.

The ecological and socio-economic consequences of those flows will be evaluated and presented in the Consequences Report (Report No. WEM/WMA7/00/CON/RDM/2624).

Table 6-1: Summary of water supply volumes and flows as a result of the scenario analyses

User Type	Present Day		Reliability of Supply							
			Scenario 1		Scenario 2		Scenario 3		Scenario 3.1	
	Demand	Supply	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON
IUA_K01										
Domestic	0.0	0.0	NA	NA						
EWR	21.1	229.8	69%	78%						
IRR	11.2	10.3	97%	94%						
Hydropower	0.0	0.0	NA	NA						
IUA_KL01										
Domestic	10.4	10.3	99%	98%	100%	99%	100%	100%	98%	83%
EWR	63.2	779.9	31%	89%	33%	89%	31%	89%	30%	85%
IRR	77.9	62.5	86%	85%	86%	85%	86%	85%	87%	79%
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA
IUA_L01										
Domestic	0.0	0.0	NA	NA	NA	NA	NA	NA		
EWR	24.0	163.3	83%	90%	83%	90%	83%	89%		
IRR	43.5	39.9	96%	96%	96%	96%	96%	96%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_LN01										
Domestic	4.4	4.3	99%	83%	97%	81%	95%	80%		
EWR	54.0	302.3	43%	84%	43%	84%	43%	84%		
IRR	367.7	111.2	72%	70%	72%	70%	72%	70%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_M01										
Domestic	126.4	126.1	100%	99%	100%	100%	100%	100%	97%	75%

User Type	Present Day		Reliability of Supply							
			Scenario 1		Scenario 2		Scenario 3		Scenario 3.1	
	Demand	Supply	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON
EWR	6.7	200.5	46%	100%	49%	100%	45%	100%	45%	100%
IRR	8.0	7.4	95%	95%	95%	95%	95%	95%	95%	95%
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA
IUA_N01										
Domestic	79.0	79.0	100%	100%	100%	100%	100%	100%		
EWR	9.8	444.6	86%	100%	86%	100%	86%	100%		
IRR	180.4	97.4	72%	72%	72%	72%	71%	71%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_P01										
Domestic	3.0	2.9	91%	90%	91%	90%	91%	90%		
EWR	8.2	143.4	1%	90%	1%	90%	1%	90%		
IRR	17.7	10.1	83%	83%	83%	83%	83%	83%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_Q01										
Domestic	1.7	1.7	100%	100%	100%	100%				
EWR	5.8	33.4	60%	97%	60%	97%				
IRR	15.1	10.0	61%	61%	61%	61%				
Hydropower	0.0	0.0	NA	NA	NA	NA				
IUA_Q02										
Domestic	9.0	8.9	90%	93%	100%	100%	100%	100%		
EWR	95.2	3039.4	93%	100%	93%	100%	93%	100%		
IRR	506.7	401.2	76%	76%	76%	76%	76%	76%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_Q03										

User Type	Present Day		Reliability of Supply							
			Scenario 1		Scenario 2		Scenario 3		Scenario 3.1	
	Demand	Supply	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON
Domestic	3.9	4.0	100%	100%	100%	100%	100%	100%	100%	100%
EWR	30.5	170.2	35%	100%	35%	100%	35%	100%	34%	100%
IRR	31.7	17.6	87%	85%	87%	85%	87%	85%	87%	85%
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA
IUA_R01										
Domestic	14.7	14.4	98%	97%	98%	95%	98%	95%		
EWR	63.1	208.5	27%	99%	26%	99%	26%	99%		
IRR	16.3	14.9	94%	91%	94%	89%	94%	89%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_R02										
Domestic	91.5	82.5	82%	74%	79%	75%	75%	72%		
EWR	53.9	162.1	44%	100%	44%	100%	44%	100%		
IRR	2.9	2.1	66%	66%	67%	66%	67%	66%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_S01										
Domestic	11.8	7.8	84%	81%	84%	81%	85%	81%		
EWR	113.9	268.3	39%	93%	40%	92%	39%	92%		
IRR	19.8	19.0	94%	92%	94%	92%	94%	92%		
Hydropower	84.9	77.4	94%	89%	94%	87%	91%	84%		
IUA_S02										
Domestic	7.2	7.2	100%	100%	100%	100%	100%	100%		
EWR	62.8	250.0	53%	100%	50%	100%	49%	100%		
IRR	23.1	22.9	99%	99%	99%	99%	99%	99%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		

User Type	Present Day		Reliability of Supply							
			Scenario 1		Scenario 2		Scenario 3		Scenario 3.1	
	Demand	Supply	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON
IUA_S03										
Domestic	9.1	9.1	100%	100%	100%	100%	100%	100%		
EWR	232.4	1644.2	56%	90%	64%	90%	63%	90%		
IRR	8.1	6.9	98%	87%	98%	87%	98%	87%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_T01										
Domestic	0.3	0.4	100%	100%	100%	100%	100%	100%		
EWR	73.8	468.1	99%	99%	99%	99%	99%	99%		
IRR	5.4	5.0	99%	99%	99%	99%	99%	98%		
Hydropower	0.0	0.0	NA	NA	NA	NA	NA	NA		
IUA_T02										
Domestic	0.0	0.0	NA	NA	NA	NA	NA	NA		
EWR	245.5	1580.3	100%	100%	100%	100%	100%	100%		
IRR	0.0	0.0	NA	NA	NA	NA	NA	NA		
Hydropower	84.9	84.8	100%	100%	100%	100%	100%	100%		
IUA_T03										
Domestic	19.0	18.9	99%	99%	99%	99%	100%	100%	99%	99%
EWR	134.9	725.2	95%	100%	95%	100%	93%	100%	95%	100%
IRR	0.0	0.0	NA	NA	NA	NA	NA	NA	NA	NA
Hydropower	132.5	132.2	100%	99%	99%	99%	100%	100%	99%	99%
IUA_T04										
Domestic	8.8	8.8	100%	100%	100%	100%				
EWR	118.3	525.7	89%	100%	84%	100%				
IRR	0.0	0.0	NA	NA	100%	100%				

User Type	Present Day		Reliability of Supply							
			Scenario 1		Scenario 2		Scenario 3		Scenario 3.1	
	Demand	Supply	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON	EWR OFF	EWR ON
Hydropower	0.0	0.0	NA	NA	NA	NA				

7. CONCLUSIONS

Scenarios have been developed capture various possible socio-economic and environmental prioritisations in the future. There are three development level scenarios that correspond to three time slices, namely:

1. The present day (around 2020)
2. The intermediate Future (around 2035) and
3. The longer-term future (around 2050).

These scenarios have been evaluated with and without the inclusion of ecological water requirements (EWRs).

Models have been adopted and refined for the purposes of this study and process, based on a combination of the latest information and models available. This includes the Reconciliation Strategies and the Water Availability Assessment (WAAS) which are proceeding in parallel with the Classification.

The results are flows at each of the EWR monitoring sites in the study area, and supply to the various water users across the scenarios. These have been expressed as both average annual volumes, as well as reliability of supply statistics. This information as important inputs, feeds into the baseline Report, and into the assessment of ecological and socio-economic consequences tasks and Reporting.

During the trade-off workshop and process, some refined scenarios may be required to try and balance the trade-off and deal with consequences. These will be reported on in subsequent reports as they are identified and developed.

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9. APPENDIX A – Climate Change Literature Review

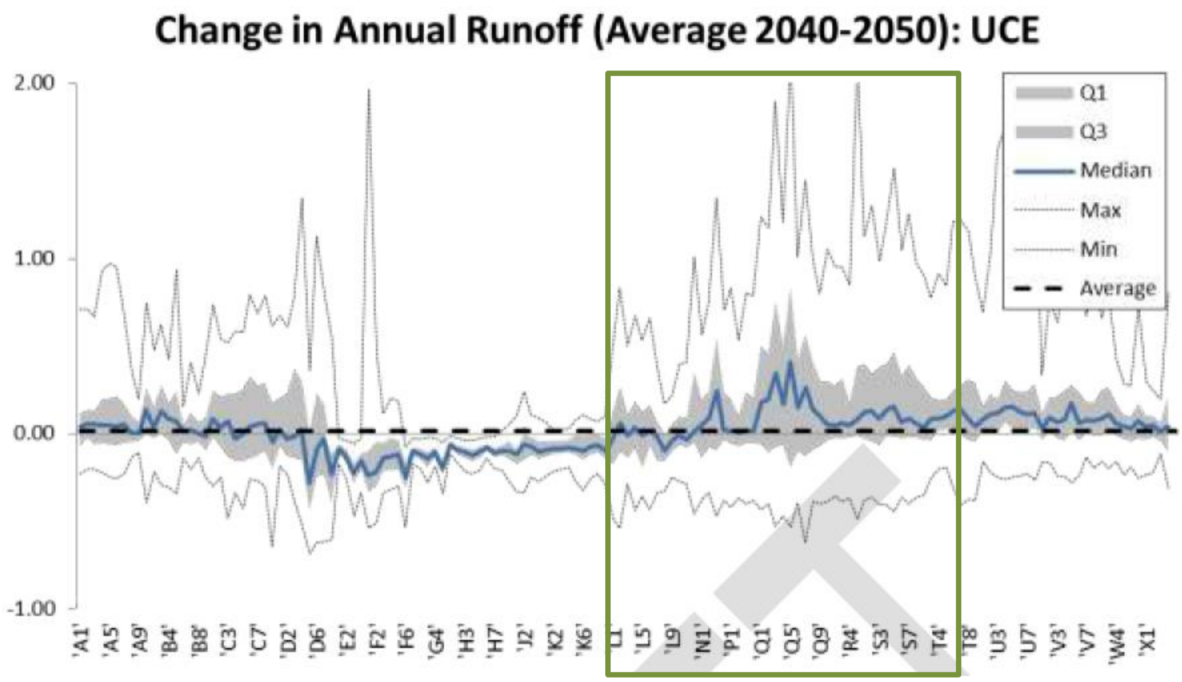
Climate change impacts on water resources for this region of the country has been considered by planning studies and identified as a potential negative impact on water availability, as well as on water requirements, e.g. irrigation. The following are approaches adopted by previous planning studies and strategies focused on water supply systems (WSS) the study area:

Algoa WSS: A negative impact of climate change has been directly accounted for in the water balances through a decrease of the water availability of existing resources of 5% by 2050 at an annual impact for the system in **Figure 5-2**. The emissions scenario that was associated with this assumed reduction in water availability needs to be clarified.

Amathole WSS: It appears that climate change impacts are variable and uncertain, and as such no specific provision was made for a reduction or increase in water availability during the latest status report update. There was an acknowledgement of the risk of climate change impacts on flows and the removal of alien invasive vegetation was recommended as a possible positive intervention to aid in off-setting the possible impacts of climate change. No volumes were provided.

9.1.1 *Previous Climate change studies (National)*

A detailed study by the National planning commission and National Treasury on the bio-physical and economic impacts of climate change on water supply potential was conducted in 2014. This study considered multiple global circulation models (GCMs) to avoid the bias of focusing on a single GCM. The results were presented per water management area, and these are presented for the study area (highlighted in the green box) (**Figure 9-1**).



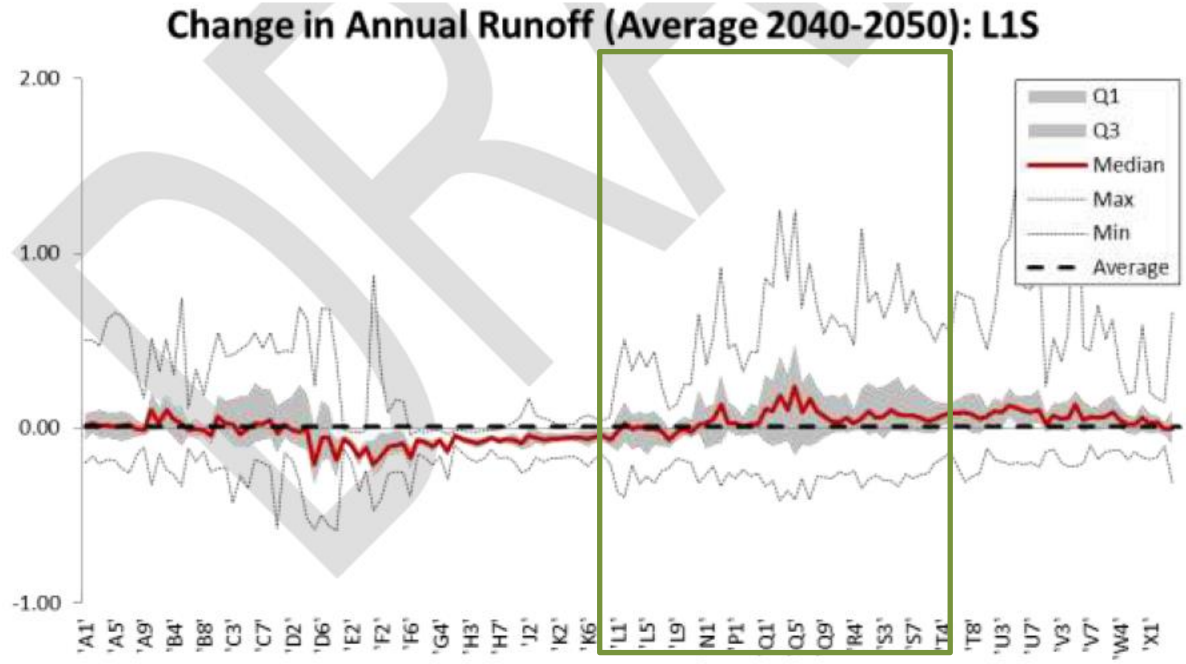


Figure 9-1: Summary of runoff impacts projected for two emmisions scenarios (2014)

The general trend is for a small reduction in runoff in the most western catchments (K primary catchments with a fairly narrow range of projections (greater agreement between models), to a possible increase in runoff in the central and north eastern parts of the study area (N, Q, R, S and T catchments) if the median is tracked, but with a greater range of possible impacts, including possible reductions in runoff. As such, the approach followed by the Reconciliation strategies of a 5% reduction in the western Algoa WSS, and no impact in the rest of the study area appears practical for the most likely climate change scenario.

Irrigation water requirements are projected to go up across the country due to increased temperatures and evaporation. The average median increase across the country is around 6% for the unconstrained emissions (UCE) scenario. This does fluctuate across the study area and is typically a little lower in the northeastern parts (**Figure 9-2**). Thus, it is recommended that an increase in crop evapotranspiration of around 6% is applied for the western catchments K and L, and that a 5% increase is applied for the rest of the study area.

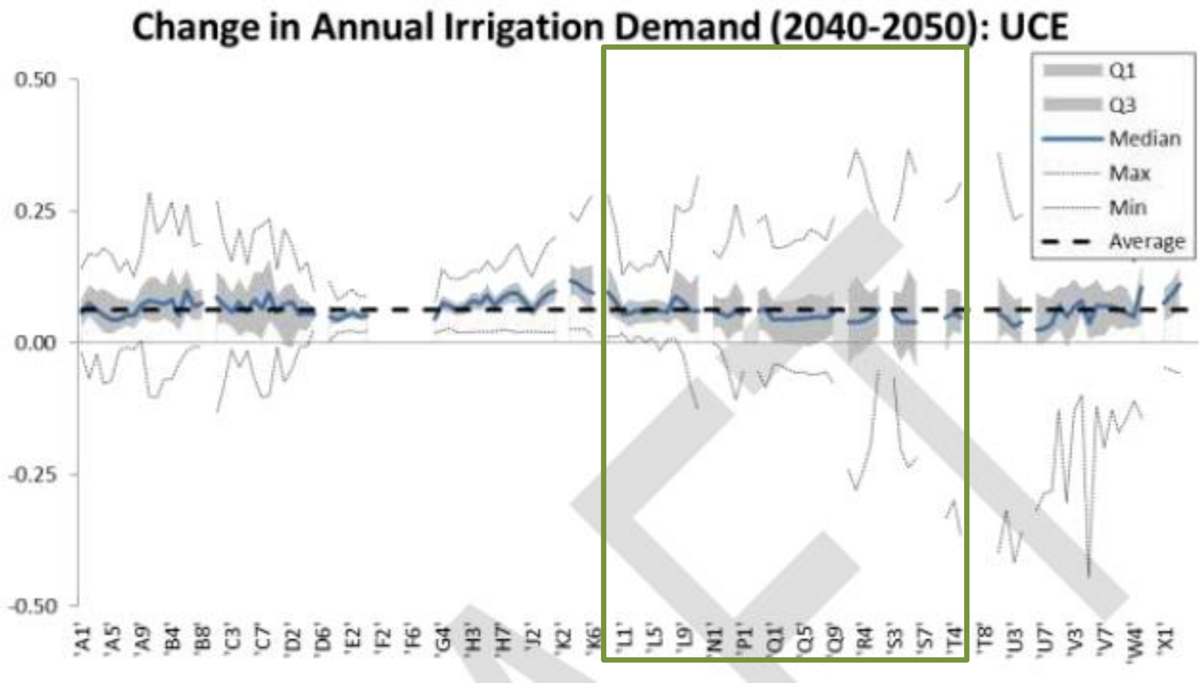


Figure 9-2: Irrigation water requirements impacts projected due to climate change by 2050

9.1.2 *Latest Climate change information*

Information was obtained from the Intercountry Pannel on Climate Change (IPCC) interactive atlas (Gutiérrez 2021 and Iturbide 2021). The selected studies or collections of data most relevant for the study area are:

- The latest Coupled Model Intercomparison Project Phase 6 (CMIP6), and
- The Coordinated Regional Climate Downscaling Experiment (CORDEX) Africa.

These two studies are recognised as two of the latest and most trusted datasets of climate modelling, with the CORDEX Africa data having a more refined downscaling due to a smaller total study area.
Within these two sets of collaborative studies and data, scenario options are available that related to various variables being considered these include:

1. The baseline against which the projection is being made.
2. The time-line into the future for which the climate change is being considered.
3. The emissions and socioeconomic development scenarios.

Baseline:

For the purposes of this assessment, the baseline period should capture the “flavour” of the natural hydrology without the climate change impacts. The natural hydrology extends for close on one hundred years from around 1920 to 2020. There are preset baseline period options provided in the IPCC atlas, namely:

- 1995 to 2014
- 1986 to 2005
- 1850 to 1900

- 1961 to 1990 (example used in Figure 4)
- 1981 to 2010

Of these options, the period 1981 to 2010 and the period 1961 to 1990 are the closest to capture the flavour of the historical periods of the baseline. The other periods are shorter, or skewed outside of the centroid of the baseline. It was found that the selection of 1961 to 1990 and 1981 to 2010 only had a small impact, and other variables such as the future development levels and emissions scenarios had a greater impact.

Future development levels:

Two options are available for the future timelines namely, a middle-term (2041 to 2060), and a long-term (2081 to 2100) projection. Both can be considered, but the middle-term scenario aligns more with the timelines of the scenarios defined for this classification process.

Emissions Scenarios:

For the emissions scenario slightly different terminology is used by the different collaborative studies and data sets (often referred to as "pathways" or "forcing" scenarios imposed on the global circulation models to assess the future impacts). For the CMIP6 data sets, these scenarios are called Shared Socioeconomic Pathways (SSP's) and are a combination of greenhouse gas emissions and other social factors such as population and GDP. The SSPs range from sustainable to fossil-fuel development scenarios, commonly known as low - SSP1 (with an RCP2.6), medium called SSP2 (with an RCP 4.5), high called SSP3 (with an RCP7) and very high called SSP5 (with an RCP 8). The more climate impactful (conservative) scenarios of SSP 2, 3 and 5 are recommended to be considered.
For CORDEX, the emissions pathways RCP 4.5 and 8.5 are the middle of the road scenario and the very high emissions scenario respectively. The lower RCP 2.6 is considered potentially too optimistic for the purposes of conservative planning.

Streamflow impacts:

The IPCC does not provide direct streamflow impacts. It does provide the following related to rainfall:

- Maximum 1-day and 5-day rainfall. These are more relevant to peak flows and possible flood impacts.
- Consecutive dry days (CDD), and
- Standardised precipitation index (SPI).
- Total precipitation

The CDD and SPI provide a greater perspective of the drier conditions, i.e. shorter-term droughts to seasonal rainfall variability respectively. The SPI is the cumulative rainfall for 6 months compared to the long-term average for that period.

The total rainfall together with the shorter-term and seasonal variability and dryness collectively provide a perspective into the likely impacts on flows, particularly the lower base-flows.

The results for these variables across the scenarios are provided in **Table 9-1**. An example of the data is shown in **Figure 9-3**, for the CORDEX- Africa data on long-term total precipitation.

This example shows that the greater impacts on rainfall are in the western part of the country and study area. The motivation to focus on the Algoa WSS as the more western part of the study area (as initially suggested by the Reconciliation strategies and the previous National Climate change study (National Planning Commission, 2014), appears to be corroborated by this latest data.

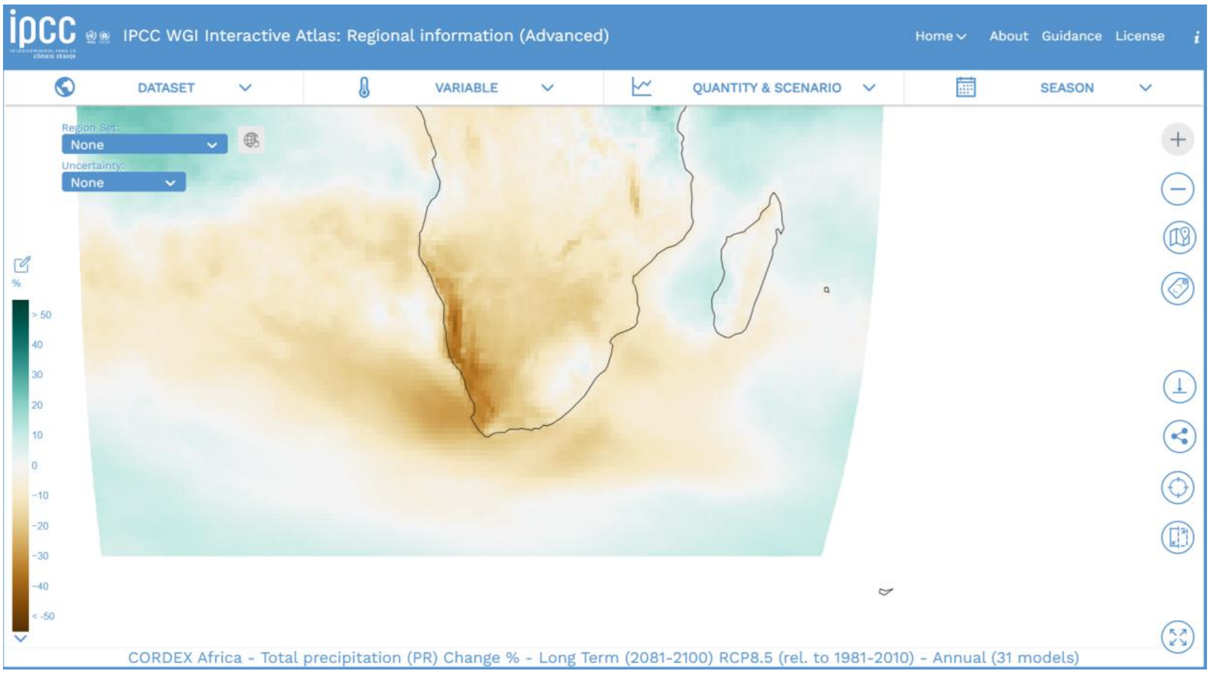


Figure 9-3: Example of changes in rainfall data as part of the IPCC Interactive Atlas

The impacts of utilising 1961 to 1990 vs 1981 to 2010 was relatively negligible. The above results project that:

- Total precipitation is decreasing around 4 to 6% for the medium-term horizon, and between 5 to 10% for the long-term horizon.
- Consecutive dry days shown either small increases or decreases, but the change is relatively small.
- The changes in SPI are all negative, suggesting a possible increase in dryness, i.e. drought risks. Considering the changes in rainfall are smaller, this is most likely due to greater variability, i.e., wetter wet periods and drier dry periods.

Based on the above and to align with the future scenario of around 2050, it is suggested that a scenario of 5% lower rainfall and runoff is selected as indicative of likely climate change impacts. This is approximately the average of the middle-term impacts in total rainfall across the emissions scenarios of model datasets (CMIP6 and CORDEX- Africa).

Table 9-1: Summary of rainfall related climate change impacts projected by IPCC data

Scenario name	Changes in rainfall variables					
	Total Precipitation (PR) - % change		Consecutive dry days (CDD) – no. of *		Standardised precipitation index (SPI) - % change	
	Medium term	Long-term	Medium term	Long-term	Medium term	Long-term
CMIP6 Data						
CMIP6_SSP2-4.5	**-4.3%**	-5.2%	-1.1 days	-1.0 days	-15.9%	-24.4%
CMIP6_SSP5-8.5	**-4.4%**	-9.8%	-1.4 days	-0.5 days	-20.5%	40.1%
CORDEX Africa Data						
RCP4.5	**-5.1%**	-6.3%	2.1 days	3.3 days	-18.5%	-21.4%
RCP8.5	**-6.9%**	-14.6%	2.2 days	4.7 days	-20%	-45.9%

*Note: * maximum consecutive dry days is around 19 without climate change*

10. APPENDIX B

The dataset containing the results for each domestic, irrigation, hydropower and ecological user is provided in **Appendix B**. Please note **Appendix B** is a separate spreadsheet that will be submitted along with this document.