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Determination of Water Resources Classes and Resource Quality Objectives for the Water Resources in the Breede-Gouritz Water Management Area

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Status Quo Report

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Ndileka Mohapi

Chief Director: Water Ecosystems

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List of Abbreviations

BAS	Best Attainable State
BGCMA	Breede-Gouritz Catchment Management Agency
BGCMS	Breede-Gouritz Catchment Management Strategy
CD: WE	Chief Directorate: Water Ecosystems
CFB	Cape Fold Belt
DWA	(Previous) Department of Water Affairs
DWS	Department of Water and Sanitation
DM	District Municipality
EC	Ecological Category
Ec	Electrical Conductivity
EGSA	Ecological goods, services and attributes
EI	Ecological Importance
EIS	Ecological importance and sensitivity
ES	Ecological Sensitivity
EWR	Ecological water requirements
FSP	Fine Scale Project
GDP	Gross Domestic Product
GRU	Groundwater Resource Unit
GVA	Gross Value Added
HGM	Hydrogeomorphic Unit
IB	Irrigation Board
ISP	Internal Strategic Perspective
IEI	Environmental importance index
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
LM	Local Municipality
MAR	Mean annual runoff
MCA	Multi-criteria Assessment
MPA	Marine Protected Area
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Area
NSBA	National Biodiversity Assessment
NPV	Net present value
NWA	National Water Act
PES	Present Ecological Sate
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RU	Resource Unit
RWQOs	Resource Water Quality Objectives
SAM	Social Accounting Matrix
SAR	Sodium Absorption Ratio
SCI	Socio-Cultural Importance
SEZ	Socio-Economic Zones
TDS	Total Dissolved Solids
TFDS	Total Foreign Direct Spends
TMG	Table Mountain Group

VFR	Visiting Friends and Relatives
WARMS	Water Authorisation and Registration Management System
WCWSS	Western Cape Water Supply System
WC/WDM	Water conservation and water demand management
WMA	Water Management Area
WRC	Water Resource Class
WRCS	Water Resource Classification System
WReMP	Water Resources Modelling Platform
WRS2000	Water Resources of South Africa 2012
WRYM	Water Resources Yield Model
WRU	Wetland Resource Unit
WUA	Water User Association

Executive Summary

INTRODUCTION

The Chief Directorate: Water Ecosystems of the Department of Water and Sanitation (DWS) has commissioned a study to determine Water Resource Classes (WRC) and associated Resource Quality Objectives (RQO) for all significant water resources in the Breede-Gouritz Water Management Area (WMA).

The purpose of the Status Quo report was to define the current status of the water resources in the study area in terms of the water resource systems, the ecological characteristics, the socio-economic conditions and the community well-being. Identification of the Integrated Units of Analysis (IUA) was provided in a separate report entitled: “Resource Unit Delineation and Integrated Units of Analysis Report”. The outcomes of this report and the “Resource Unit Delineation and Integrated Units of Analysis Report” overlap and therefore should be read in conjunction with each other.

WATER RESOURCES STATUS QUO

The ecological sub-step of the Water Resource Classification System (WRCS) involves describing the water resources of the study area and integrating these conditions with the socio-economic component in order to develop a decision support framework for the WMA. The water resources were delineated and significant resources were defined as those that are significant from a user perspective.

Surface water status quo

The surface water resources of the study area were assessed according to water resource zones, namely for the Gouritz sub-area as: Gamka, Groot, Olifants, Western Coastal River and Eastern Coastal Rivers, and for the Breede sub-area as Upper Breede, Central Breede, Lower Breede, Riviersonderend, Overberg West and Overberg East. These zones were assessed according to rainfall, water allocations and requirements and dams. The more recent WR2012 Study’s WRSM2000/Pitman configurations were considered adequate to support various specialist tasks for the study area.

Groundwater status quo

The groundwater resources of the study area were assessed according to groundwater resource units (GRUs). This delineation considered surface water divides on a quaternary and secondary level, geological structures, river systems recharge and discharge zones, groundwater use and groundwater management. The GRUs were assessed in terms of recharge, discharge, groundwater use and groundwater quality.

Water quality status quo

The water quality targets used for the assessment of water quality in the study area were derived using the Resource Water Quality Objectives Model (Version 4.0) (DWS, 2006). The fitness for use is described using four water quality categories, namely Ideal (blue), Acceptable (green), Tolerable (yellow) and Unacceptable (red). The more blue and green colours visible in the classification tables, the better the water quality, and the more yellow and red, the poorer the water quality. The variables for assessment were Electrical conductivity, Total dissolved solids, Orthophosphate, Ammonia, Nitrate, Chloride, Sulphate, Sodium adsorption ratio and pH.

Estuaries ecological state status quo

A broad level overview of the current state of knowledge of the 26 significant estuaries within the study area was conducted. Estuaries were assessed according to estuarine biota, conservation importance and levels of protection, impacts on estuaries, present ecological status and recommended ecological status based on health and importance.

Wetlands ecological state status quo

Wetlands within the study area were defined according to wetland resource units (wetland RUs). The typical wetland types and HGM types for each wetland RU were described. The priority wetlands within each wetland RU were also assessed. The major threats and impacts for each wetland resource unit was assessed and the ecological condition for priority wetlands were assessed.

Rivers ecological state status quo

The four main categories used to determine river type were flow, geomorphological zonation, riparian vegetation and adjacent terrestrial vegetation types. The 1999 and 2014 DWS present ecological state (PES) data sets were the main inputs to the status quo descriptions, although ecological condition with post-script dates 1999 or 2014 were used instead of PES.

NODES

A suite of biophysical and allocation nodes that will be used as modelling points for the Classification Process was provided. For river nodes the biophysical and allocation river nodes for the study area were assessed and for estuary nodes the National Biodiversity Assessment approach was followed.

SOCIO ECONOMICS AND ECOSYSTEM SERVICES STATUS QUO

The objective of the socio-economic component was to define the relationships that will link change in the configuration of the Water Resource Class (WRC) scenario to a resulting economic value and social wellbeing across the WMA that will be used to inform the selection of the preferred WRC scenario.

STATUS QUO PER IUA: GOURITZ

The 8 IUAs for the Gouritz were presented with socio-economics and ecosystem services, surface water and ecology status quo being described per IUA. The IUAs described were as follows:

- Gamka-Buffels (C6)
- Gouritz-Olifants (D7)
- Touws (E8)
- Duiwenhoks (F12)
- Lower Gouritz (F13)
- Groot Brak (G14)
- Coastal (G15)
- Hessequa (I18)

STATUS QUO PER IUA: BREEDE

The 10 IUAs for the Breede were presented with socio-economics and ecosystem services, surface water and ecology status quo being described per IUA. The IUAs described were as follows:

- Upper Breede Tributaries (A1)
- Breede Working Tributaries (A2)
- Middle Breede Renosterveld (A3)
- Riviersonderend Theewaters (B4)
- Overberg West (B5)
- Lower Riviersonderend (F9)
- Overberg East Renosterveld (F10)
- Lower Breede Renosterveld (F11)
- Overberg West Coastal (H16)
- Overberg East Fynbos (H17)

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1 INTRODUCTION

1.1 Background

Chapter 3 of the National Water Act (NWA) lays down a series of measures which are together intended to ensure protection of the water resources. In accordance with these measures, the Department of Water and Sanitation (DWS) in line with Section 12 of the NWA, established a Water Resources Classification System (WRCS) that is formally prescribed by Regulations 810 dated 17 September 2010. The WRCS provides guidelines and procedures for determining Water Resource Classes, Reserve and Resource Quality Objectives.

Section 13 of the NWA states that "as soon as reasonable practicable after the Minister prescribed a system for classifying water resources, the Minister must, subject to subsection (4), by notice in the gazette, determine for all or part of every significant water resource-

a) A class in accordance with the prescribed classification system; and

b) Resource quality objectives based on the class determined in terms of paragraph (a)."

The Chief Directorate: Water Ecosystems has therefore commissioned a study to determine Water Resource Classes (WRC) and associated Resource Quality Objectives (RQO) for all significant water resources in the Breede-Gouritz Water Management Area (WMA).

The Gouritz Catchment consists of the Gouritz River, as well as other rivers such as the Buffels, Touws, Groot, Gamka, Olifants, Kammanassie, and catchments of smaller coastal rivers. The Breede Catchment area consists of the Breede River, its main tributary, the Riviersonderend River and the Overberg River, as well as other smaller coastal rivers.

The 7-step WRCS procedure is prescribed in the WRCS Overview Report (DWAF, 2007) leading to the recommendation of the Class of a water resource (the outcome of the Classification Process). The determination of the Integrated Unit of Analysis (IUAs) represents one component of Step 1 in the 7-step procedure. The other component of the Step 1 is the description of the status quo of the identified significant water resources in the WMA.

1.2 Objectives of the Study

The main objectives of the Study are to undertake the following:

- Co-ordinate the implementation of the WRCS, as required in Regulation 810 in Government Gazette 33541, by classifying all significant water resources as part of the Breede-Gouritz Water Management Area (WMA).
- Determine RQOs using the DWS Procedures to Determine and Implement RQOs for all significant water resources in the Breede-Gouritz WMA.

In addition the project will require extensive stakeholder engagement and capacity building of DWS and Breede-Gouritz Catchment Management Agency (BGCMA) staff.

The final outcome from the study will be the recommended Water Resources Classes and associated RQOs presented to DWS for gazetting.

1.3 Extent of the Study Area

The study area covers all significant water resources of the Breede-Gouritz WMA (see Figure 1.1 overleaf). The Breede and Gouritz Catchments and their primary tributaries, Riviersonderend, Groot, Gamka and Olifants rivers, dominate the study area, but it also includes numerous smaller coastal catchments. The Breede-Overberg region is characterised by mountain ranges in the north and west, the wide Breede River valley, and the rolling hills of the Overberg in the south. The Gouritz region is characterised by mountain ranges in the south-west, south and south-east and the vast flat landscape of the Karoo in the north. The smaller coastal rivers include the Palmiet, Rooi-Els, Onrus, Klein, Bot, Stanford, Uilenkraals, Ratel, Heuningnes, Klipdriftsfontein, Duiwenhoks, Hartenbos, De Hoop, Goukou, Klein-Brak, Groot-Brak, Kaaimans, Touws, Karatara, Goukamma, Swart, Maalgate, Gwaiing, Malgas, Noetsie, Knysna, Piesang and Keurbooms rivers.

1.4 Purpose of this Status Quo Report

The first step of the classification procedure to recommend the Water Resource Class (WRC) of a resource is to delineate the integrated units of analysis (IUAs) and describe the status quo of the water resources. The IUAs represent the spatial units that will be defined as significant water resources. Each IUA represents a homogenous area which requires its own specification of the WRC. A provisional delineation of IUAs for the Breede-Gouritz WMA is described in the companion document to this Status Quo Report, namely the *Resource Unit Delineation and Integrated Units of Analysis Report* (DWS, 2016b).

Our appointment brief specifies that the details and outcomes of Step 1 of the Classification Procedure for this study must be reported in two separate documents, namely a *Resource Unit Delineation and Integrated Units of Analysis* Report and a *Status Quo* Report. Whilst the *Resource Unit Delineation and Integrated Units of Analysis* Report outlines the units of analysis, this Report describes the catchment status quo (Figure 1-2).

The purpose of this Report is therefore as follows:

- provide an overview of the status quo of the entire WMA concerning all aspects that affect water resources (Chapter 2)
- review the provisional delineation of Resource Units and IUAs and related nodes (Chapter 3)
- provide an overview of the status quo of the entire WMA concerning all socio-economics and ecosystem services (Chapter 4)
- describe the status quo of each individual IUA (Chapter 5 and 6)

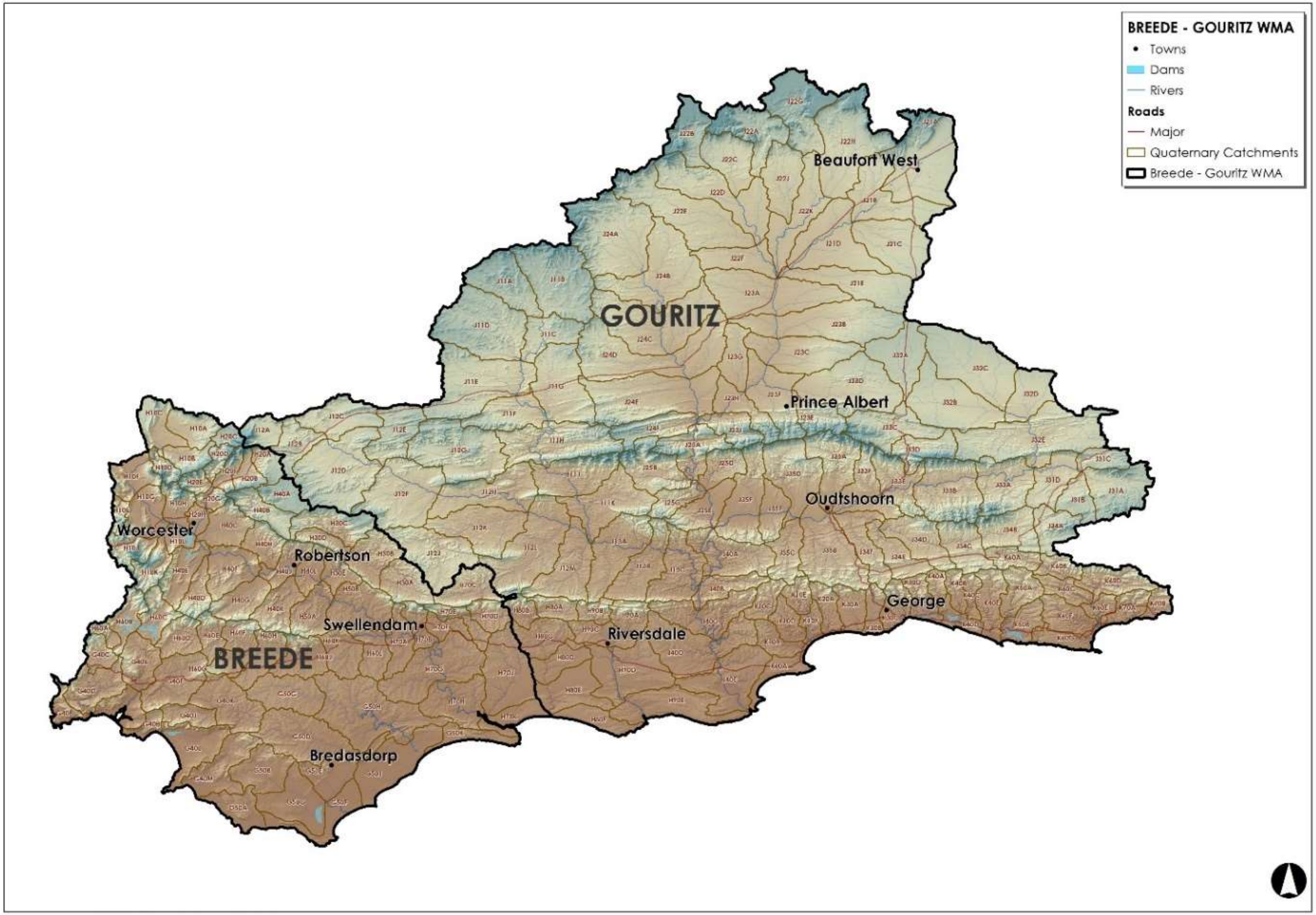

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Figure 1-1. **Map of the study area**

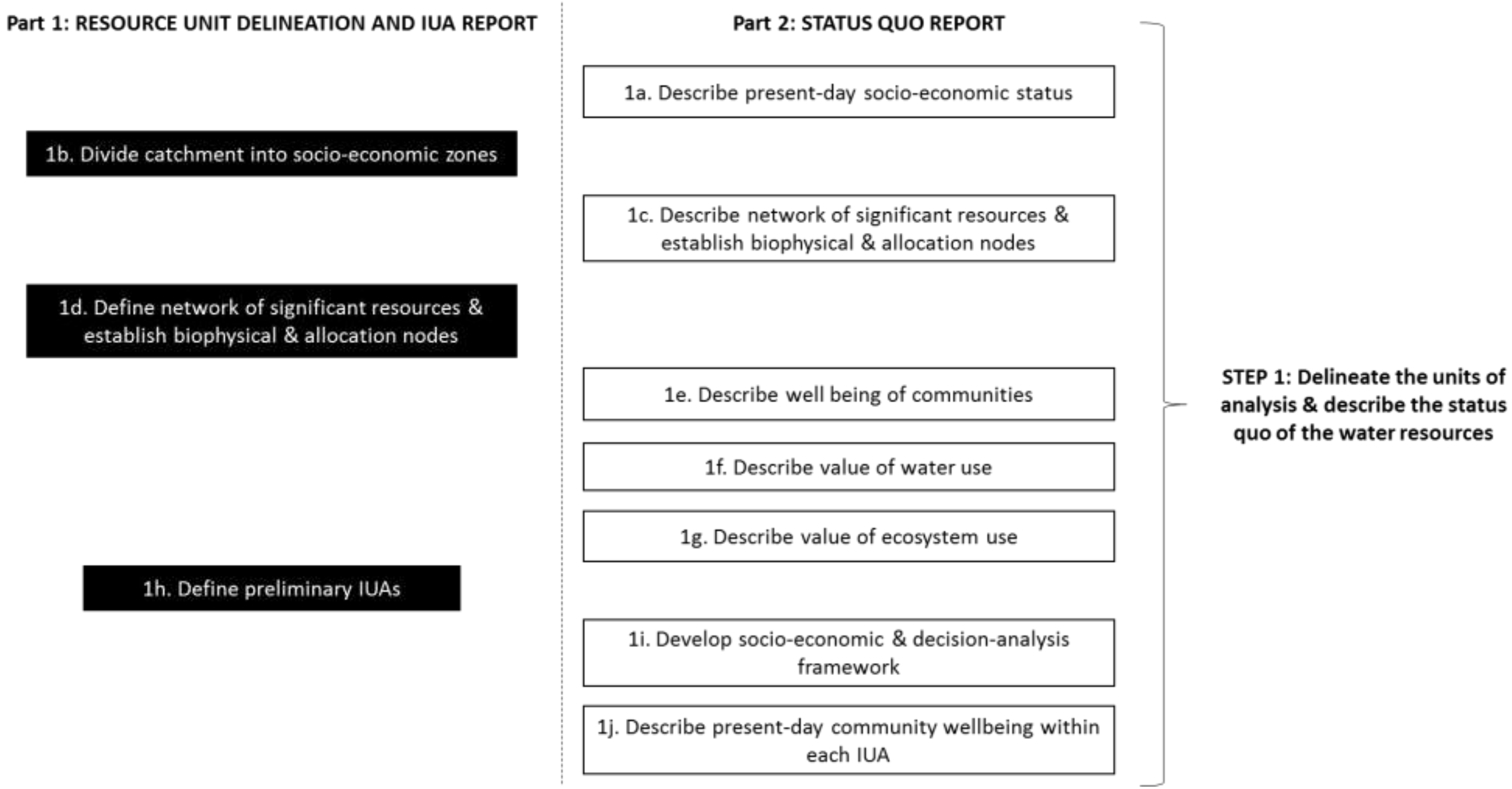

Figure 1-2. The inputs from the two reports which will inform Step 1 of the classification procedure

2 STATUS QUO OF SIGNIFICANT WATER RESOURCES

For the ecological component of Step 1, two sub-steps (relating to the ecological component) and one combined sub-step (combined with the socio-economic and decision-analysis component) are required (Figure 2-1).

- **Step 1c:**

  The objective of this step is to delineate the resources that will be utilized for the Classification Process. Significant resources are defined as those that are significant from a use perspective, for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in water quantity and quality. Significant resources may be defined as mainstem rivers, estuaries, wetlands and aquifers. These resources are as identified by nationally-defensible classification system. The objective of describing the water resource infrastructure is to ensure that the selection of the biophysical and allocation nodes takes account of existing water resource infrastructure for (later) modelling and allocation purposes. The required outcomes are as follows:

  - An identified network of significant resources for the WMA including mainstem rivers, estuaries, wetlands and aquifers
  - A description of the water resource infrastructure for the WMA including dams and canals.
  - A description of water use allocations.

- **Step 1d**:

  The objective of this step is to establish a suite of biophysical and allocation nodes that will be used as modelling points for the Classification Process. The nodes will be used to assess the responses of the upstream resources to changes in water quality, quantity and timing. The biophysical nodes should be located at the end-points of ecosystem reaches that will allow for meaningful trade-offs between different parts of the catchment in terms of the quantity and quality of water that remains in the resources, and thus the quantity and quality of water available for off-stream use. The outcomes for this step are as follows:

  - A defined network of significant resources including ecosystem-specific units (i.e. rivers, estuaries, wetlands, groundwater), identified areas of interaction between ecosystem-specific units, identified nodes to account for the interactions and allocation nodes.
  - A suite of river nodes
  - A suite of estuary nodes
  - A suite of wetland nodes
  - A suite of surface water and groundwater nodes
  - A node table for rivers, estuaries, wetlands and groundwater

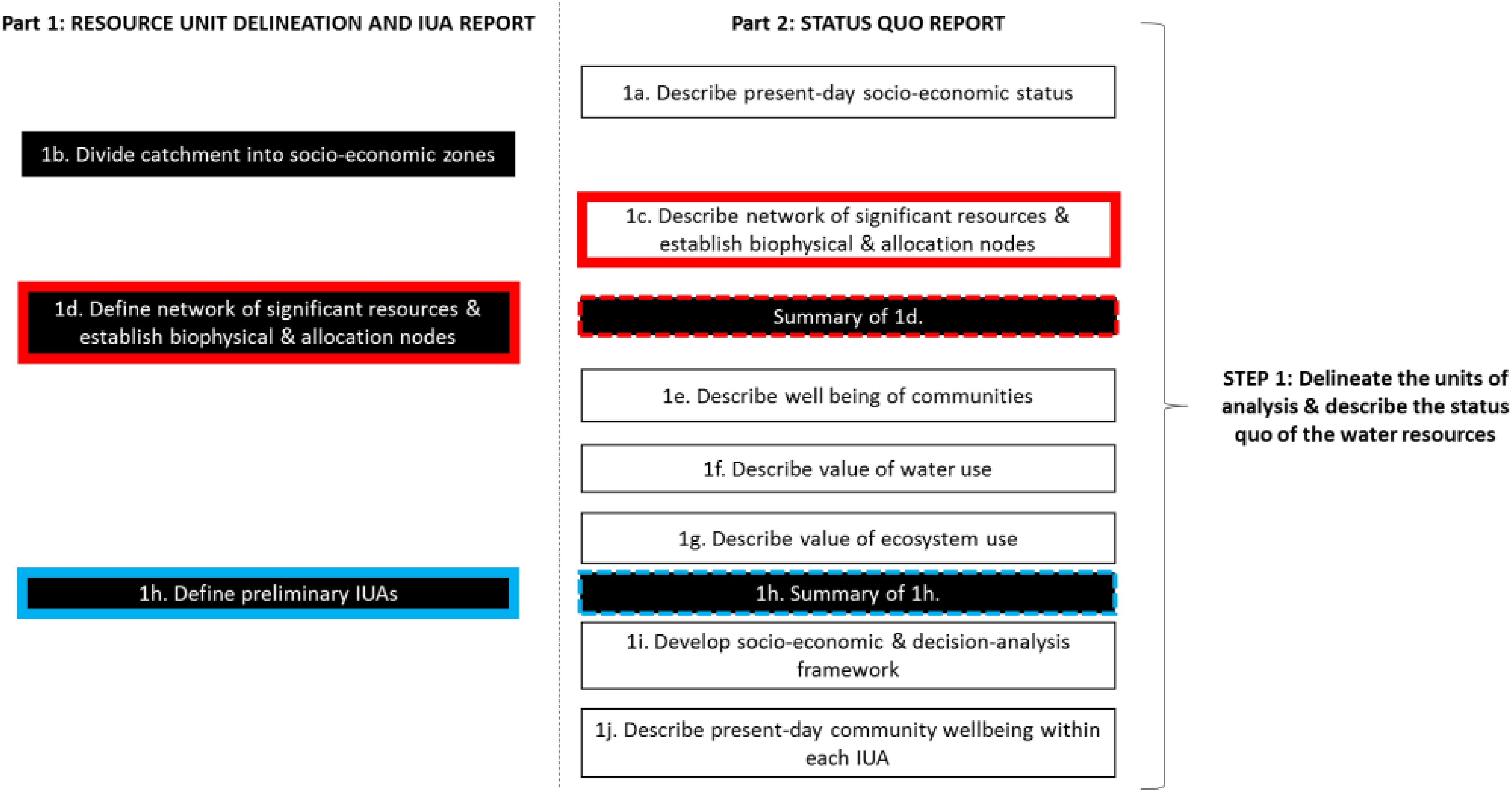

Figure 2-1. The ecological sub-steps for Step 1 of the Classification Procedure, with sub-steps highlighted in red and combined sub-step highlighted in blue

- **Step 1h**:

  The objective of defining IUAs is to establish broader-scale units for assessing the socio-economic implications of different catchment configuration scenarios and to report on the ecological conditions at a sub-catchment scales. IUAs are a combination of the socio-economic zones and watershed boundaries, within which ecological information is provided at a finer scale. This requires that the nodes established in Step 1d be nested within the IUAs. The required outcome is as follows:

  - A defined set of IUAs for a target catchment
  - A list of the nested biophysical and allocation nodes within each IUA
  - An integration point at the IUA outlet at which socio-economically relevant ecological data can be summarised.

These sub-steps have been followed in order to define the ecological component of the water resources in the WMA. The section is divided into surface water, groundwater, water quality, estuaries, wetlands and rivers sections. Sub-step 1d is outlined in Section 3.

2.1 Surface water status quo

2.1.1 Approach

The information presented in this section was derived from a number of sources, prime among which are the Situation Assessment Report for the Development of a Catchment Management Strategy (CMS) by the Breede-Gouritz CMA (August 2016), as well as DWS's 2004 Internal Strategic Perspectives Reports (ISPs) for the Breede-Overberg and the Gouritz WMAs and 2014/15 Reserve Determination Studies for the Gouritz WMA report series.

The National List of Registered Dams administered by the Dam Safety Office of DWS was also perused, which indicates the presence of 717 very small, small, medium and large dams across the WMA. The capacities of the vast majority of these dams are relatively insignificant; hence, for the purposes of this status quo assessment, the details for only those dams (27 in total) with full supply capacities larger than 5 million m^3 are outlined.

Additionally, the availability of existing configured rainfall-runoff catchment models, as well as water resources system models, for the various catchments that make up the WMA was examined. These various configured models provide indispensable decision support for the alternative scenario analyses that guide the Classification/RQO determination processes under this Project. The spatial differences in availability of these various configured models across the WMA are outlined in relevant sections below.

2.1.2 Description of surface water resources

2.1.2.1 Gouritz

In order to reflect the spatial variation in the water resource characteristics for the purposes of the status quo assessment, the Gouritz sub-area is divided into five surface water resources zones, namely, Gamka, Groot, Olifants, Western Coastal Rivers and Eastern Coastal Rivers, as depicted in Figure 2-2.

The Gouritz River and its major tributaries drain an area of 45 702 km^2. The main stem of the river is 267 km long from its source in the Great Karoo to Gouritzmond where it enters the Indian Ocean. The Gouritz River's main tributaries include the Groot, Gamka and Olifants Rivers. Secondary tributaries include the Touws, Buffels, Dwyka and Kammanassie Rivers. Several smaller rivers drain the coastal belt (east and west of the Gouritz River), including the Duiwenhoks, Hartenbos, De Hoop, Goukou, Klein-Brak, Groot-Brak, Kaaimans, Touws, Karatara, Goukamma, Swart, Maalgate, Gwaiing, Malgas, Noetsie, Knysna, Piesang, Keurbooms and Bloukrans Rivers. The natural MAR of the Gouritz component of the WMA is about 1 557 million m^3/a, while the present-day MAR is about 1 237 million m^3/a.

Rainfall

The spatial distribution of mean annual precipitation (MAP) across the Gouritz sub-area is depicted in Figure 2-3. The entire northern half of the Gouritz sub-area (Gamka, Groot and northern Olifants zones) is arid to semi-arid and has an MAP varying from less than 200mm to about 400mm. In contrast, all the mountainous regions and entire the Eastern Coastal Rivers zone experience markedly higher rainfall, with MAPs exceeding 1000mm in places. The Gamka, Groot and Olifants zones are summer rainfall areas, while the Eastern Coastal Rivers and the eastern part of the Western Coastal Rivers experience both winter and summer rainfall. Winter rainfall predominates in the western part of the Western Coastal Rivers.

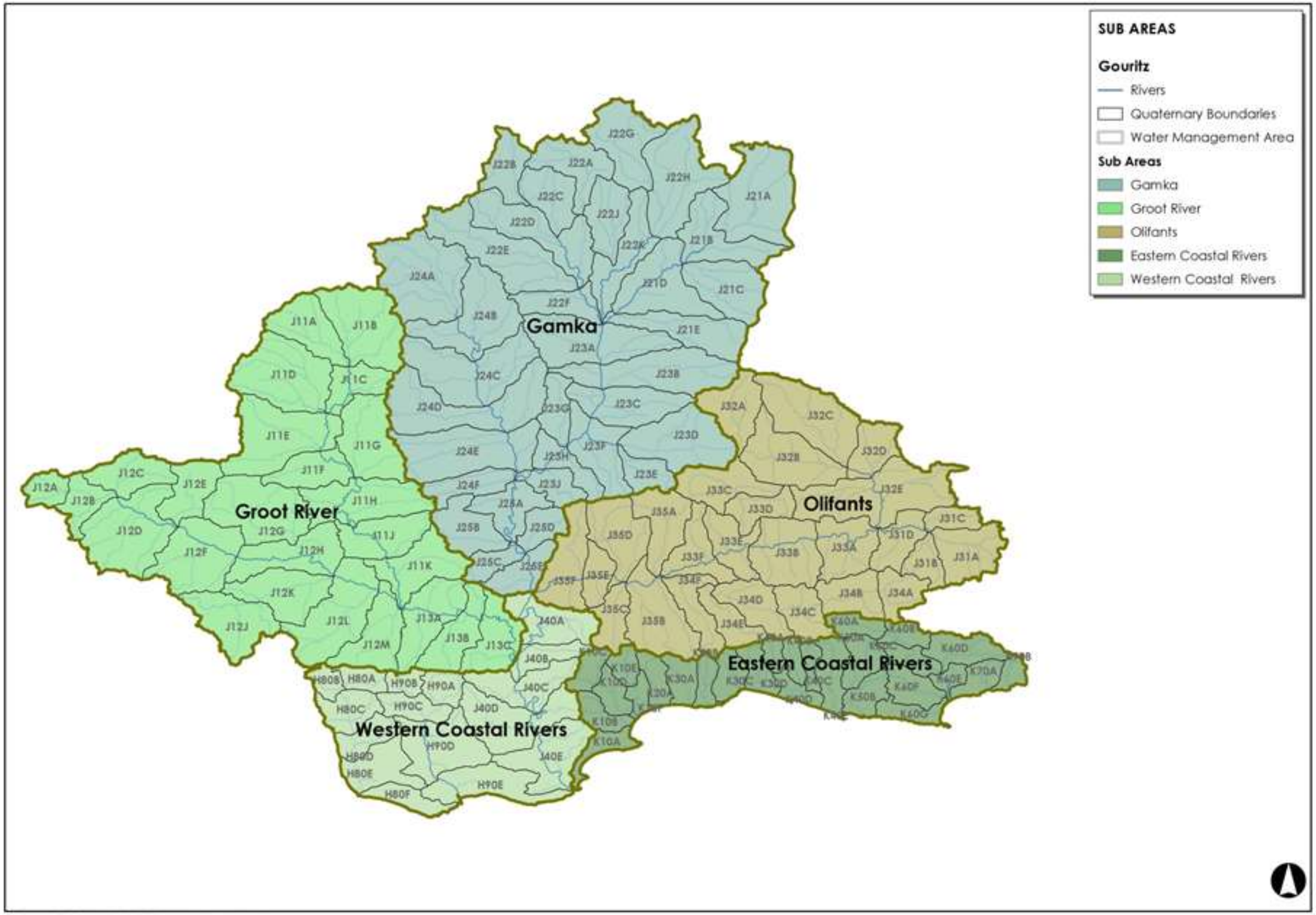

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Figure 2-2. Gouritz surface water resources zones

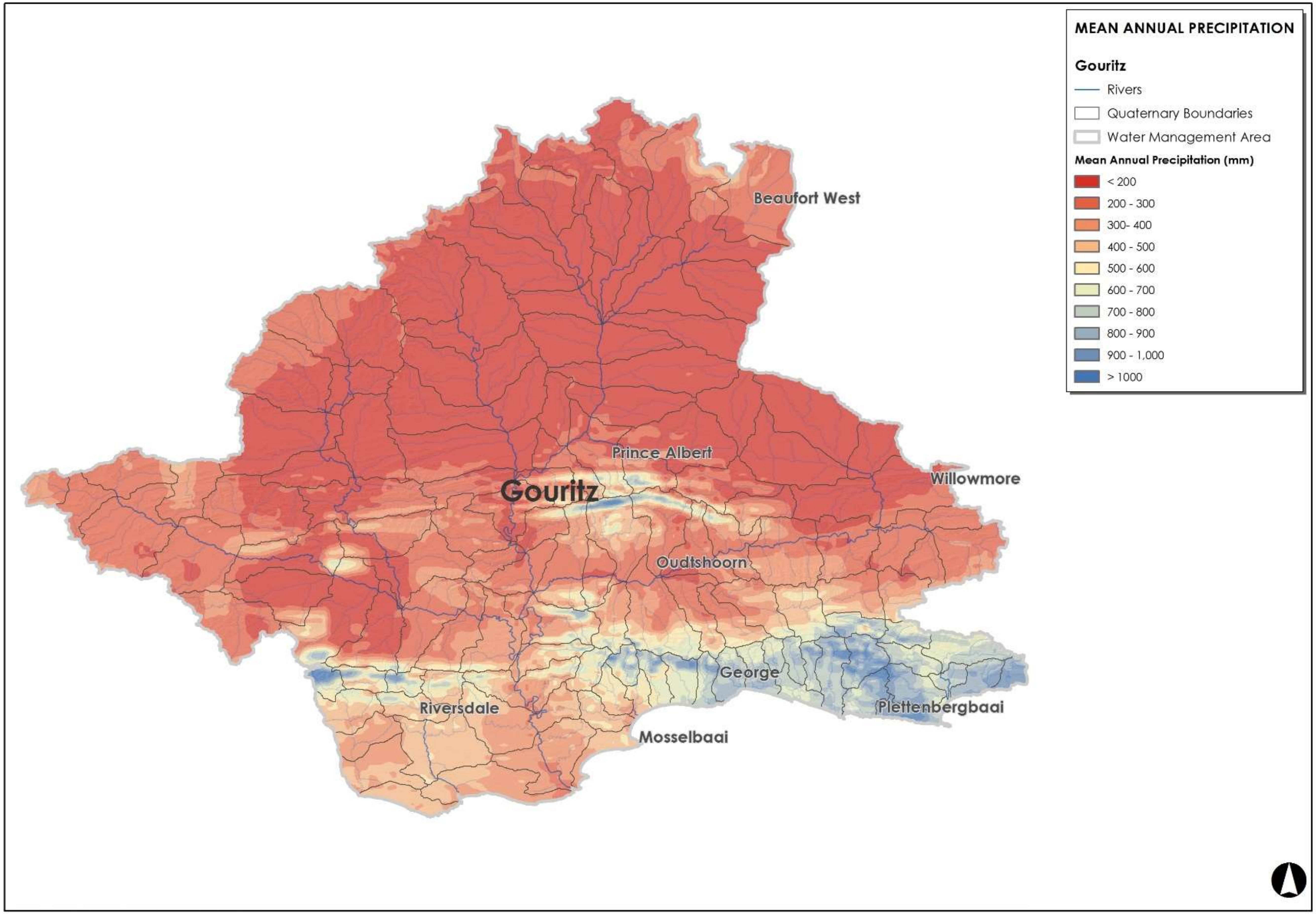

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Figure 2-3. Gouritz mean annual precipitation (MAP) in mm

Water allocations and requirements

The water allocations for the Gouritz sub-area according to the WARMS database are compared in Table 2-1 with the 2000 water requirements according to DWS's ISP report for the Gouritz sub-area, as well as with the water requirements imbedded in the more recent WR2012 model configurations.

Table 2-1. Gouritz water allocations and requirements (million m^3/a)

Sector	WARMS Allocation (Mean Annual Volume)	ISP (2000) (Impact on Yield)	WR2012 (Mean Annual Volume)
Domestic + Industrial	69	69	60
Irrigation	391	254	223
Afforestation	11	15	Imbedded

Dams

The locations of the 11 largest dams in the Gouritz sub-area are provided in Figure 2-4 and their details appear in Table 2-2.

Table 2-2. Significant dams in the Gouritz component of the WMA

Name of Dam	Quaternary	IUA No.	River	Capacity (10^6 m^3)	Purpose / Use
Stompdrift Dam	J33B	D7	Olifants River	55.3	Irrigation
Floriskraal Dam	J11G	C6	Buffels	50.4	Irrigation
Gamkapoort Dam	J25A	D7	Gamka	36.0	Flood control
Kammanassie Dam	J34E	D7	Kammanassie	35.8	Irrigation
Wolwedans Dam	K20A	G14	Groot Brak	25.5	Municipal and industrial
Leeu-Gamka Dam	J22K	C6	Leeu	14.6	Irrigation
Koos Raubenheimer Dam	J35A	D7	Klein Le Roux	9.2	Municipal and industrial
Korentepoort Dam	H90B	F12	Korinte River	8.2	Irrigation, domestic and industrial
Garden Route Dam	K30C	G15	Swart	8.0	Domestic and industrial
Hartebeeskuil Dam	K10B	G14	Hartenbos	7.1	Agricultural
Duivenhoks Dam	H80A	F12	Duiwenhoks	6.3	Irrigation, domestic and industrial

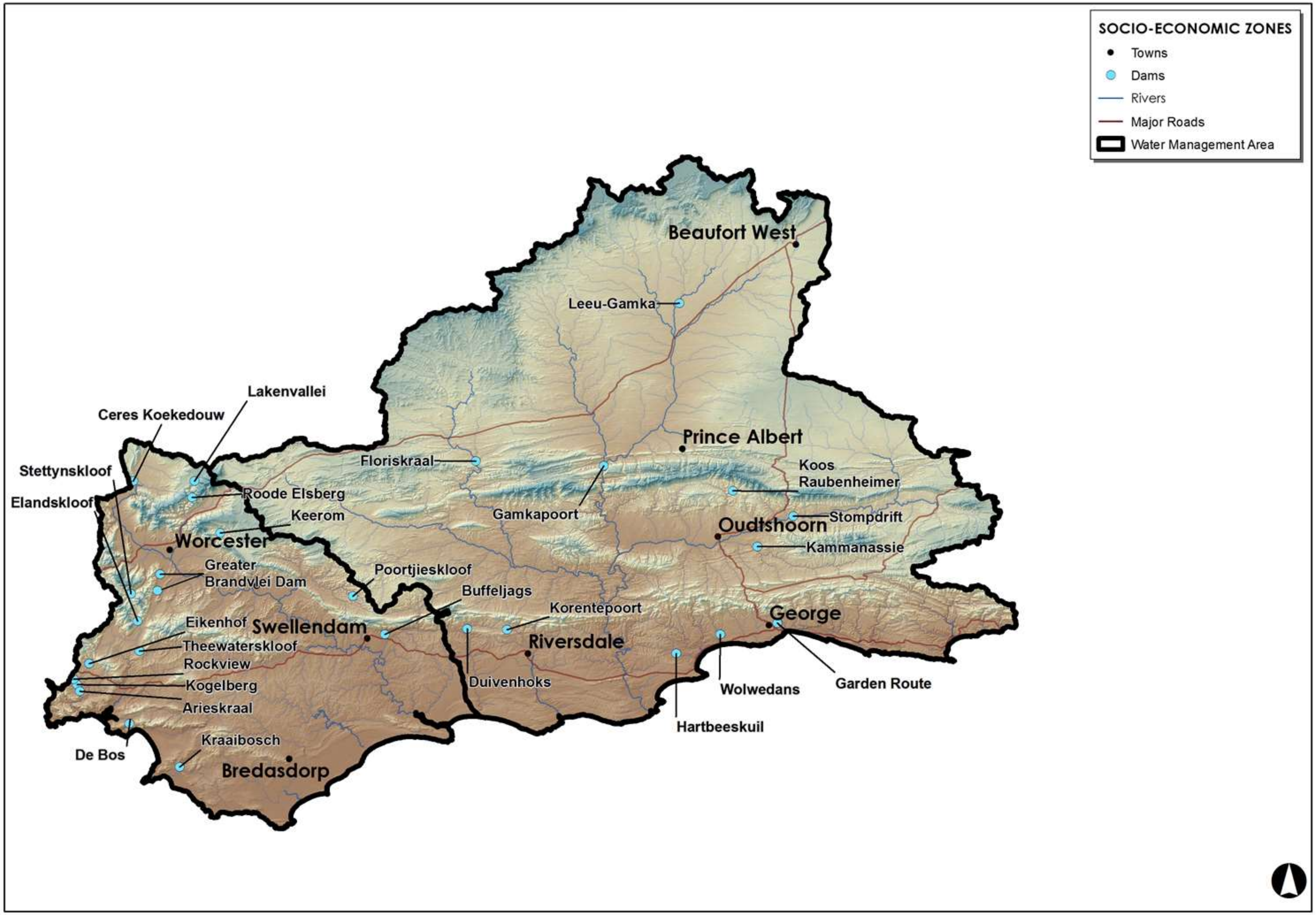

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Figure 2-4. Locations of dams with capacities exceeding 5 million m^3 across the entire WMA

2.1.2.2 Breede

In order to reflect the spatial variation in the water resource characteristics for the purposes of the status quo assessment, the Breede-Overberg sub-area is divided into six zones, namely, Upper Breede, Central Breede, Lower Breede, Riviersonderend, Overberg West and Overberg East, as depicted in Figure 2-5.

The Skurweberg Mountains near Ceres form the headwaters of the Breede River, which then flows in a south-easterly direction over a distance of approximately 320km to its Indian Ocean estuary. Numerous tributaries join the main stem from the mountain ranges that flank the Breede River Valley. The largest tributary of the Breede River, the Riviersonderend River, joins the Breede River approximately 20km upstream from Swellendam. The natural mean annual runoff (MAR) of the Breede-Riviersonderend system is about 1 857 million m^3/a and its present-day MAR is about 1 156 million m^3/a.

Across both the Overberg West and Overberg East zones numerous smaller rivers drain into either the Indian or Atlantic Oceans, namely the Rooiels, Buffels, Palmiet, Bot, Onrus, Mossel, Klein, Uilkraals, Haelkraal, Rietfontein, Ratel, Heuningnes, Klipdrifsfontein, Papkuils Rivers. Of these, the Palmiet is the most highly utilised, mainly because of extensive irrigation agriculture, and also because it is a source for transfer of water to the Western Cape Water Supply System. The natural and present-day MARs of the Western Overberg zone are about 534 and 392 million m^3/a, respectively. However, the natural and present-day MARs of the Overberg East zone are relatively lower at about 93 and 74 million m^3/a, respectively, given that it is a relatively low rainfall area.

Rainfall

The spatial distribution of mean annual precipitation (MAP) across the Breede-Overberg sub-area is depicted in Figure 2-6. The mountainous western region of the area experiences markedly higher rainfall than the rest of the Breede-Overberg sub-area. At many locations in the west the MAP exceeds 1000mm. Across the rest of this region MAPs vary from about 400mm to 600mm, with the exception of the mountains near Swellendam where the MAP rises to about 800mm in places. Winter rainfall predominates across the entire Breede-Overberg sub-area.

Water allocation and use

The water allocations for the Breede-Overberg sub-area according to the WARMS database are compared in Table 2-3 with the 2000 water requirements according to DWS's ISP report for the Breede-Overberg sub-area, as well as with the water requirements imbedded in the more recent WR2012 model configurations.

Table 2-3. Breede-Overberg water allocations and requirements (million m^3/a)

Sector	WARMS Allocation (Mean Annual Volume)	ISP (2000) (Impact on Yield)	WR2012 (Mean Annual Volume)
Domestic + Industrial	48	47	77
Irrigation	857	772	755
Afforestation	4	6	Imbedded

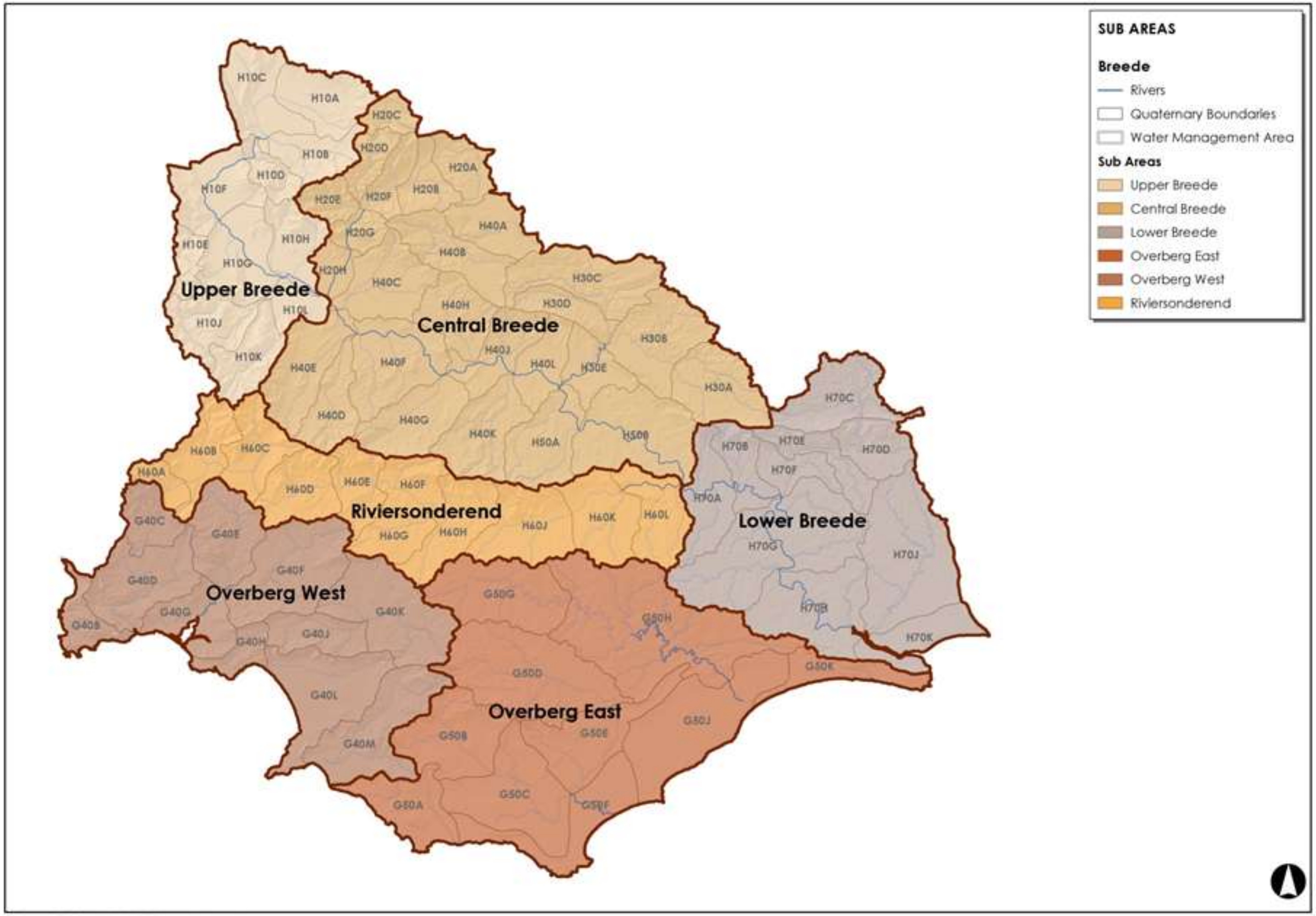

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Figure 2-5. Breede-Overberg surface water resources zones

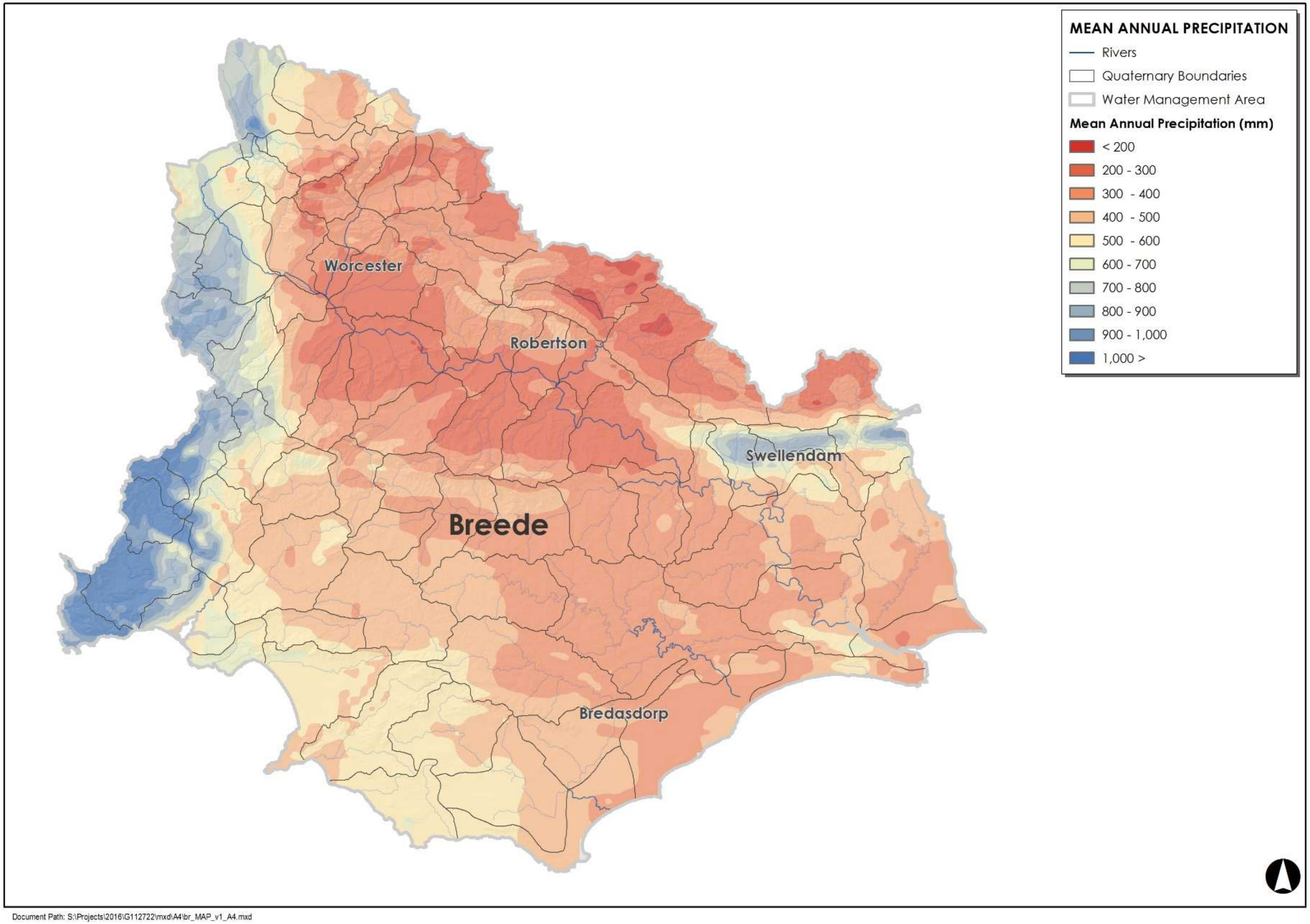

Figure 2-6. Breede-Overberg mean annual precipitation (MAP) in mm

Dams

The locations of the 16 largest dams in the Breede-Overberg sub-area are provided in Figure 2-4 and their details appear in Table 2-4.

Table 2-4. Significant dams in the Breede-Overberg

Name of Dam	Quaternary	IUA No.	River	Capacity (10^6 m^3)	Purpose / Use
Theewaterskloof Dam	H60D	B4	Riviersonderend	480.4	Municipal, industrial and irrigation
Brandvlei Dam	H10L	A2	Breede Tributary	456.0	Irrigation
Eikenhof Dam	G40C	B5	Palmiet	29.0	Irrigation and domestic supply
Kogelberg Dam	G40D	B5	Palmiet	19.3	Industrial (hydropower)
Ceres/Koekedouw Dam	H10C	A1	Koekedouw	17.2	Irrigation
Rockview Dam	G40D	B5	Palmiet	16.4	Hydropower and domestic
Stettynskloof Dam	H10K	A1	Stettynskloof	15.0	Municipal and industrial
Elandskloof Dam	H60C	B4	Elands	11.5	Irrigation and water supply
Lakenvallei Dam	H20D	A1	Sanddrif	10.2	Irrigation
Poortjieskloof Dam	H30A	A2	Groot	9.6	Irrigation
Keerom Dam	H40B	A2	Nuy	9.1	Irrigation
Roode Elsberg Dam	H20D	A1	Sanddriftskloof	7.7	Irrigation and domestic
De Bos Dam	G40H	H16	Onrus	5.9	Municipal and industrial
Arieskraal No.2 Dam	G40D	B5	Palmiet River	5.5	Irrigation
Kraaibosch Dam	G40M	H17	Uilenkraals	5.5	Irrigation and municipal
Buffeljags Dam	H70E	F11	Buffeljags	5.2	Irrigation

2.1.3 Status quo assessment

2.1.3.1 Gouritz

Models for surface water decision support

The rainfall-runoff catchment and water resources system analysis models that have been configured in previous studies, for all or parts of the Gouritz sub-area, are outlined in Table 2-5.

Table 2-5. Gouritz surface water decision support models configured in previous studies

Model	Year Configured	Catchments and River Systems
WRSM2000/Pitman	2013/2014	The entire Gouritz component of the WMA.
WRYM	2012	Gouritz System; Duiwenhoks; Goukou; Knysna System; Keurbooms System
WReMP	2012	Groot-Brak; Klein-Brak; Wilderness System

The majority of the above WRYM and WReMP configurations were populated with natural monthly streamflows up to hydrological year 1999/2000, produced during the WRC's earlier national surface water resources survey, known as WR2005. These natural streamflows were produced on a Quaternary catchment scale by means of the calibrated WRSM2000 model. The latter national survey has recently been updated and extended by the WRC, in a study known as WR2012, with both natural and current-day monthly streamflows up to the hydrological year 2009/2010. During this process, the WRSM2000 model configurations countrywide were updated, while the model itself was improved and is now called WRSM2000/Pitman (after the model's original developer).

The current Catchment Management Strategy (CMS) development project by the Breede-Gouritz CMA, which runs in parallel with this Study, is expected to deliver updated and/or newly configured WRYM configurations for all catchments and river systems that comprise the Gouritz sub-area. However, because the CMS project is out of phase with this Study, it was decided to utilise the more recent WR2012 Study's WRSM2000/Pitman configurations to support the various specialist tasks for this region in this Study.

Surface water status quo

As outlined above, the WR2012 Study provides the most up-to-date information on the surface water situation across the Gouritz sub-area. Table 2-6 presents the status quo in line with the Gouritz water resources zones identified earlier.

Table 2-6. Gouritz surface water status quo according to WR2012 (million m^3)

	Natural MAR	Present-day MAR	Domestic + Industrial	Irrigation
Gamka	111	59	8	34
Groot	79	34	7	36
Olifants	254	134	4	121
Western Coastal	379	334	3	17
Eastern Coastal	734	676	38	15
Totals	**1557**	**1237**	**60**	**223**

NB: It should be noted that the differences between natural and present-day MARs do not necessarily match the sum of domestic, industrial and irrigation water requirements, because the former do not include the impacts of afforestation, invasive alien plants, irrigation/wastewater treatment return flows and nett evaporation from water bodies which are present in the WRSM2000/Pitman simulations, as these cannot be efficiently extracted from the model outputs.

2.1.3.2 Breede Overberg

Models for surface water decision support

The rainfall-runoff catchment and water resources system analysis models that have been configured in previous studies, for all or parts of the Breede-Overberg sub-area, are outlined in Table 2-7.

Table 2-7. Breede-Overberg surface water decision support models configured in previous studies

Model	Year Configured	Catchments and River Systems
WRSM2000/Pitman	2013/2014	The entire Breede-Overberg component of the WMA.
WRYM	2009	Upper Breede; Palmiet; Upper Riviersonderend
	2002	Central and Lower Breede; Central/Lower Riviersonderend

In the light of the uneven availability of relatively up-to-date WRYM configurations for this component of the WMA outlined by Table 2-7, it was decided to utilise the more recent WR2012 Study's WRSM2000/Pitman configurations to support the various specialist tasks for this region in this Study.

Surface water status quo

As outlined above, the WR2012 Study provides the most up-to-date information on the surface water situation across the Breede-Overberg sub-area. Table 2-8 presents the status quo in line with the Breede-Overberg water resources zones identified earlier.

Table 2-8. Breede-Overberg surface water status quo according to WR2012 (million m^3/a)

WR Zone	Natural MAR	Present-day MAR	Domestic + Industrial	Irrigation
Upper Breede	851	533	25	112
Central Breede	321	196	12	299
Lower Breede	201	155	6	36
Riviersonderend	484	272	149	58
Overberg West	534	392	46	90
Overberg East	93	74	6	11
Totals	**2484**	**1622**	**244**	**606**

NB: It should be noted that the differences between natural and present-day MARs do not necessarily match the sum of domestic, industrial and irrigation water requirements, because the former do not include the impacts of afforestation, invasive alien plants, irrigation/wastewater treatment return flows and nett evaporation from water bodies which are present in the WRSM2000/Pitman simulations, as these cannot be efficiently extracted from the model outputs.

2.2 Groundwater status quo

2.2.1 Approach

The description of the groundwater status quo starts with an overview of the geology and hydrostratigraphy of the study area, followed by a summary of the delineation of groundwater resource units. The groundwater status quo assessment includes a description of key groundwater characteristics (recharge, discharge, groundwater use and groundwater quality) across the groundwater resources units, followed by a detailed status quo and trend analysis of groundwater level and groundwater quality per groundwater resource unit (Appendix B).

All available point data (borehole geology, abstraction, groundwater level, groundwater quality) was collated (Refer to the Water Resources Information and Gap Analysis Report (DWS, 2016a)), and interrogated for the trend analysis, and points with sufficient time-series including recent data is analysed to provide a current status quo. Sources of data used to populate the tables included in the trend analysis per GRU include:

- National Groundwater Archive,
- HYDSTRA database
- WMS datasets
- WARMS data
- Point data extracted from various reports assessing the response to bulk abstraction (i.e. municipal monitoring reports)
- Data from DWS project All Towns Reconciliation project (Phase 1 and Phase 2)
- Various reports (as referenced in the trend analysis per GRU)

The trend analysis is presented in a standard table format per groundwater resources unit (GRU). Very few data points (boreholes) are available with both water level, water quality, and geology log details enabling the data to be assigned to a particular aquifer. Surface geology has been assigned to all data points, but this is not a conclusive indicator of aquifer penetrated. Within each GRU groundwater quality and water level trends are rather described for water use clusters, with an indication of the surface geology of the data presented.

Groundwater monitoring is in most cases completed by municipalities using groundwater for domestic supply, to monitor the response to bulk (point) abstraction, (or by consultants on behalf of the municipality). This data is rarely reported to or uploaded to DWS databases, only the monitoring reports are shared. As such, the majority of municipal wellfield monitoring is not incorporated within the datasets collated, and hence in the trend analysis. The datasets collated rather contain long term DWS-owned monitoring boreholes, and any other boreholes for which there is long term data (a significant number of private boreholes). These boreholes are dispersed, and are capable of illustrating the background trends in particular locations or aquifers. Given the predominance of disperse agricultural abstraction (86% of registered groundwater abstraction is for agricultural irrigation), this data is likely to be sufficient for an indication of regional trends and typical water levels and water qualities in particular aquifers and locations. This will form a valuable basis for future phases of the project. Monitoring data illustrating the response to bulk point abstraction at municipal wellfields will be sought for prioritised GRUs.

This status quo analysis does not include an assessment of groundwater availability, which will be incorporated in future stages of the project.

2.2.2 Description

Under natural conditions an aquifer is in a state of dynamic equilibrium: wet and dry years balance out, aquifer discharge equals the recharge, and the groundwater levels (equivalent to the stored volume) are constant over the long-term. When an aquifer is pumped this equilibrium is disturbed, and "water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in the recharge, or a combination of these changes" (Theis, 1940). On pumping, water levels will therefore decline, natural discharge may decline, and recharge may increase. Over time (and with the same rate of pumping), a new dynamic equilibrium will form in response to the changes fluxes (i.e. new discharge mechanisms to abstraction, reduced discharge and or enhanced recharge). Once the new dynamic equilibrium is formed, there is no further loss from storage i.e. groundwater levels no longer decline in response to abstraction.

The time taken to reach this new dynamic equilibrium (the "response time") can vary from relatively short to hundreds of years, depending on the aquifer parameters and location of abstraction compared to aquifer boundaries (Sophocleous 2000; Bredehoeft and Durbin, 2009). The magnitude of storage depletion (water level change before new equilibrium is met), is also dependent on the aquifer parameters and location of abstraction.

If the abstraction can be met by changes in the aquifer fluxes (reduced discharge, enhanced recharge) and a new equilibrium can be established (halting water level decline), then the abstraction can be considered maintainable (note, not sustainable) (Delvin and Sophocleous, 2005; WRC, 2016). If "sustainable groundwater use" is defined as groundwater use that is socially, environmentally (ecologically), and economically acceptable, then abstraction of a maintainable yield is not necessarily sustainable. A critical step from quantification of a maintainable aquifer yield to quantification of sustainable groundwater use, is to determine the volume contribution from each source under the new dynamic equilibrium (projected reduced discharge, enhanced recharge, impact on storage / groundwater levels), and then take a socio-economic-environmental decision as to whether this is acceptable (Sophocleous, 2000, Alley and Leake, 2004, WRC, 2016). Projection of the impact of pumping on storage / water levels can be completed (for simple situations) with analytical models that derive a characteristic water level decline over time when pumped ("pump curves", Kruseman and de Ridder, 1991). Determination of the impact on natural discharge or enhanced recharge generally requires a numerical model to be setup for the aquifer in question to simulate the abstraction and impacts on flow regime.

Not all abstraction can be maintained. Abstraction from groundwater without an active flow regime (fossil groundwater) simply harvests stored groundwater and groundwater levels continue to fall. "Runaway" drawdown, in which the rate of decline of groundwater level increases over time, is an indication that the abstraction rate cannot be met by changes in the aquifer fluxes (it is not maintainable).

The above-mentioned theory is relevant to the status quo trend analysis. Water level decline is to be expected in response to pumping. Groundwater level decline (alone) is not an indication of abstraction rates being too high or not maintainable, and certainly not an indication of un-sustainability (using the definition of sustainable groundwater use mentioned above). Water level decline is simply a reflection of the aquifer transitioning to a new dynamic equilibrium after pumping. Water level analysis using numerical / analytical equations to determine whether abstraction yields are maintainable, and to determine the maximum drawdown that is to be expected under the abstraction conditions, is not possible within this regional study. Barring this level of detail, some comments on monitored water level decline and what it might represent are nevertheless possible through comparing the shape of the water level decline by eye to characteristic pump curves, and through consideration of rainfall changes.

2.2.2.1 Geology

The geology of both the Breede and Gouritz basins exerts a dominating control on the topography, provides an orographic control over precipitation, influences the drainage, and even influences the agricultural crops and land-use potential, through and the widely variable geochemical composition of the different formations.

The oldest rocks in the area are the meta-sediments of the Malmesbury Group which are exposed mainly by fault controlled valleys. Granite plutons of the Cape Granite Suite have intruded into the Malmesbury Group and small outcrops are evident throughout the WMA (Figure 2-7).

The basement is unconformably overlain by the Cape Supergroup (including the Table Mountain Group at its base, overlain by the Bokkeveld Group, in turn overlain by the Witteberg Group) which dominates the geology in terms of outcrop areas. The largely arenaceous Table Mountain Group (TMG) and Bokkeveld groups (composed predominantly of argillaceous beds) have the greatest areal occurrence and form the majority of the surface geology of the southern coastal area. The Witteberg Group (consisting of alternating shales and sandstones) is limited to the northernmost extent of the Cape Supergroup exposure (DEA&DP 2011). In both catchments the TMG is intensely folded with a predominantly east-west trend and the resistant quartzites of the

TMGs Peninsula and Skurweberg Formations form the ridge tops of the Cape Fold Belt Mountains. The overlying Bokkeveld Group infills the valleys formed generally by large synclines of the TMG.

In the northern area of the Gouritz catchment (Groot Karoo, north of Swartberg Mountains), the basal units of the Karoo Supergroup outcrop and are represented by the basal Dwyka Group (glacial diamictite), the mostly argillaceous Ecca Group and the shales and subordinate sandstones of the Beaufort group (DEA&DP, 2011).Tertiary and Quaternary deposits unconformably overlie the older geology in various areas of the two catchments, consisting mostly of unconsolidated to semi-consolidated shelly, calcareous sands of the Bredasdorp Formation and alluvium.

There are a number of Tertiary and Quaternary deposits within the Breede-Gouritz WMA and they consist mostly of unconsolidated to semi-consolidated shelly, calcareous sands of the Bredasdorp Formation. There is also a considerable deposit of alluvium consisting of clay, sand, pebbles and boulders which occurs in the valley of the major Rivers and their tributaries (DEA&DP, 2011). The geological succession present in the region, with the associated thickness and lithological compositions, is summarised in Figure 2-8.

2.2.2.2 Structural geology

The Cape Fold Belt (CFB) is the dominant structural feature in the greater Southern and Western Cape area. Rocks of the Cape and Karoo Supergroups were deformed by what is termed the Cape Orogeny which is the dominant cause of the outcrop pattern of the geology, characterized by mega-anticlinal mountain ranges separated by synclinal intermontane valleys. The CFB consists of three structural provinces, a northern branch from Vanrhynsdorp to Ceres, a syntaxis around Worcester and to the southwest to False Bay, and a southern branch from Touws River to Port Elizabeth (Mielke and De Wit, 2009). The Cape Orogeny largely also produced a series of south dipping imbricate thrusts affecting both basement and cover rocks. The most noticeable is the regional Kango-Baviaanskloof and Worcester south-ward-dipping faults, which are usually regarded as regional boundaries of groundwater regimes (WRC, 2009), at least to flow across them.

2.2.2.3 Aquifer Types

The lithology and structural characteristics of the underlying geology control the flow of groundwater in the study area. The various geological (stratigraphic) units that occur throughout the Breede-Gouritz WMA can be related to hydrogeological units (aquifers/aquitards) and distinct aquifer types. However, for the purpose of this regional study only the major hydrogeologically significant aquifers will be elaborated on as these form the basis for resource delineation. The existing 1: 500 000 hydrogeological mapping of the study domain is shown in. The map presents the distribution of aquifer types based on surface outcrop of lithology and further subdivided based on borehole yield.

Four types of aquifer occur within the Breede-Gouritz WMA, namely

- Intergranular (“primary” or porous sandy aquifers),
- fractured (“secondary” aquifers),
- Intergranular-and-fractured (also termed “regolith” aquifers),
- Karst aquifers

Directly linked to the geology present, Fractured aquifers dominate in both catchments, with 88% coverage in the Breede by area, and 94% in the Gouritz. The quaternary alluvium and Bredasdorp alluvium forms an intergranular primary aquifer, significant in many areas.

Intergranular aquifers

These aquifers consist of unconsolidated to semi-consolidated coastal and alluvial deposits in which the granular interstices and pore spaces contain groundwater, formed by the Cenozoic deposits. These aquifers cover large areas but have variable thickness and are often largely unsaturated where they are poorly developed. The Bredasdorp Group calc-arenites and unconsolidated sands form an extensive coastal aquifer. The aquifer stretches along the majority of the southeast coast of the Breede between Hermanus and Port Beaufort. The aquifer also extends inland up to more than 20 km in a number of areas. Higher yields are associated with the

Bredasdorp Group to the west of Agulhas than to the east thereof related to rainfall distribution, recharge and fractured rock aquifers and faulting. Intergranular aquifers are also present inland, composed of alluvium consisting of clay, sand, pebbles and boulders, and occur predominantly within the synclinal and fault controlled valleys in the northwest of the Breede Catchment, in the valleys of the Breede River and its tributaries. The Breede River Alluvial aquifer is a significant intergranular aquifer, infilling the valley north of Rawsonville (DWAF, 2008). In the Gouritz Catchment a significant coastal intergranular aquifer is again formed by the Bredasdorp Formation, along the coast between George and Plettenberg Bay.

Fractured aquifers

Units of the TMG form the most important fractured aquifers, while rocks of the Malmesbury (basement), Witteberg and Karoo Supergroup can yield water where fractured. The Bokkeveld Group is considered to be an aquifer of lesser importance because of lower borehole yields and poorer groundwater quality. Due to its argillaceous nature, the formations within the Bokkeveld Group may act as an aquitard.

The TMG is made up of the Nardouw Sub-Group (including the Skurweberg Formation considered a fractured aquifer), and the Peninsula Formation (Peninsula Aquifer), separated by the Cedarberg (shale) Formation which forms an aquitard between the two main aquifers. The Peninsula Aquifer usually outcrops at higher altitudes. The Peninsula and Skurweberg Formations units are composed of thick quartzite successions of high compressive and tensile strength, and are therefore capable of supporting open, permeable fractures to depths of several kilometres. Geothermal evidence from hot springs (Figure 2-9), indicates that groundwater circulation of depths of up to 2 000 m can occur (WRC, 2002).

According to WRC (2009) the TMG distribution area can be divided into TMG outcrop areas and non-TMG outcrop areas. Generalising broadly; in TMG outcrop areas, the subdivision of Nardouw outcrop and Peninsula outcrop is applied.

Generalising broadly, where the Nardouw outcrops, the Nardouw aquifer can be considered to be an unconfined aquifer while the Peninsula is confined by the Cedarberg Aquitard (WRC, 2009). In the Peninsula outcrop areas where the Cedarberg formation has been denuded, the Peninsula aquifer becomes unconfined (and the Nardouw aquifer is absent). Where sediments younger than the TMG outcrop (i.e. Bokkeveld Group and Karoo Supergroup), both the Peninsula and Nardouw can be regarded as confined aquifer system (sometimes at significant depth) because overlying Gydo Formation at the base of the Bokkeveld is usually regarded as an aquitard.

Intergranular (weathered) and Fractured aquifers

Fractured and intergranular (also termed weathered or regolith) aquifers are limited in extent (only 2% of the Breede). They coincide with exposures of the Cape Granite Suite. However, the Malmesbury, Witteberg and Bokkeveld Group can also be termed a ‘regolith’ aquifer and was classified as such during the Berg Catchment water availability assessment study (DWAF, 2008)

Because the different geological groupings directly relate to aquifer types (basement forming regolith aquifers; TMG and Karoo generally forming fractured aquifers, Witteberg and Bokkeveld generally form regolith aquifers, Cenozoic deposits forming intergranular aquifers), it is possible to group the geology into these major geological groups for hydrogeological interpretation.

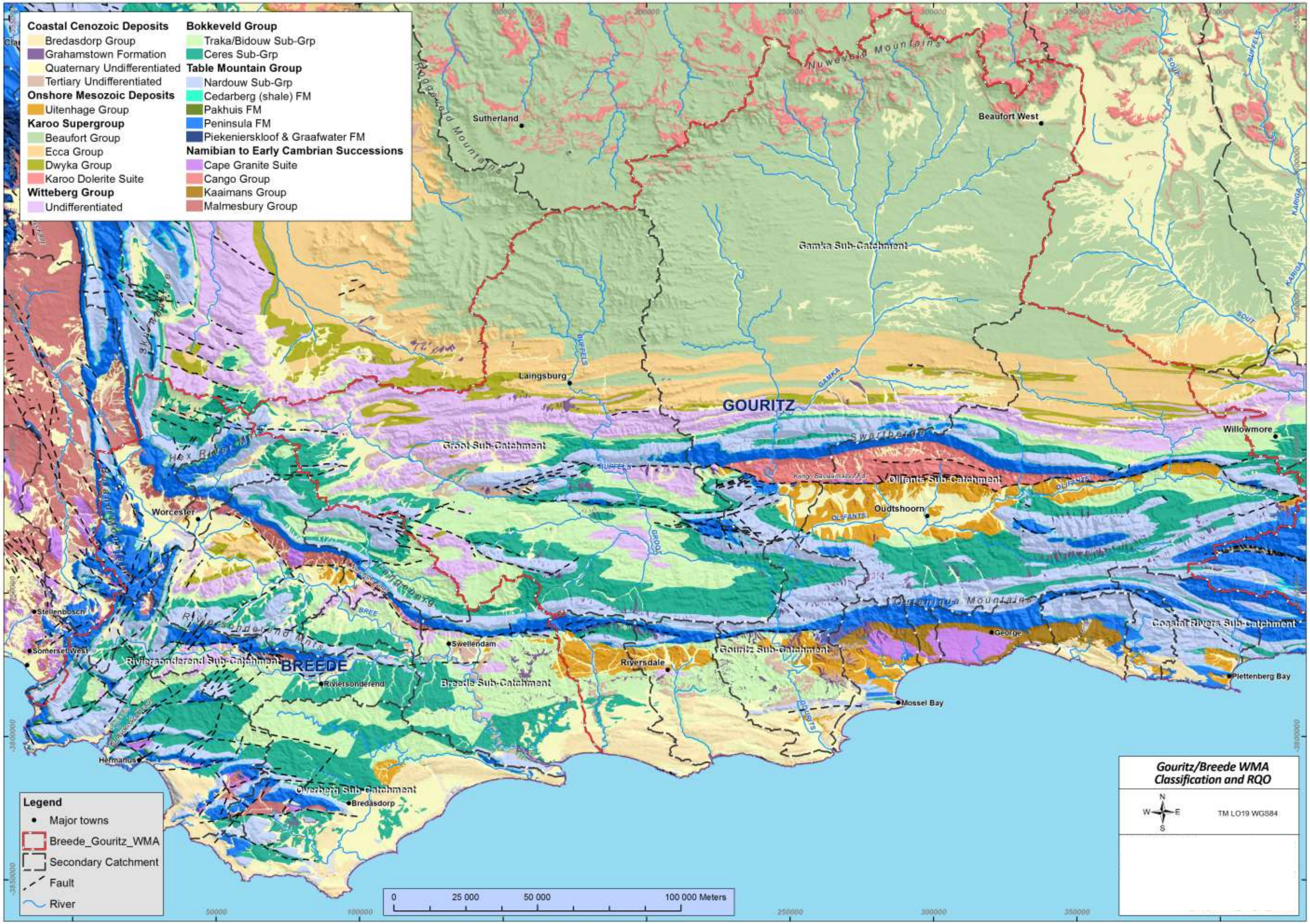

Figure 2-7. Regional Geology

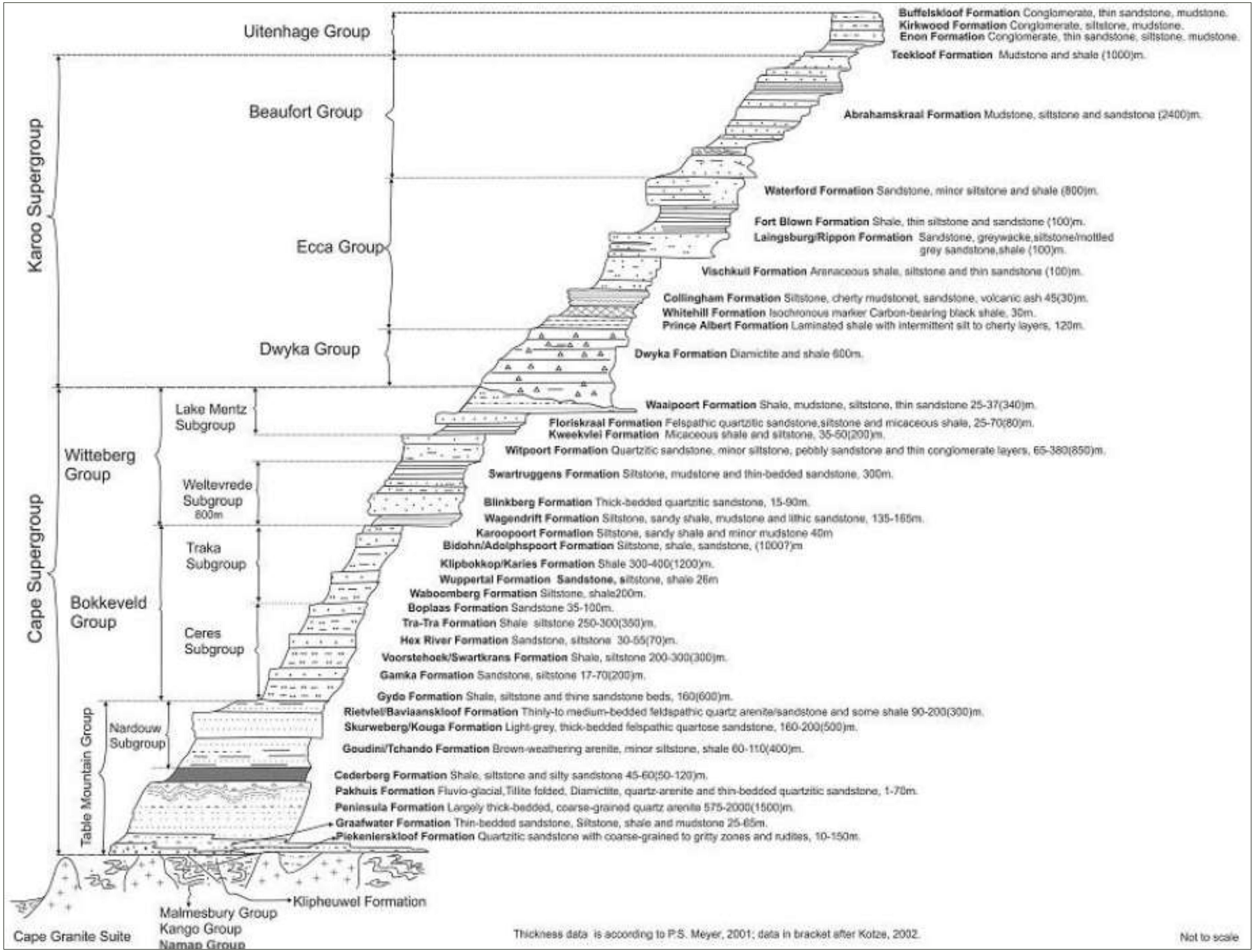

Figure 2-8. Geological sequences in the study area (adapted from Wu, 2005)

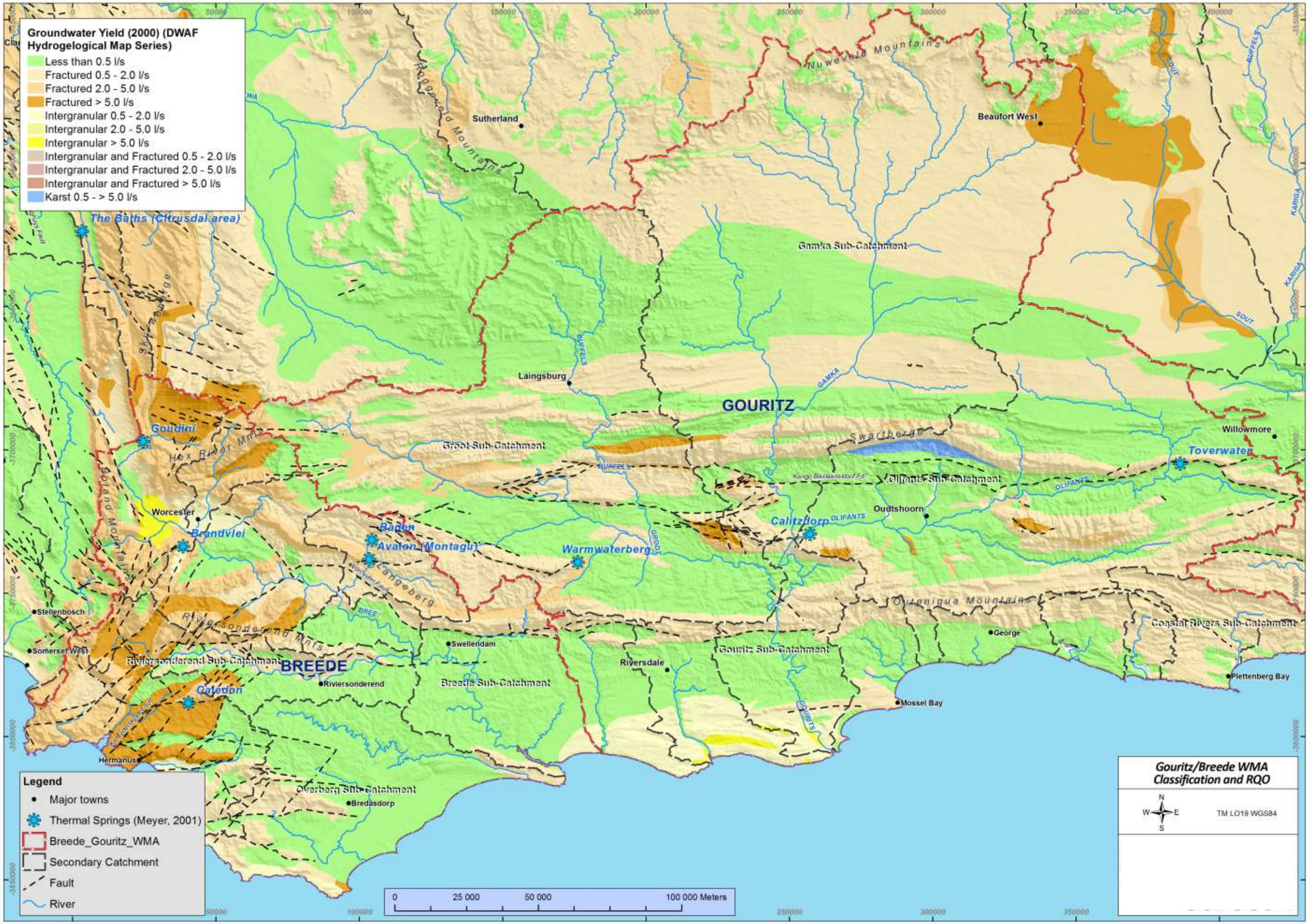

Figure 2-9. Aquifer type and yield

2.2.3 Status quo assessment

The ‘Groundwater Reserve’ is usually determined per quaternary catchment which is used as the primary delineation of water resource units in Resource Directed Measures (RDM) assessments. The delineation of groundwater units relate specifically to hydrogeological criteria and might not necessarily correlate to quaternary surface water catchments or surface water units of analysis. Due to the strongly compartmentalised nature of the TMG, due to faults or fault zones, and the associated deep confined flow paths, the aquifer boundaries mostly do not coincide with surface water catchment boundaries. The delineation of resource units is complex within the TMG and requires knowledge of the recharge zone and the discharge zones of the flow paths of the various aquifers. Previous hydrogeological divisions of the area were reviewed to provide insight into the approach for delineating resource units for the Breede-Gouritz WMA (*Resource Unit Delineation and Integrated Units of* Analysis Report (DWS, 2016b)).

2.2.3.1 Delineation approach and results

The ‘Groundwater Reserve’ is usually determined per quaternary catchment, which is used as the primary delineation of water resource units in Resource Directed Measures (RDM) assessments. The delineation of groundwater resource units (GRUs) relate specifically to hydrogeological criteria and might not necessarily correlate to quaternary surface water catchments or surface water units of analysis. Due to the very different characteristics of each of the major geology groups (namely the basement, the Cape Supergroup, Karoo Supergroup, and the Sandveld Group) corresponding to different aquifer types, and the strongly compartmentalised nature of the TMG due to faults or fault zones, aquifer boundaries mostly do not coincide with surface water catchment boundaries. The delineation of resource units requires knowledge of the recharge zone and the discharge zones of the flow paths of the various aquifers.

Previous hydrogeological divisions of the area were reviewed to provide insight into the approach for delineating resource units for the Breede-Gouritz study area. The Peninsula Formation often forms the head water of major (surface) drainage system (sometimes in the opposite direction of the deep groundwater flow system) and depending on the geological setting can contribute to recharge and groundwater flow on either side of the drainage divide. It’s generally observed that the Skurweberg aquifer contributes more directly to river baseflow both via the river bottom and via springs at the Nardouw – Cedarberg contact, while the Peninsula contributes to river flow mainly as surface run-off (WRC, 2003). DWAF (2008) recognised that a water balance based on (surface water) catchment boundaries may lead to erroneous recharge allocated to an adjacent groundwater unit. To overcome this DWAF (2008) differentiated between the Peninsula Formation outcrop area and the confined Peninsula Formation (i.e. Peninsula Formation that is covered by other geological units). This approach was adapted here for the current delineation for classification, but the resulting groundwater unit was not limited to the Peninsula Aquifer alone.

For consistency during the delineation process the contact between the top of the Peninsula Formation and the remainder of the TMG and the overlying Cape Supergroup was used in cases where it was deemed necessary (i.e. main recharge/run-off area). An example of this Groundwater Resource Unit (GRU) delineation approach is shown in a section in Figure 2-10Figure 2-10. Cross-section of TMG flow (Adapted from Wu, 2005).. Using standard procedures the groundwater classification can be applied to each resource unit but some links will exist between resource units. This approach means that shallow groundwater flow in the Peninsula Formation would be accommodated within the same GRU as the recharge area, yet deep flow in the Peninsula will flow across GRU boundaries. These links can be quantified by applying different recharge estimates for lithologies and disaggregating the quaternary baseflow estimates into resource units.

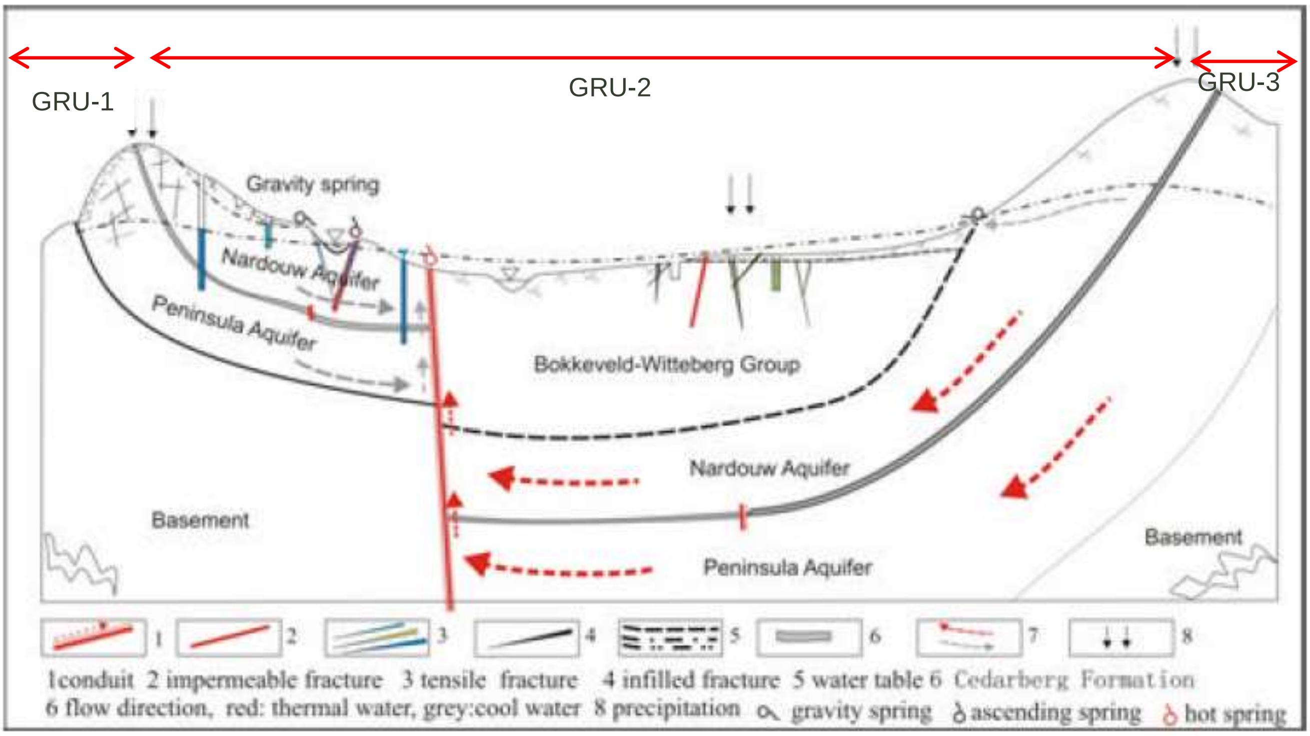

Figure 2-10.Cross-section of TMG flow (Adapted from Wu, 2005).

The delineation of resource units is largely a GIS based exercise with taking the following into consideration:

- Surface water divides on a quaternary and secondary level
- Geological structures (i.e. fault, hydrostratigraphy or lithological contact zones)
- River systems
- Recharge and discharge zones
- Groundwater use
- Groundwater management (size and extent of units)

The resource units were grouped primarily into the different sub-catchments with consideration of the groundwater system in that area. The delineated resource units generally combine several quaternary catchments, but boundaries do not always coincide with surface water divides. However, the integration of surface water and groundwater systems was largely achieved. Thirteen groundwater resource units (GRUs) were delineated in the Breede, and nineteen resource units delineated in the Gouritz. The spatial distribution of the resource units in relation to geology and surface catchments is shown in Figure 2-11. Each GRU is described in detail in Appendix B.

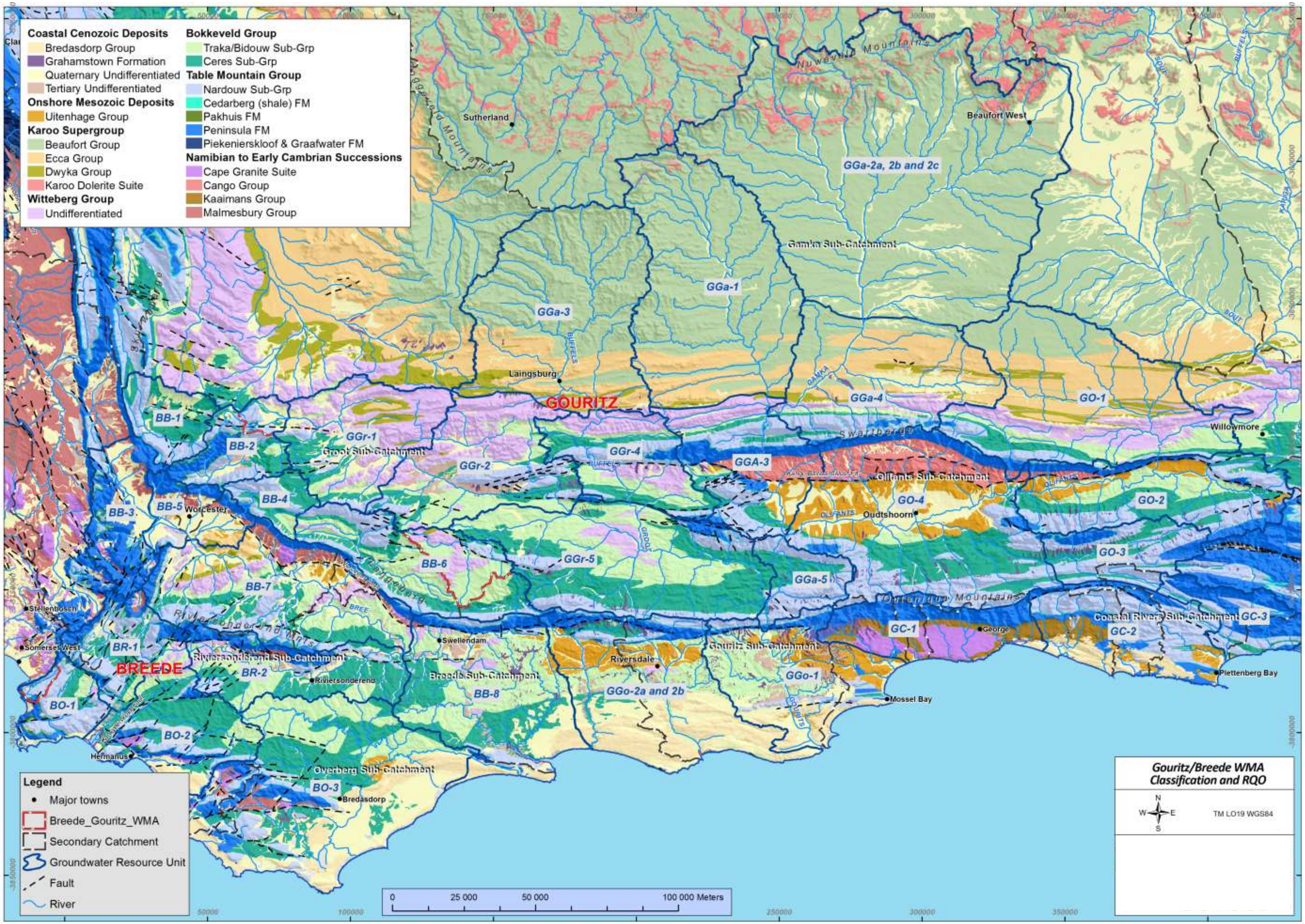

Figure 2-11. Delineated groundwater resource units

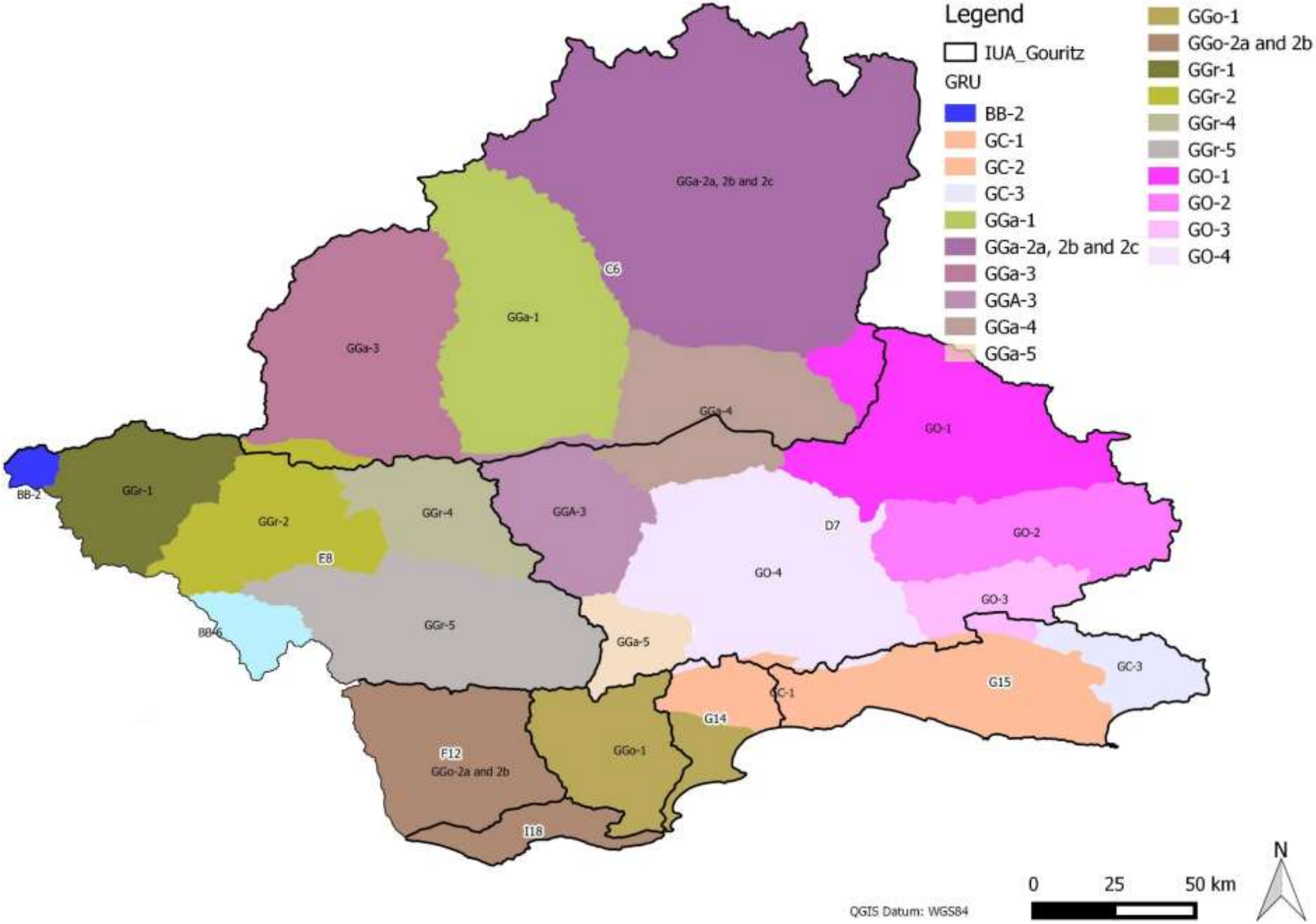

Figure 2-12. Delineated groundwater resource units and IUAs for the Gouritz

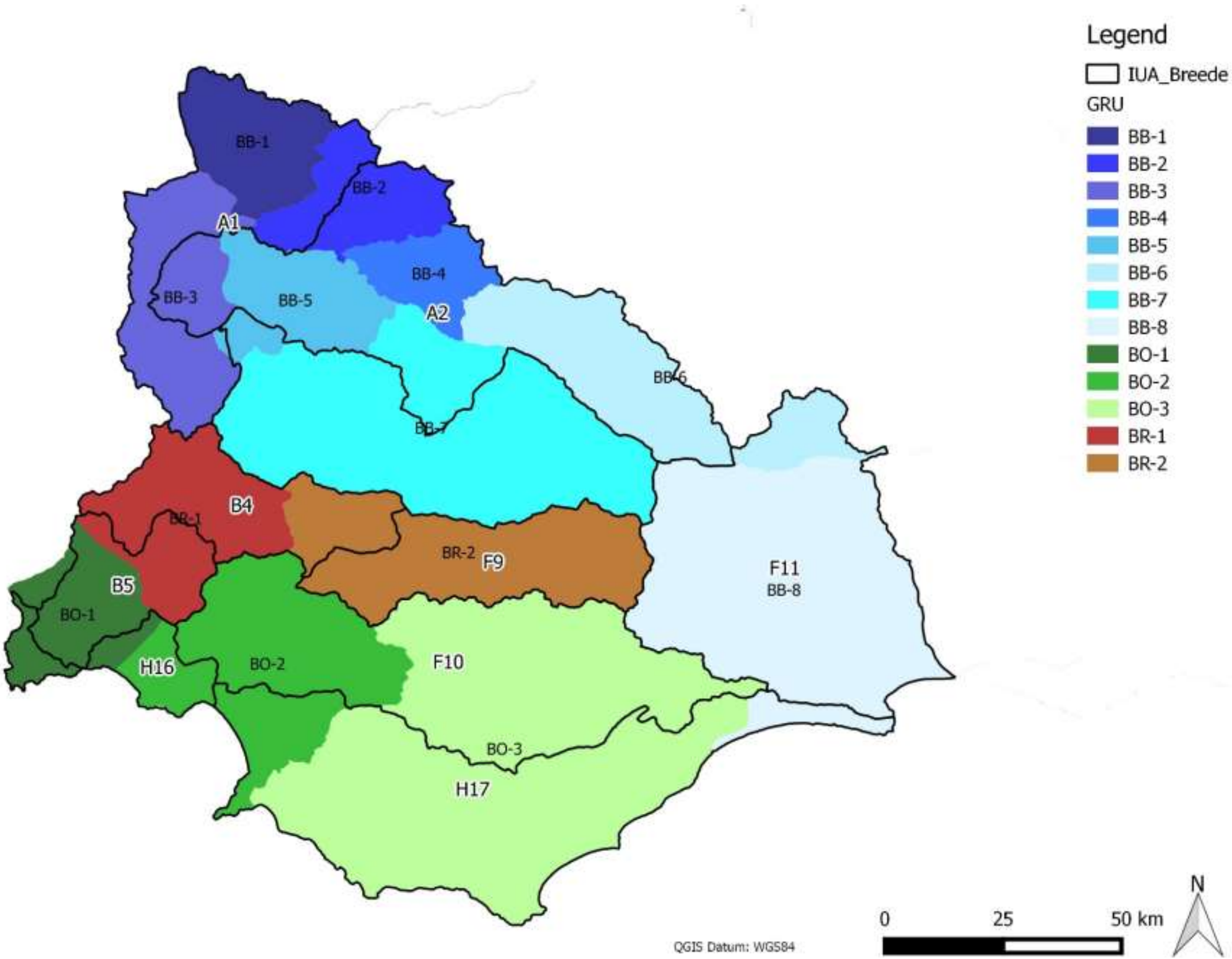

Figure 2-13. Delineated groundwater resource units and IUAs for the Breede

Table 2-9. The IUAs within which the GRUs overlap

IUA code	IUA name	GRU	IUA code	IUA name	GRU
C6	Gamka Buffels	GGa-3	A1	Upper Breede Tributaries	BB-1
		GGa-1			BB-3
		GGa-2a,2b,2c			BB-2
		GGa-4	A2	Breede Working Tributaries	BB-3
		GO-1			BB-5
D7	Gouritz Olifants	GGA-3			BB-2
		GGa-4			BB-4
		GO-1			BB-6
		GO-2			BB-7
		GO-3	A3	Middle Breede Renosterveld	BB-7
		GO-4	F11	Lower Breede Renosterveld	BB-8
					BB-6
		GGa-5	B4	Riviersonderend Theewaters	BR-1
E8	Touws	GGr-1			BR-2
		GG2-2	B5	Overberg West	BR-1
		GGr-4			BO-1
		GGr-5	H16	Overberg West Coastal	BO-1
		BB-6			BO-2
		BB-2	F10	Overberg East Renosterveld	BO-2
F12	Duiwenhoks	GGo-2a, 2b			BO-3
F13	Lower Gouritz	GGo-1	F17	Overberg East Fynbos	BO-2
I18	Hessequa	GGo-2a, 2b			BO-3
G14	Groot Brak	GGo-1			BB-8
		GC-1			
G15	Coastal	GC-1			
		GC-2			
		GC-3			

2.2.3.2 Recharge

The latest nationally available recharge dataset, GRAII (DWAF, 2006) is shown in Figure 2-12, and summed in Table 2-10 (per GRU) and Table 2-11 (per major geology), and also in Appendix B (per GRU per geology). The recharge distribution is largely controlled by the precipitation distribution, which in turn is related to the topography. At the broadest scale, areas of high rainfall largely correspond (at least in the theoretical datasets) to areas of high recharge. In certain areas the correlation is not direct and the underlying geology, and aquifer type, influences the recharge.

It is intuitive therefore that recharge is higher along the western borders of the Upper Breede in the TMG-formed mountainous areas, and along parts of the coastal areas where the TMG-formed mountains are close to the coast (i.e. south of the Outeniqua area). Recharge reduces significantly in the Karoo basin. The available recharge datasets provide information on recharge derived from direct infiltration only. This is only one mechanism by which recharge occurs. There is however no regional spatial dataset for information on rivers that recharge groundwater ("losing rivers"). Recharge mechanisms and groundwater flow dynamics will be expanded during the subsequent project phases.

Table 2-10. Recharge sum (GRAII, DWAF 206) per GRU

GRU	Recharge sum (million m^3/a)	GRU	Recharge sum (million m^3/a)
BB-1	63.48	GGa-1	4.12
BB-2	55.11	GGa-2a, 2b and 2c	26.42
BB-3	232.47	GGa-3	16.41
BB-4	18.42	GGa-4	10.61
BB-5	45.43	GGa-5	19.43
BB-6	42.94	GGo-1	44.73
BB-7	50.47	GGo-2a and 2b	145.13
BB-8	128.05	GGr-1	14.50
BO-1	146.34	GGr-2	20.15
BO-2	66.62	GGr-3	12.89
BO-3	78.11	GGr-4	14.88
BR-1	168.20	GGr-5	29.72
BR-2	49.85	GO-1	11.35
GC-1	167.80	GO-2	33.90
GC-2	216.59	GO-3	27.48
GC-3	92.45	GO-4	75.86

Table 2-11. Recharge sum (GRAII, DWAF 206) per major geology

Major geological unit	Recharge sum (million m^3/a)
TMG	1247.68
Coastal Cenozoic Deposits	298.94
Bokkeveld Group	277.59
Basement And Intrusive	163.26
Witteberg Group	41.22
Karoo	39.14
Uitenhage Group	38.82

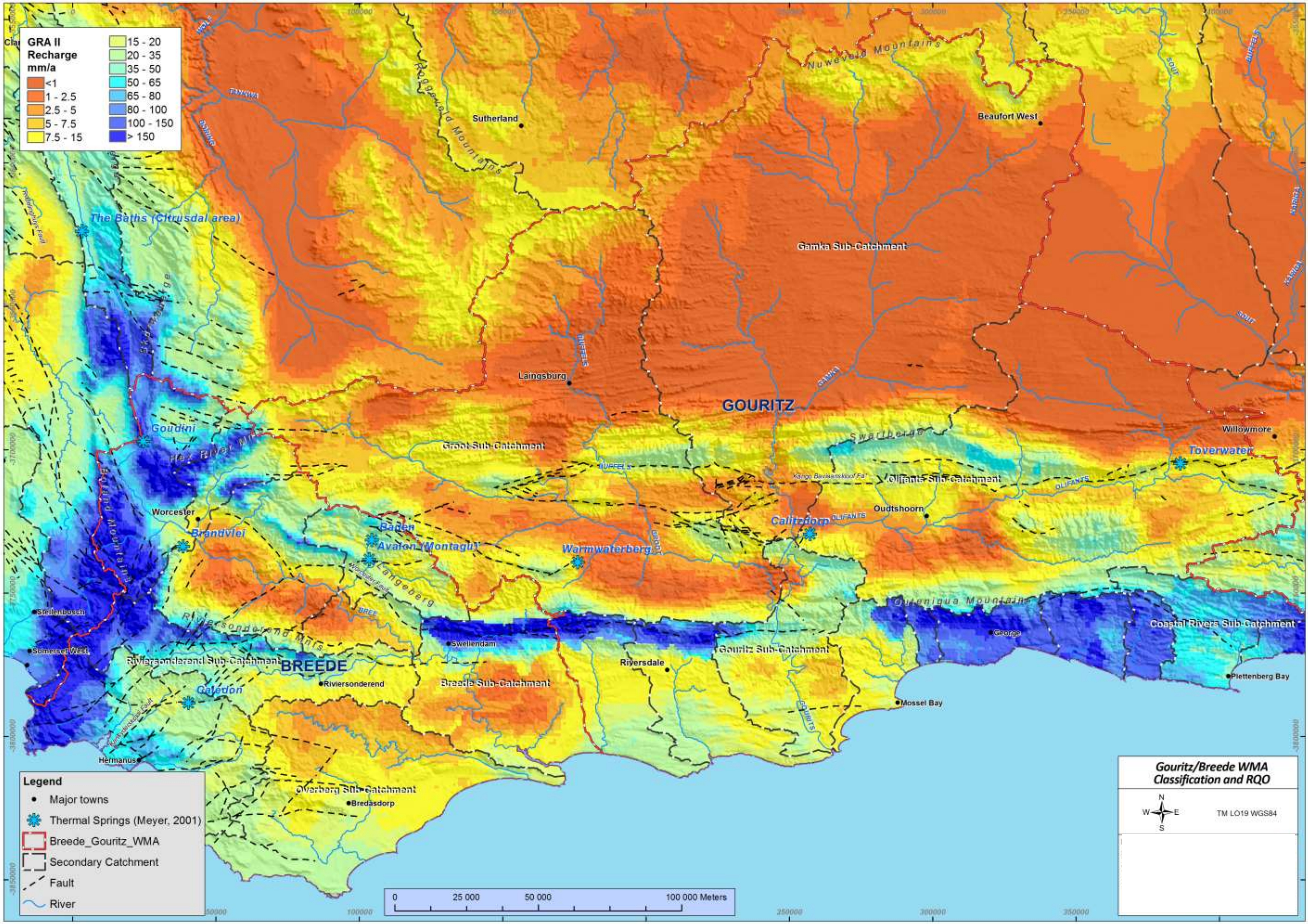

Figure 2-14. Groundwater recharge distribution (GRAII, 2006)

2.2.3.3 Discharge

One groundwater discharge mechanism is through discharge to surface water, as groundwater contribution to baseflow (river baseflow, springs and seeps). The available information for groundwater contribution to baseflow for the region is a national dataset derived from the GRAII assessment and at quaternary catchment scale (DWAF, 2006), shown in Figure 2-15. It is based on various estimates of baseflow, from the Pitman, Schultze and Hughes methods (DWAF, 2006). This same baseflow and groundwater contribution to baseflow dataset is incorporated in the GRDM software. The distribution of groundwater contribution to baseflow closely correlates with the distribution of recharge. Rainfall has a dominant control on recharge, and aquifers with high recharge, can also be reasonably expected to have high groundwater discharge, given a state of dynamic equilibrium in the long term.

This dataset is often the only or major (natural) discharge considered from groundwater. It is simply the only one for which there is a spatial dataset available. Interflow between aquifers, oceanic discharge, direct evapotranspiration, are discharge mechanisms for which there is not readily available spatial data at regional scale. A widely applied equation for groundwater availability equates availability to recharge minus use (existing abstraction and groundwater contribution to baseflow) minus the reserve. This equation simply yields unquantified groundwater discharge. All natural discharge (and some enhanced recharge) may be available, or only a small portion of it, depending on the ability to capture this yield. This is mentioned here in the context of discharge datasets for the status quo, and will be built upon in later stages of the project.

2.2.3.4 Groundwater use

Groundwater use registered in DWS's Water Authorisation Registration Management System (WARMS) database is used as an indicator for groundwater use across the region. Known inaccuracies with the dataset include potential under-estimate of rural domestic groundwater use, as schedule 1 users only register when use is above 10 m3/day, and under-estimate of use in the case of illegal or unlicensed groundwater users, and over-estimates in the case of actual use being lower than registered.

The sum of registered groundwater use per GRU is shown in Table 2-12, and a map showing the distribution of registrations is in Figure 2-16. This map also illustrates a density function which sums the groundwater registration (l/s) per km^2, emphasising clustered users and high registrations.

Groundwater use is significantly higher in the west of the Breede-Gouritz area, in the Breede Sub-Catchment GRUs (highest in BB-1, followed by BB-3, BB-2, BB-5, and BB-6) compared with the remainder of the region, as illustrated by the sum per BB GRU (Table 2-12), and by the density function (Figure 2-16). Groundwater use also clusters around Beaufort West in the GRU GGa-2a, 2b and 2c, which has the 7th highest sum of groundwater use registrations. This result is also a function however of the size of the GRU, and groundwater use (as l/s per km^2) is certainly higher in the west than east.

The high use in the west coincides with the high rainfall, recharge and high baseflow region, and the major agricultural areas of Ceres, Worcester and the Breede Valley, the Hex, Nuy, and De Doorns valleys, further illustrates the dominance of groundwater use for agriculture: 86% of the registered groundwater use is registered to agricultural irrigation. Only 8% of the registered use is for water supply services.

The surface geology at each registration point has been determined, and the use per major geological grouping summed (Table 2-14). This suggests that the highest abstraction occurs from Cenozoic deposits (including the Sandveld/ Bredasdorp Group, undifferentiated Quaternary and Tertiary deposits). With the point data available it is a challenge at regional scale to determine aquifer-specific use. A borehole whose surface geology is Cenozoic is in certain areas likely to penetrate deeper formations, for example laterally discontinuous Cenozoic deposits (assumed to be thin) on the edges of TMG slopes would in this process be classified as abstraction from Cenozoic deposits whereas it is likely that the TMG is penetrated. It is also simplistic given abstraction from one deposit (even where the borehole only penetrates one geological unit), may derive groundwater laterally from another aquifer source, for example alluvial fans in the Upper Breede Valley (i.e. Slanghoek) receive lateral recharge from the surrounding Peninsula Formation (DWAF, 2008). Nevertheless, the results at least indicate that the majority of abstracted groundwater is derived from Cenozoic deposits, from the Bokkeveld

Group and from the TMG. Less abstracted groundwater is derived from basement and Karoo aquifers. The Karoo aquifers have a lower average abstraction per registration, suggesting the lower yields are part of the reason for the lower total use (Table 2-14). The pattern of groundwater use is most significantly related to the geomorphology and socio-economics: the population density in the areas underlain by Karoo is lower, and the major agricultural areas are related to the high rainfall areas (and soil characteristics) of the Cape Fold Belt (underlain by TMG, Cenozoic deposits, and Bokkeveld group). Further details for water use (registered use per water use sector, per major geology per GRU) is included in Appendix B.

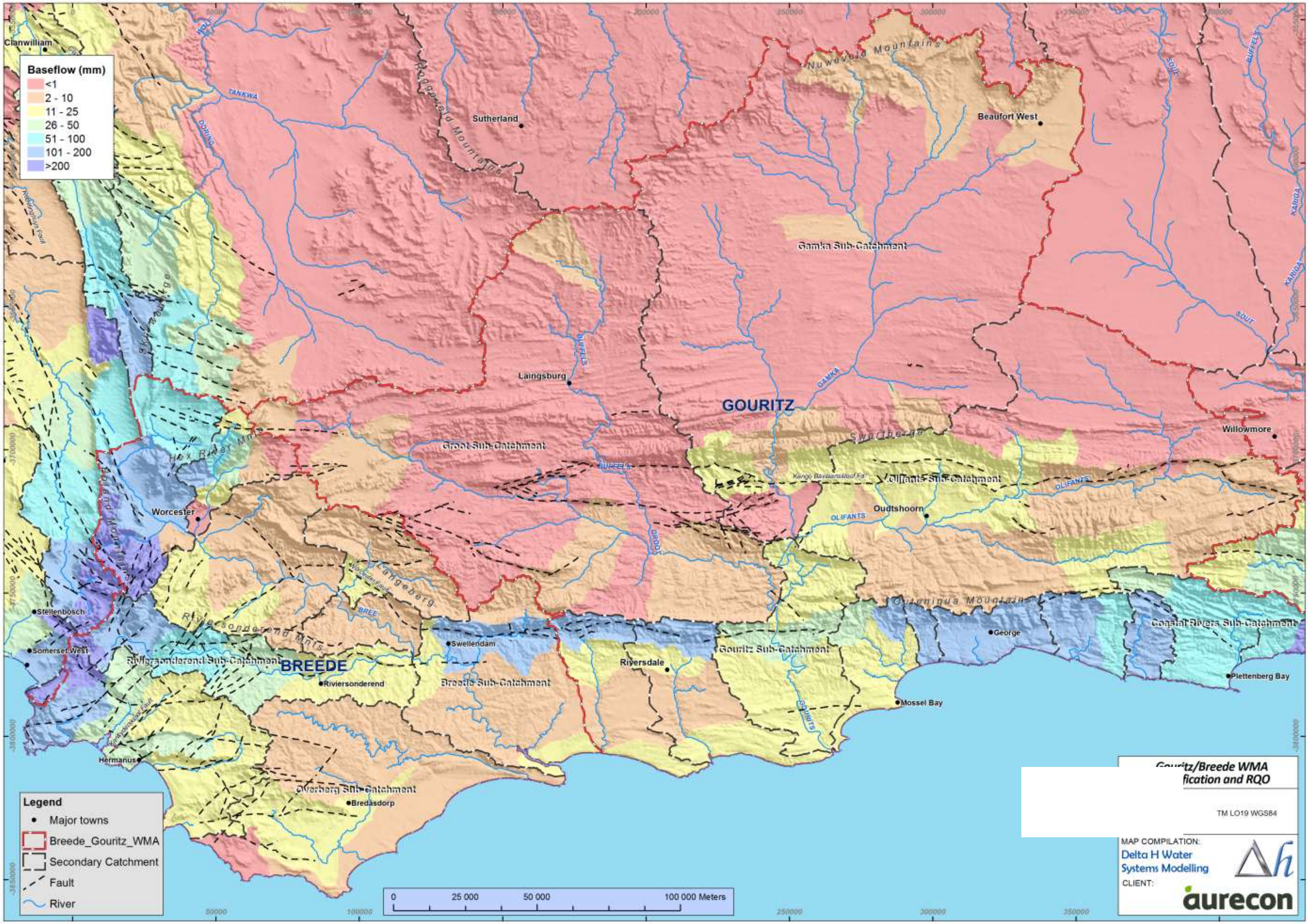

Figure 2-15. Distribution of Groundwater contribution to Baseflow, per quaternary catchment (GRAII, 2006)

Not all groundwater use is registered, including some use by municipalities for water supply. Although domestic groundwater supply makes up only 8% of the total use, groundwater is heavily relied upon by several communities. Those settlements in the Breede-Gouritz where groundwater makes up >50% of the supply source are listed in Table 2-15, illustrating:

- There are 28 settlements in the region (or groups of settlements, in the case of the Klein Karoo RWSS) where groundwater is considered the “sole supply” (>50%, as defined by DWA, 2011)
- In 20 of these, groundwater is the *only* supply source (100% of the supply)

In addition to those settlements listed, large-scale groundwater use is planned for Plettenberg Bay, and is a potential for the City of Cape Town (from aquifers located within the west of the Breede catchment).

Converse to the distribution of WARMS points, which is dominated by the high groundwater use by agricultural irrigation, most of the sole supply settlements are not in the Breede Sub-Catchment GRUs /west of the Breede-Gouritz area. The sole supply settlements cluster in the Overberg Sub-Catchment (BO-2 and BO-3), and in the coastal region of the Gouritz Sub-Catchment (GGo-2a and 2b) (Figure 2-11). Sole supply settlements are also scattered across the Gamka Sub-Catchment, Groot Sub-Catchment, and Olifants sub catchments (GGa-1, GGa-2a, 2b, and 2c, GGr-3, GGr-5, GO-1 and GO-4). The distribution essentially reflects areas away from the major mountain ranges / TMG, which in turn drive the major surface water systems. The use of groundwater is therefore because of a lack of surface water sources.

Table 2-12. Groundwater use as registered in WARMS, per GRU

GRU	Sum of registrations (million m^3/a)	GRU	Sum of registrations (million m^3/a)
BB-1	32.89	GGa-1	1.12
BB-2	22.95	GGa-2a, 2b and 2c	9.44
BB-3	24.28	GGa-3	0.63
BB-4	2.02	GGa-4	2.37
BB-5	18.80	GGa-5	0.09
BB-6	14.12	GGo-1	3.54
BB-7	9.03	GGo-2a and 2b	7.74
BB-8	0.83	GGr-1	4.74
BO-1	0.94	GGr-2	0.82
BO-2	11.55	GGr-3	3.50
BO-3	5.80	GGr-4	4.28
BR-1	3.70	GGr-5	2.06
BR-2	1.20	GO-1	1.15
GC-1	2.63	GO-2	1.93
GC-2	4.70	GO-3	2.60
GC-3	0.43	GO-4	8.40

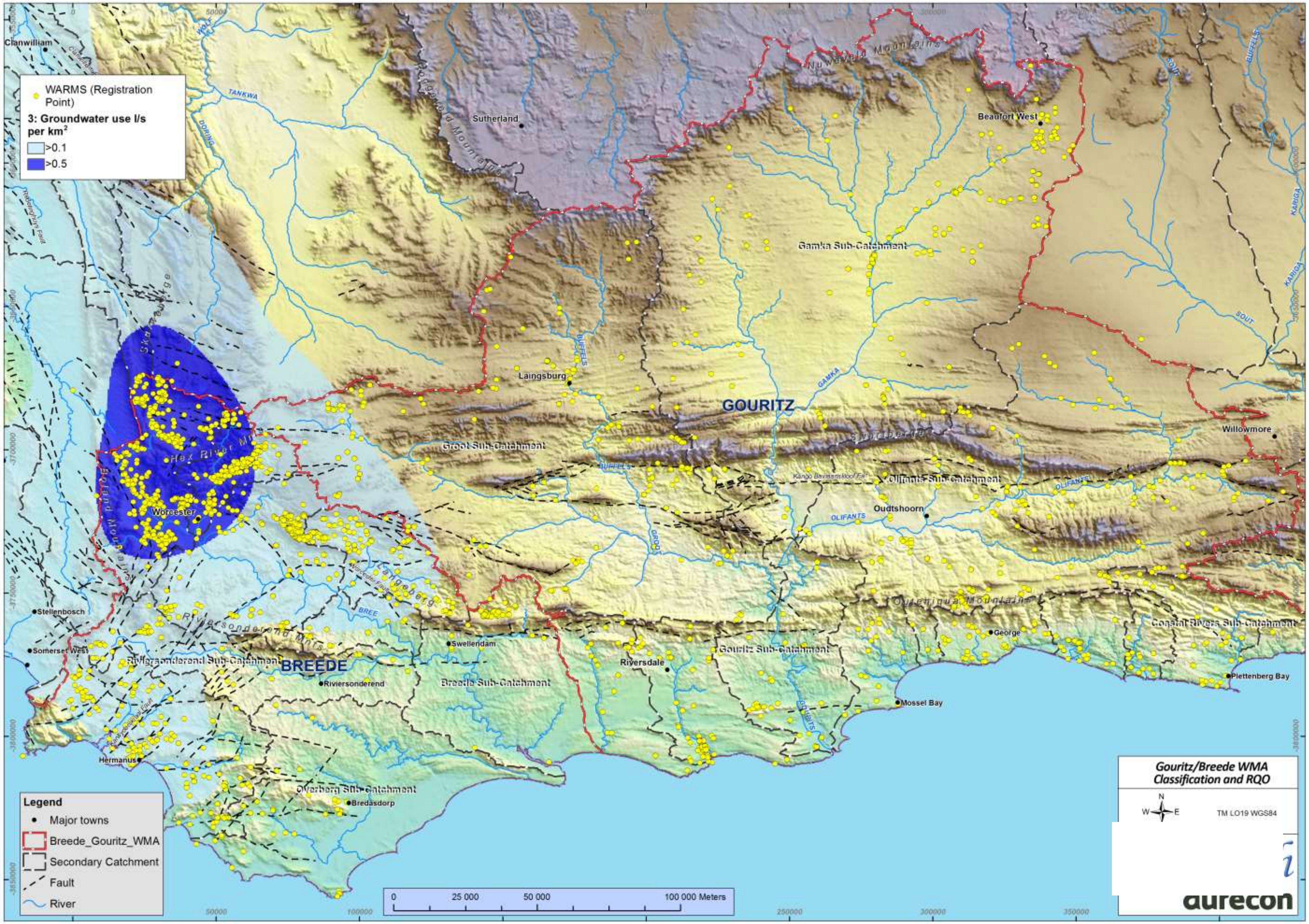

Figure 2-16. Map showing distribution of WARMS registered groundwater abstractions (points), and groundwater use density function (l/s/km² shaded areas)

Table 2-13. Groundwater use as registered in WARMS, per water use sector

Water Use Sector	Sum of registrations (million m^3/a)
AGRICULTURE: IRRIGATION	180.92
WATER SUPPLY SERVICE	17.78
INDUSTRY (URBAN)	5.48
AGRICULTURE: WATERING LIVESTOCK	3.91
SCHEDULE 1	0.89
INDUSTRY (NON-URBAN)	0.64
RECREATION	0.44
AGRICULTURE: AQUACULTURE	0.13
MINING	0.05
URBAN (EXCLUDING INDUSTRIAL &/OR DOMESTIC)	0.01
Total	**210.2**

Table 2-14. Groundwater use as registered in WARMS, per major geological division

Geological grouping	Sum of registrations (million m^3/a)	Number of registrations	Average registration volume (m^3/a)
Coastal Cenozoic Deposits	90.05	1202	74918
Bokkeveld Group	52.38	1002	52272
TMG	41.39	640	64667
Basement And Intrusive	11.25	200	56245
Karoo	8.67	260	33365
Uitenhage Group	4.08	92	44395
Witteberg Group	2.33	48	48555
Total	**210.2**	**3444**	**n/a**

Table 2-15. Settlements with groundwater making up >50% of the supply source ("sole supply") within the Breede-Gouritz

GRU	Settlement	% GW supplied	GW Yield (million m^3/a)
BB-5	Rawsonville	90	0.62
BO-2	Hermanus	53	3.20
	Stanford	100	1.60
BO-3	Napier	100	0.42
	Wolvengat	100	0.01
	Bredasdorp	66	0.70
	Struisbaai	100	1.14
	L'Agulhas	100	0.30
	Pearly Beach	69	0.21
	Elim	100	0.06
	Buffeljachtsbaai	100	0.03
	Suiderstrand	100	0.10
BR-1	Botrivier	100	0.46
GGa-1	Prince Albert Road	100	Unknown
	Merweville	100	0.32
GGa-2a, 2b and 2c	Beaufort West	77	2.71
	Leeu Gamka and Bitterwater	100	0.10
	Murraysburg	100	0.45
GGo-1	Albertinia	100	0.50
GGo-2a and 2b	Melkhoutfontein	100	0.16
	Jongensfontein	100	0.16
	Gouritzmond	100	0.15
	Stilbaai	79	0.94
GGr-3	Matjiesfontein	100	0.12
	Laingsburg	91	1.19
GGr-5	Van Wyksdorp	68	0.05
GO-1	Klaarstroom	100	0.03
GO-4	Klein Karoo RWSS	100	1.27

2.2.3.5 Groundwater quality

Average (mean) groundwater quality parameters are shown in Table 2-16, calculated based on (mean average of) all available groundwater quality data. This data is presented per GRU in Appendix B. Medians are preferable for analysis of groundwater quality however due to the large datasets automated averaging was necessary which does not accommodate medians. The values should be considered over estimates as a mean can be significantly skewed by outliers. Groundwater quality will also vary significantly spatially, based on aquifer setting and local influences. Nevertheless, natural groundwater quality is directly related to geology, and recharge, and therefore results can provide an illustration of the *relative* water quality differences between the major geological units. The spatial variability of groundwater quality (using electrical conductivity as an indicator for quality) is shown in Figure 2-17.

Groundwater quality, on average, is excellent in the TMG with all parameters falling below or within Class 1 Drinking Water Quality. The water quality is related to high recharge (i.e. high influx of fresh water), and the almost pure quartzite content of the Peninsula and Skurweberg Formations (into which most of the boreholes for which water quality is available will be situated). The Cenozoic deposits, Witteberg Group, Karoo Supergroup, and Uitenhage Group also have good water quality with all parameters falling below Class 1, within Class 1, or within Class 2.

Water quality is generally poorer in the basement, and Bokkeveld Group (occurrences of parameters falling within Class 3), which relates to higher clay contents, and lower recharge values. High salinity in surface waters (i.e. lower Breede) can be attributed to a combination of factors, including the contribution of salts from underlying geology. Again, these results are a broad generalisation; some individual units in the basement, Bokkeveld and Karoo sediments, and individual locations will maintain excellent quality. Furthermore, in some cases the TMG has high iron requiring pre-treatment. It is also important to note that Class 3 natural groundwater quality does not preclude its use for domestic supply: surface water is not expected to be of Class 0 drinking water quality on abstraction, it is treated prior to use.

Table 2-16. Average water quality parameters for major geological groupings, compared to DWAF Drinking Water Quality Limits[1]

Major Geology Grouping	Number of locations	pH Value at 25⁰C	Conductivity at 25⁰C	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Fluoride (F)	Chloride (Cl)	Sulphate (SO_4)	Total Alkalinity ($CaCO_3$)	NO_3 -N
		mg/l	mS/m	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Bokkeveld Group	329	7.45	339.16	444.79	444.79	80.88	0.58	777.37	234.00	202.54	2.67
Coastal Cenozoic Deposits	1167	7.49	166.89	228.94	228.94	38.00	0.48	374.85	127.69	165.12	1.80
TMG	353	6.86	78.86	111.91	111.91	16.75	0.26	187.40	57.77	50.76	0.53
Basement	85	7.79	240.98	295.64	295.64	79.30	0.56	635.18	169.10	174.03	1.53
Witteberg Group	39	7.44	174.95	218.58	218.58	58.38	0.51	410.79	144.70	154.20	2.15
Karoo Supergroup	1360	7.78	142.45	161.65	161.65	37.73	0.71	257.40	131.98	223.41	2.47
Uitenhage Group	34	7.48	151.90	234.10	234.10	23.66	0.54	353.47	61.08	149.91	2.65
	Drinking Water Quality Limits - DWAF, 1996; DWAF, DOH and WRC, 1998*										
	Class 1	*5-6 or 9-9.5*	*70-150*	*100-200*	*80-150*	*30-70*	*0.7-1*	*100-200*	*200-400*		*6-10*
	Class 2	*4-5 or 9.5-10*	*150-370*	*200-600*	*150-300*	*70-100*	*1-1.5*	*200-600*	*400-600*		*10-20*
	Class 3	*3.5-4 or 10-10.5*	*370-520*	*600-1200*	*>300*	*100-200*	*1.5-3.5*	*600-1200*	*600-1000*		*20-40*

[1] Note: mean averages are presented. Medians are preferable for analysis of water quality however due to the large datasets automated averaging was necessary which does not accommodate medians. The values should be considered maximums as a mean can be significantly skewed by outliers.

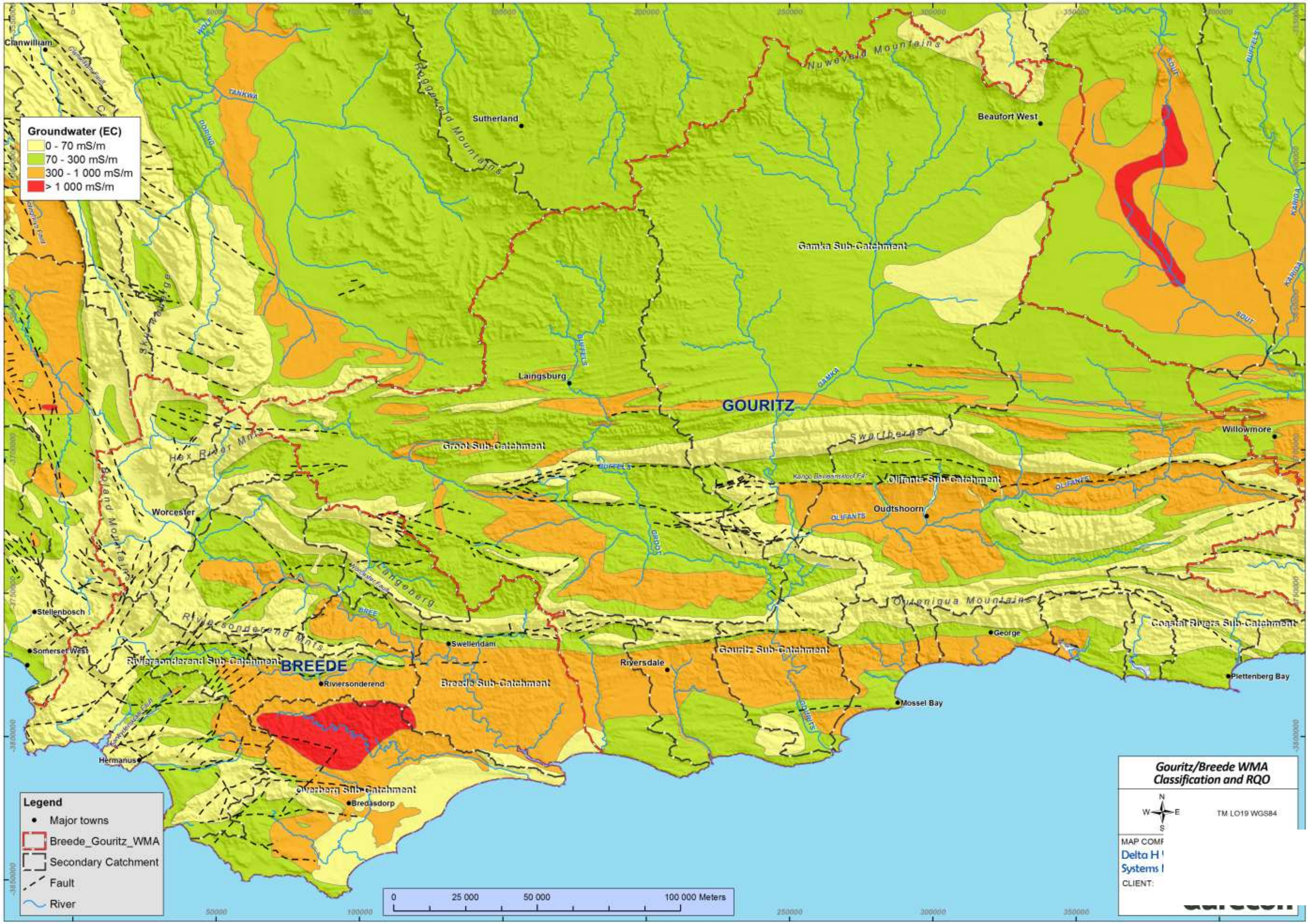

Figure 2-17. **Map showing distribution of Groundwater Electrical Conductivity (DWAF Hydrogeological Map Series, 1995)**

2.3 Water quality status quo

2.3.1 Approach

Assessment of the present water quality status quo was based on assessing the fitness for use of the water for key water user sectors, namely irrigation water use, domestic water use, and aquatic ecosystems. The assessment was aligned with the methodology that was used in the Olifants WMA classification study (DWA, 2011). The water quality targets used for the assessment (Table 2-17) were derived using the Resource Water Quality Objectives (RWQOs) Model (Version 4.0) (DWAF, 2006) which uses as its basis the South African Water Quality Guidelines (DWAF, 1996), Quality of Domestic Water Supplies: Assessment Guide, Volume 1 (WRC, 1998) and Methods for determining the Water Quality Component of the Reserve (DWAF, 2008) and are based on the strictest water user criteria (thus represent fairly conservative limits). The fitness for use is described using four water quality categories, namely Ideal (blue), Acceptable (green), Tolerable (yellow), and Unacceptable (red) for concentrations greater than the upper boundary of the Tolerable range. The more blue and green colours are visible in the classification tables, the better the water quality. The more yellow and red visible in the classification tables, the poorer the water quality.

Table 2-17. Water quality criteria used to assess the present water quality status

Variable	Units	Bound	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Alkalinity ($CaCO_3$)	mg/l	Upper	20	AAq	97.5	AAq	175	AAq
Ammonia (NH_3-N)	mg/l	Upper	0.015	Eco	0.044	Eco	0.073	Eco
Calcium (Ca)	mg/l	Upper	10	Dom	80	BHN	80	BHN
Chloride (Cl)	mg/l	Upper	40	In2	120	In2	175	In2
Ec	mS/m	Upper	30	In2	50	In2	85	Eco
Fluoride (F)	mg/l	Upper	0.7	Dom	1	Dom	1.5	Dom
Magnesium (Mg)	mg/l	Upper	70	Dom	100	Dom	100	Dom
NO_3 (NO_3-N)	mg/l	Upper	6	AIr	10	AIr	20	AIr
pH	units	Upper	≤ 8	In2	<8.4	In2		
		Lower	≥6.5	Air, Aaq, In2	>8.0	Air, Aaq, In2		
Potassium (K)	mg/l	Upper	25	Dom	50	Dom	100	Dom
PO_4-P (Rivers)	mg/l	Upper	0.025	Eco	0.075	Eco	0.125	Eco
PO_4-P (Dams)	mg/l	Upper	0.005	Eco	0.015	Eco	0.025	Eco
SAR	mmol/l	Upper	2	AIr	8	AIr	15	AIr
Sodium (Na)	mg/l	Upper	70	AIr	92.5	AIr	115	AIr
Sulphate (SO_4)	mg/l	Upper	80	In2	165	In2	250	In2
TDS	mg/l	Upper	200	In2	350	In2	800	In2
Si	mg/l	Upper	10	In2	25	In2	40	In2

Note on sensitive users: Air – Agriculture: Irrigation users, AAq – Agriculture: Aquaculture users, BHN – Basic human needs users, Dom – Domestic users, Eco – Aquatic ecosystems, In2 – Industrial 2 users

2.3.2 Description

The primary source of data for the water quality analysis was the Directorate Resource Quality Information Services of the Department. Historical data for water quality monitoring points in the Breede-Gouritz WMA were obtained from the national monitoring network (Water Management System). The monitoring network is described in the Water Resources Information and Gap Analysis Report (RDM/WMA8/00/CON/CLA/0316). The routine DWS river and reservoir water quality monitoring points for the Breede-Gouritz WMA are listed in Table 2-18.

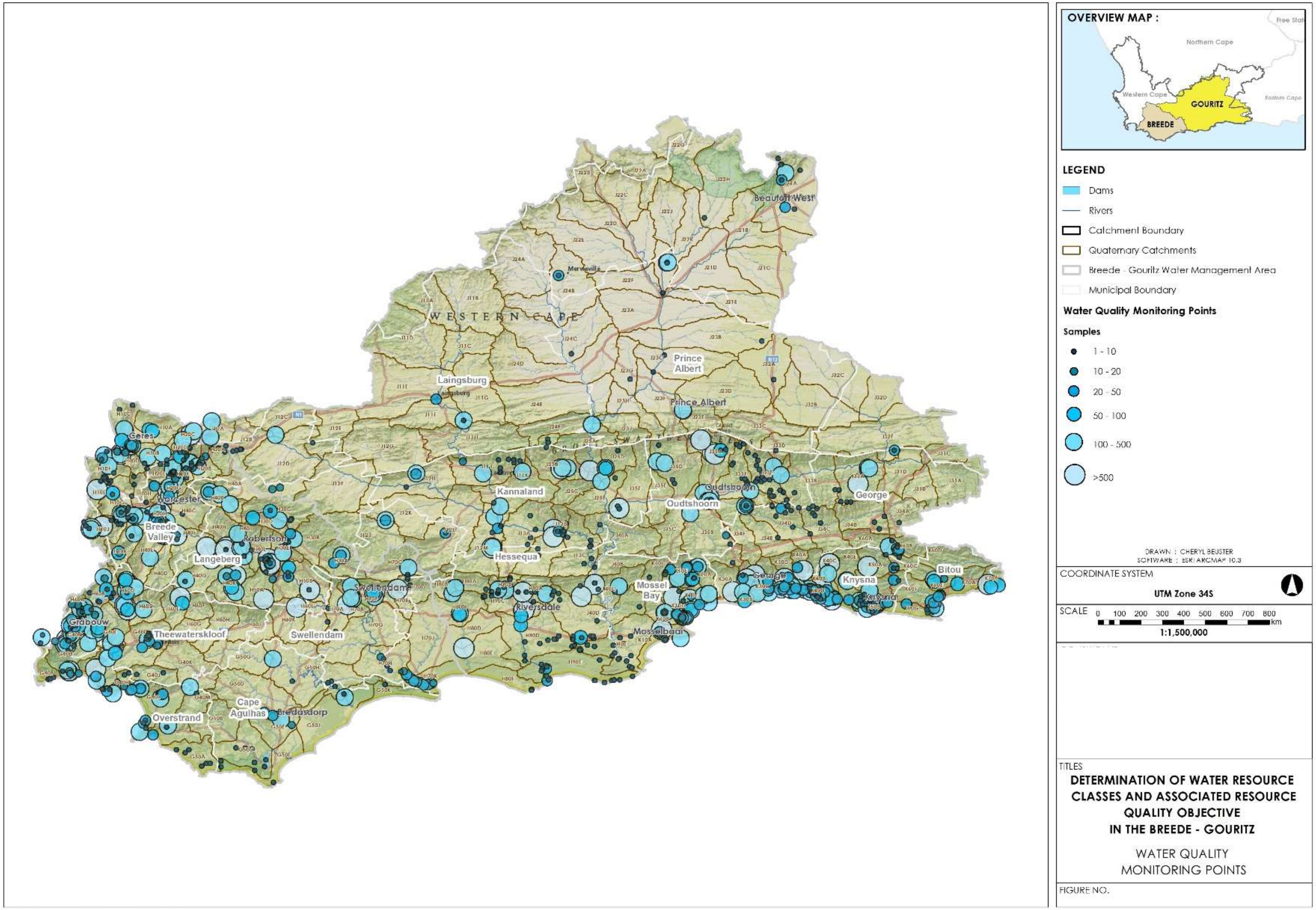

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Figure 2-18. Surface water quality monitoring within the study area

Table 2-18. River and reservoir water quality monitoring points in the Breede-Gouritz WMA

The number of samples, first and last date refers to the complete data record

IUA	Monitoring Point Name	Type	Quat	n	First	Last
A1	H1h014q01 Vals River At Ben Etive	Rivers	H10B	248	20/10/1967	26/01/1984
A1	H1h016q01 Rooikloof River At Ben Etive	Rivers	H10B	140	29/09/1977	04/12/1996
A1	H1h003q01 Bree River At Ceres Commonage	Rivers	H10C	1287	20/08/1971	10/06/2015
A1	H1h013q01 Koekedou River At Ceres/Persephone	Rivers	H10C	513	20/08/1971	22/07/2015
A1	Cmnt-Ceres-Mr800a-Low Water Bridge At Fairfield Farm In Prince Alfred Hamlet	Rivers	H10C	138	18/04/1995	13/11/2013
A1	Cmnt-Ceres-Sr800a-Low Water Bridge On Fairfield Farm	Rivers	H10C	142	18/04/1995	13/11/2013
A1	Cmnt-Ceres-Dw800a-Low Water Bridge At Klein Pruise Farm	Rivers	H10C	328	28/11/1988	13/11/2013
A1	Cmnt-Ceres-Dw800a1-After Runoff From Cfp Irri Area On Mazoe	Rivers	H10C	140	18/04/1995	13/11/2013
A1	Cmnt-Ceres-Dw800a2-Low Water Bridge In Hugo Street In Ceres	Rivers	H10C	140	18/04/1995	13/11/2013
A1	Cmnt-Ceres-Dw800a3-At Weir After Runoff From Cfg Irrig Area	Rivers	H10C	134	16/05/1995	13/11/2013
A1	Cmnt-Ceres-Dw800d-At Ceres Golf Course	Rivers	H10C	141	06/12/1988	08/08/2006
A1	Ceres Wwtp-Overflow Ex Last Mat Pond To Dwars River	Rivers	H10C	649	23/02/1988	26/01/2016
A1	H1h006q01 Bree River At Ceres Commonage/Witbrug	Rivers	H10D	1230	20/08/1971	22/07/2015
A1	H1h007q01 Wit River At Drosterskloof	Rivers	H10E	1265	20/08/1971	19/08/2015
A1	Witbrug At Abstraction Weir On Bree River	Rivers	H10F	391	09/03/2006	25/09/2013
A1	Cmnt-Ceres-Dw800e-At Witbrug-Dwars Riv Irrigation Board Weir	Rivers	H10F	183	02/11/1992	13/11/2013
A1	H1h017q01 At Hawequas Forest Reserve On Elands river	Rivers	H10J	699	12/06/1970	26/08/1992
A1	H1h018q01 Molenaars River At Hawequas Forest Reserve	Rivers	H10J	1324	03/06/1970	12/06/2015
A1	H1h033q01 At Hawequas Forest Reserve On Elands River	Rivers	H10J	208	21/06/1995	12/06/2015
A1	H1h012q01 Holsloot River At Daschbosch River	Rivers	H10K	316	14/09/1971	08/06/2015
A1	H2h008q01 Valsgat River At Hottentots Kraal	Rivers	H20C	391	23/09/1982	02/01/1996
A1	H2r002q01 Roode Els Berg 71 - Lakenvallei Dam On Sanddrifskloof River: Near Dam Wall	Dam	H20D	203	04/07/1968	27/07/2015
A1	H2h004q01 Sanddrifskloof River At Zanddrifts Kloof	Rivers	H20D	230	15/03/1973	10/10/1996
A1	H2h015q01 Roode Els Berg Dam On Sanddrifskloof Riv: D/Str W	Rivers	H20D	353	30/01/1978	31/07/2015
A1	H2h016q01 Lakenvallei Dam On Sanddrifskloof Riv: D/Stream W	Rivers	H20D	407	13/01/1977	27/07/2015
B4	H6h008q01 Riviersonderend At Swarte Water/Nuweberg Forest R	Rivers	H60A	378	27/02/1967	24/08/1992
B4	H6h007q01 Du Toits River At Purgatory Outspan	Rivers	H60B	375	17/04/1973	24/08/1992
B4	H6h011q01 Waterkloof River At Tydsgenoeg/Vyeboom	Rivers	H60B	174	03/02/1977	01/12/1982

IUA	Monitoring Point Name	Type	Quat	n	First	Last
B4	H6r001q01 Theewaterskloof Dam On Riviersonderend: Near Dam Wall	Dam	H60C	583	28/01/1980	18/09/2015
B4	H6r001q02 Theewaterskloof Dam On Rivier-Sonderend: Tunnel Inlet	Dam	H60C	240	07/10/1983	28/07/2010
B4	H6r002q01 Elandskloof Dam On Elands River: Near Dam Wall	Dam	H60C	420	15/06/1977	22/07/2015
B4	H6h006q01 At Twistniet Radyn On Elands River	Rivers	H60C	176	20/02/1973	18/03/1999
B4	H6h010q01 Waterkloof River At Wagensbooms Kloof	Rivers	H60C	174	13/04/1973	01/12/1982
B4	H6h012q01 Theewaterskloof Dam On Riviersonderend Riv: D/St	Rivers	H60D	629	03/02/1977	23/06/2015
B4	H6h005q01 At Genadendal Mission Station On Baviaans River	Rivers	H60E	516	28/11/1972	21/07/2015
B5	G4r002q01 Klein Wessels Gat 287 - Eikenhof Dam On Palmiet River: Near Dam Wall	Dam	G40C	290	20/12/1982	23/07/2015
B5	Kleine Wesselsgat 287 Grabouw At Worcester Street Bridge On Klipdrif River	Rivers	G40C	511	08/07/2004	18/07/2013
B5	Cmnt-Bot+Palmiet-Kr400a-KlipdrIf R At Two-A-Day Dumpsite	Rivers	G40C	117	14/04/1988	02/12/2013
B5	Cmnt-Bot+Palmiet-Kr400b-KlipdrIf R Before Bridge At Pumpstation In Grabouw	Rivers	G40C	146	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Pr400a-Palmiet R At Nuweberg Forestry Station	Rivers	G40C	124	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Pr400b-Palmiet R At Molteno Brothers	Rivers	G40C	125	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Pr400c-Palmiet River At Oudebrug	Rivers	G40C	125	25/07/1995	21/11/2013
B5	G4h005q01 Palmiet River At Van Aries Kraal/Applethwaite	Rivers	G40D	883	07/06/1972	23/07/2015
B5	G4h007q01 Palmiet River At Farm 562-Welgemoed/Kleinmond	Rivers	G40D	1314	23/02/1960	23/07/2015
B5	G4h029q01 Kogelberg Dam On Palmiet River: Downstream Weir	Rivers	G40D	596	31/08/1987	23/07/2015
B5	Cmnt-Bot+Palmiet-Pr400d- Palmiet River D/S Dams	Rivers	G40D	128	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Ko400a-Ribbok River At De Rust	Rivers	G40D	124	23/08/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Pr400e-Palmiet River Above Estuary	Rivers	G40D	117	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Ko400b-Krom River Before Confluence	Rivers	G40D	128	25/07/1995	21/11/2013
B5	G4h010q01 Jakkals River At Lebanon Forest Reserve	Rivers	G40E	396	15/12/1977	03/03/1992
B5	G4h014q01 At Roode Heuvel On Botrivier	Rivers	G40E	827	14/07/1981	22/07/2015
B5	Cmnt-Bot+Palmiet-Hr400a- Houwhoek River On Vd Stel Pas	Rivers	G40E	171	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Br400a-Bot River Above The Town	Rivers	G40E	169	25/07/1995	21/11/2013
B5	Cmnt-Bot+Palmiet-Br400b-Bot River At Rooiheuwel	Rivers	G40E	212	25/07/1995	21/11/2013
C6	J1R003Q01 Floris Kraal 136 - Floriskraal Dam On Buffels River: Near Dam Wall	Dam	J11G	463	06/04/1968	29/07/2015
C6	J1H028Q01 Floriskraal Dam On Buffels River: Downstream Weir	Rivers	J11G	330	13/03/1972	26/08/2015

IUA	Monitoring Point Name	Type	Quat	n	First	Last
	J2R004Q01 Alwins Gate 186 - Gamka Dam On Gamka River: Near Dam Wall	Dam	J21A	302	24/01/1973	17/07/2015
	J2H018Q01 Gamka Dam On Gamka River: D/Stream Weir For Leaka	Rivers	J21A	197	16/03/1983	12/08/2015
	J2R002Q01 Stinkfontein 7 - Leeugamka Dam On Leeu River: Near Dam Wall	Dam	J22K	219	09/08/1977	20/05/2015
D7	J2R003Q01 Baviaans Kloof 136 - Oukloof Dam On Cordiers River: Near Dam Wall	Dam	J23E	316	05/03/1973	26/08/2015
	J2R006Q01 Dwuka River 199 - Gamkapoort Dam On Gamka River: Near Dam Wall	Dam	J25A	382	28/01/1972	30/07/2015
	J2H010Q01 Gamka River At Huis River	Rivers	J25A	765	04/11/1971	25/08/2015
	J2H016Q01 Gamkapoort Dam On Gamka River: Downstream Weir	Rivers	J25A	144	06/05/1983	27/08/2015
	J2H005Q01 Huis River At Zoar	Rivers	J25B	539	05/11/1971	25/08/2015
	J2H006Q01 At Opzoek On (Boplaas River) Wilge River	Rivers	J25B	330	04/11/1971	28/07/2015
	J2H007Q01 Joubert River At Opsoek	Rivers	J25B	349	04/11/1971	25/08/2015
	J2R001Q01 Quarrieveldt 13 - Calitzdorp Dam On Nels River: Near Dam Wall	Dam	J25D	299	08/07/1968	25/08/2015
	J2H008Q01 Gamka River At Calitzdorp	Rivers	J25D	114	15/09/1965	05/11/1981
	J3H004Q01 Olifants River At Pardekloof/Barandas/Kromlaagte	Rivers	J33A	139	19/11/1965	05/06/1995
	J3h016q01 Wilge River At Wilgehoute River	Rivers	J33A	510	05/09/1973	11/08/2015
	J3H021Q01 Olifants River At Pardekloof/Barandas	Rivers	J33A	172	29/09/1982	13/04/1993
	J3R002Q01 Farm 67 - Stompdrif Dam On Olifants River: Near Dam Wall	Dam	J33B	353	08/04/1968	11/08/2015
	J3H012Q01 At De Rust On Groot River	Rivers	J33D	395	20/11/1965	25/04/2012
	J3R001Q01 Kamanassie 135 - Kammanassie Dam On Kammanassie River: Near Dam Wall	Dam	J34E	279	09/07/1968	13/08/2015
	J3H013Q01 Perdepoort River At Groenefontein/De Hoek	Rivers	J35A	567	09/07/1970	27/08/2015
	J3H014Q01 Grobbelaars River At De Kombuys/Schoemanskloof	Rivers	J35A	623	23/03/1977	25/06/2015
	J3H015Q01 Little Leroux River At De Kombuys/Schoemanskloof	Rivers	J35A	618	23/03/1977	24/04/2015
	Oudtshoorn @ Low Water Bridge Next To ATKV Theater On Grobbelaars	Rivers	J35A	265	05/03/2007	15/07/2013
	J3H017Q01 Kandelaars River At Paardendrift/Up/Stream Olifants	Rivers	J35B	492	30/11/1977	23/06/2015
	Onverwacht 143 At Bridge On George Road (R62) On Olifants River	Rivers	J35B	115	02/06/2008	15/07/2013
	Onverwacht 143 Directly After Oudtshoorn WWTW Discharge Point On Olifants	Rivers	J35B	111	02/06/2008	15/07/2013
	J3H018Q01 Wynands River At Koetzers Kraal	Rivers	J35D	398	11/04/1969	25/06/2015
	J3H020Q01 Meul River At Vogelfontein	Rivers	J35D	450	03/10/1974	25/06/2015
	J3H011Q01 Olifants River At Warm Water	Rivers	J35F	1082	08/10/1968	28/07/2015
E8	J1H015Q01 At Lot B Bokke River Government Forest On Bok River	Rivers	J12A	326	12/02/1975	27/07/2015
	J1H016Q01 Smalblaar River At Verlorenvalley	Rivers	J12A	319	15/09/1977	27/07/2015
	J1H022Q01 Prins River Dam On Prins River: Downstream Weir	Rivers	J12G	307	11/03/1986	26/08/2015
	J1R002Q01 Bellair Dam On Brak River: Near Dam Wall	Dam	J12K	319	17/07/1977	26/08/2015
	J1R004Q01 Miertjes Kraal 262 - Miertjieskraal Dam On Brand River: Near Dam Wall	Dam	J12M	766	23/08/1977	25/08/2015
	J1H009Q01 Brand River At Miertjies Kraal	Rivers	J12M	272	03/05/1967	03/11/1983

IUA	Monitoring Point Name	Type	Quat	n	First	Last
	J1H018Q01 Touws River At Okkerskraal	Rivers	J12M	239	30/09/1982	28/07/2015
	J1H031Q01 Miertjeskraal Dam On Brand River: Downstream Weir	Rivers	J12M	588	26/03/1983	25/08/2015
	J1H017Q01 Sand River At Buffelsfontein/Van Wyksdorp	Rivers	J13B	613	27/03/1981	29/07/2015
	J1H019Q01 At Buffelsfontein Van Wyksdorp On Groot River	Rivers	J13B	748	11/12/1982	29/07/2015
F10	Cmnt-Bot+Palmiet-Sw400a-Swart River At Low Water Bridge	Rivers	G40F	96	25/07/1995	21/11/2013
	G4h006q01 Klein River At Can Q5-8/Wagenboomsdrift	Rivers	G40K	418	10/06/1968	22/07/2015
	G5h008q01 Sout River At Kykoedy	Rivers	G50H	323	30/07/1965	02/12/2014
F11	H7H006Q01 At Swellendam On Bree River	Rivers	H70A	980	16/03/1966	21/07/2015
	H7H005Q01 @ Swellendam Forest Reserve On (Hermitage) Klipriv	Rivers	H70B	359	03/12/1973	21/07/2015
	H7h003q01 At Suurbraak On Buffeljags River	Rivers	H70D	636	04/04/1979	03/06/1998
	H7R001Q01 Eenzaamheid 145 - Buffelsjags Dam On Buffeljags River: Near Dam Wall	Dam	H70E	100	27/01/1972	21/10/1998
	H7H013Q01 Buffelsjags Dam On Buffeljags River D/S Weir	Rivers	H70E	208	02/01/1978	23/07/2015
	H7H007Q01 Grootkloof River At Sparkenbosch	Rivers	H70F	400	23/02/1968	19/06/2015
F12	H8h003q01 Duiwenhoks Dam On Duiwenhoks River: Downstream W	Rivers	H80A	349	05/04/1976	19/08/2015
	Duiwenhoks River 305 South Of Heidelberg On Duiwenhoks River	Rivers	H80C	97	17/06/2008	01/07/2013
	H8h001q01 Duiwenhoks River At Dassjes Klip	Rivers	H80E	933	22/04/1967	18/06/2015
	H9h004q01 Kruis River At Aan De Kruisrivier/Swq 3-44	Rivers	H90A	496	20/08/1969	17/06/2015
	H9r001q01 Korentepoortdam 595 - Korinte-Vet Dam On Korinte River: Near Dam Wall	Dam	H90B	323	12/05/1968	18/06/2015
	H9h002q01 At The Camp On Vet River	Rivers	H90B	327	28/07/1980	19/06/2015
	H9h010q01 Korinte-Vet Dam On Korinte River: Downstream Weir On Vet	Rivers	H90B	342	25/03/1987	18/06/2015
	H9h005q01 At Farm 216 Swq 4a-11 On Goukou River	Rivers	H90C	543	10/04/1969	21/07/2015
	Soetmelksfontein 529 Near Riversdale 300m From Brak River Confluence On Goukou	Rivers	H90D	92	17/06/2008	01/07/2013
F13	J4h002q01 Gouritz River At Zeekoedrift/Die Poort	Rivers	J40C	643	05/11/1965	21/07/2015
	J4h003q01 Weyers River At Weyers River	Rivers	J40C	640	14/10/1965	17/06/2015
G14	K1R001Q01 Hartebeestkuil 213 - Hartebeestkuil Dam On Hartenbos River: Near Dam Wall	Dam	K10B	403	10/10/1971	04/08/2015
	K1H017Q01 Hartebeestkuil Dam On Hartenbos River D/S Weir	Rivers	K10B	336	08/01/1973	09/07/2015
	K1H004Q01 At Brandwacht On Brandwag River	Rivers	K10D	598	18/08/1973	04/08/2015
	Leeukloof At Low Water Bridge On Paardekop River	Rivers	K10E	230	05/03/2007	17/07/2013
	K1R002Q01 Klipheuwel Dam: Near Dam Wall	Dam	K10F	214	01/02/1995	02/06/2015
	K1H005Q01 Moordkuil River At Banff	Rivers	K10F	542	29/11/1976	04/08/2015
	K2r001q01 Jonkersberg Staatsbos - Ernest Robertson Dam On Great Brak River: Near Dam Wall	Dam	K20A	121	18/08/1973	14/08/2015

IUA	Monitoring Point Name	Type	Quat	n	First	Last
	K2r002q01 Voorburg 255 - Wolwedans Dam On Great Brak River: Near Dam Wall	Dam	K20A	297	17/06/1992	05/06/2015
	K2h002q01 At Wolwedans On Great Brak River	Rivers	K20A	980	28/08/1970	08/07/2015
	K2h006q01 At Grootbrug Wolwedans Dam On Great Brak River	Rivers	K20A	162	02/07/1997	06/08/2015
G15	K3h003q01 Maalgate River At Knoetzie Kama/Buffelsdrift	Rivers	K30A	542	01/09/1971	04/06/2015
	K3h002q01 Rooi River At George	Rivers	K30B	903	18/10/1977	06/08/2015
	K3h004q01 Malgas River At Blanco	Rivers	K30B	572	28/10/1967	06/08/2015
	K3h006q01 Rooi River At George Regional Office	Rivers	K30B	280	31/08/1987	19/01/1998
	K3h007q01 Rooi River At George Regional Office (Sharp Crest)	Rivers	K30B	373	09/01/1995	09/07/2015
	Gwayang D/S Of Stw @ Causeway On Gwaing River	Rivers	K30B	254	12/03/2007	15/07/2013
	K3r002q01 George - Garden Route Dam On Swart River: Near Dam Wall	Dam	K30C	317	29/11/1984	06/08/2015
	K3h001q01 Kaaimans River At Upper Barbiers Kraal	Rivers	K30C	587	28/06/1971	05/08/2015
	Sand Kraal 197 At Pacaltsdorp On Skaapkop River	Rivers	K30C	124	17/06/2008	15/07/2013
	Kraai Bosch 195 1km From Ballotsbaai Downstream Of Confluence On Meul River	Rivers	K30C	127	17/06/2008	15/07/2013
	K3h005q01 Touws River At Farm 162/Geo.F.12-8	Rivers	K30D	565	11/04/1969	08/07/2015
	K3h011q01 Duiwe River At Klein Krantz	Rivers	K30D	243	21/07/1998	05/08/2015
	K4h003q01 Diep River At Woodville Forest Reserve	Rivers	K40A	518	10/08/1971	04/08/2015
	K4h002q01 Karatara River At Karatara Forest Reserve	Rivers	K40C	765	15/09/1971	04/08/2015
	K4h001q01 Hoekraal River At Eastbrook	Rivers	K40D	560	18/08/1969	04/08/2015
	K5h002q01 Knysna River At Milkwood Forest Reserve/Laer Streepbos	Rivers	K50A	580	29/06/1971	11/08/2015
	Knysna WWTW Knysna Sparrebosch Golf Estate @ Irrigation Dam On Golf Estate	Dam	K50B	142	31/01/2001	11/05/2010
	Knysna WWTW Knysna @ Storage Dam At WWTW - Sparrebosch	Dam	K50B	164	13/11/2001	15/10/2015
	Eastford South At Knysna/Sedgefield Road (N2) On Sout River Mouth	Rivers	K50B	96	17/06/2008	09/09/2013
	K6h001q01 Keurbooms River At M Kama/Peters River	Rivers	K60A	453	29/06/1971	11/08/2015
	K6h002q01 At Newlands On Keurbooms River	Rivers	K60E	327	28/10/1967	05/06/2009
	K6h013q01 Piesang River (Mouth) At Plettenbergbaai	Rivers	K60G	137	05/12/1996	30/07/2013
	K7h001q01 Bloukrans River At Lottering Forest Res/Blaauwkrans	Rivers	K70B	830	28/10/1967	12/08/2015
H16	Cmnt-Bot+Palmiet-Br400c-Bot River At Karwyderskraal	Rivers	G40G	110	25/07/1995	21/11/2013
H17	Uylenkraal Kraaibos Dam 100m Upstream Of Dam Wall	Dam	G40M	188	05/11/2004	29/09/2015

The water quality status assessment has been based on the routine monitoring data collected by the Department in the past 5 years. The present day water quality status at key points for the period 2010 to 2015/16 was assessed by categorising the current water quality state using the fitness for use criteria (Table 2-18). For each sampling point the median (50^{th} percentile), 75^{th} percentile, and 95^{th} percentile statistics were calculated for nine water quality variables that are of concern to the key water user sectors in the WMA. The median statistic is representative of average water quality conditions, the 75^{th} percentile statistic means that 75 percent of the concentrations were lower or equal to the statistic, and the 95^{th} percentile represents the high concentrations observed at the sampling point.

The variables that were selected for the assessment were Electrical conductivity (Ec), Total dissolved solids (TDS), Orthophosphate (PO_4-P), Ammonia (NH_3-N), Nitrate (NO_3+NO_2-N), Chloride (Cl-), Sulphate (SO_4), Sodium adsorption ratio (SAR) and pH.

The selection of the variables was based on the following reasoning:

- Ec and TDS provides an indication of the salinity of water resources;
- Orthophosphate (PO_4-P) and Nitrate plus nitrite nitrogen (NO_3+NO_2-N) are indicators of the nutrient enrichment in water resources;
- Sulphate (SO_4) is an indicator of mining and industrial mining impacts, as well as sea water intrusion in coastal rivers;
- Chloride (Cl) in an indicator of agricultural impacts, sewage effluent discharges and industrial effluent impacts;
- Unionised ammonia (NH_3-N) is an indicator of aquatic ecosystem toxicity;
- SAR is a measure of the effects of irrigation water on soil physical conditions, and
- pH (pH units) is an indicator of acidity/alkalinity, particularly mining impacts as well as natural variability.

In the IUA description colour coded tables are used to indicate the fitness for use category of the median, and the 95^{th} percentile concentration. The full results are for each sampling points is presented in Appendix C.

2.3.3 Status quo assessment

2.3.3.1 Gouritz

The water quality of the Gouritz River is characterised by elevated salt concentrations. Water quality is generally good in the headwaters of the tributaries but salinity increases in a downstream direction due to the geology of the region, high evaporation, and agricultural impacts. Le Maitre et al. (2009) stated that much of the groundwater in the Klein Karoo was saline because the geological formations which form most of the aquifers gave rise to naturally saline groundwater combined with high evaporation rates. This high salinity made the water naturally less suitable for agricultural purposes. Natural salinity also affected the river systems draining the Great Karoo and has been increased by the return flows from the irrigated lands in the Touws, Buffels and Groot River catchments.

In the Buffalo River at Floriskraal Dam (J1H028) the salinity is “tolerable”[2] but further downstream on the Groot River at Vanwyksdorp (J1H019), it has deteriorated to an unacceptable category. In the lower Gamka River at J2H010, and the lower Olifants River at J3H011, and in the Gouritz River at J4H002, elevated Ec and TDS concentrations are regarded as mostly in an “unacceptable” category. Elevated salt concentrations were also recorded in the Duiwenhoks River (H8H001) and the Goukou River

[2] The water quality categories “Ideal”, “Acceptable”, “Tolerable” and “Unacceptable” are used to describe the water quality status. These terms are defined in DWAF (2011) and it describes the fitness for use ranging from ideal with no impacts on any water uses, to unacceptable for a quality where the water becomes unfit for most uses.

(H9H005) where the water was categorised as an "unacceptable" category. Salinity in the short coastal rivers of the K catchment is generally regarded as in an "ideal" category in the Kaaimans River (K3H001), Knysna River (K5H002) and the Bloukrans River (K7H001). In the lower reaches of the Brandwag River (K1H004) and Moordkuil River (K1H005) salinity was categorised as varying between "acceptable" and "tolerable". However, salinities in the lower reaches of the Groot-Brak River (K2H002), Maalgate River (K3H003), Swartvlei (K4R002) and Hoekraal River (K4H001) was regarded as in an "unacceptable" category. Some of the monitoring points might have been affected by saltwater intrusion from the sea (like the one in Swartvlei). Nitrogen and ammonia concentrations were regarded as in an "ideal" category in the coastal (K catchment) rivers but sulphate concentrations were "unacceptable" in the Groot-Brak River and Swartvlei, probably the result of seawater intrusion. Phosphate concentrations were regarded as "unacceptable" throughout the catchment. This could be due to the impacts of agricultural return flows and treated wastewater discharges in the catchment (DWAF, 2011).

In the Duiwenhoks River (H8H001) all the constituents exhibit an increasing trend over time except phosphates that shows a decreasing trend. However, in the Goukou River (H9H005), constituents show a slight increasing trend and phosphates slight decreasing trend. Constituents in the Touws River (J1H018) show an increasing trend except for phosphate and pH. In the Groot River (J1H019) and Olifants River (J3H011) constituents show a decreasing trend except for ammonia in the Groot and ammonia and nitrates in the Olifants River. Increases in nitrogen is generally associated with treated wastewater effluent discharges. The Gouritz River (J4H002) exhibits a slight increase in salinity but large increases in ammonia and nitrates.

A number of water quality issues have been identified in the WMA (DWAF, 2008):

- Salinity in the Great and Little Karoo - The elevated salinity found in the Gouritz River and its major tributaries occurs naturally over the inland catchments of the Great and Little Karoo as a result of the natural geology and high evaporation. This is a historical situation and one to which the ecology and the farmers have adapted. The selection of crop types by farmers has allowed them to continue financially viable farming operations, making best use of the available water for irrigation. Outside of government controlled irrigation schemes, irrigation is largely opportunistic in the inland catchments. Elevated salinities do not occur to the same extent in the coastal catchments (H8 and H9) and the K catchments. The effects include the water becoming unsuitable for irrigation agriculture, corrosion of household appliances and equipment, and alteration of the taste of drinking water.
- Urban impacts on water quality - In the developed urban areas, particularly the more densely populated coastal towns, man-made activities result in problems commonly associated with urban water use. These include discharge of water containing waste, WWTWs not meeting their required effluent water quality standards and diffuse pollution from informal settlements. The impacts include poor bacterial water quality, impacts on the health of downstream users, human health risks, low dissolved oxygen in affected rivers, and ecosystem impacts as a result of the low DO.
- Sewage and wastewater treatment systems - Concerns have been expressed about sewage and wastewater treatment systems in the WMA. In the larger urban centres such as Oudtshoorn, vandalism of the sewage reticulation and pumpstation infrastructure occasionally leads to sewage spills into the Olifants River. The industrial expansion taking place in the Oudtshoorn area would introduce additional loads on the WWTW and upgrading of the works will be necessary to avoid spills. Impacts of poor quality discharges are similar to those listed for urban impacts on water quality, i.e. high bacterial counts and risks to domestic and recreational users, and ecosystem impacts resulting from low dissolved oxygen concentrations.
- Disposal of wood processing waste - The disposal of wood processing waste is a potential problem throughout the coastal catchments (K catchment). Many saw mills operate without the necessary permits for discarding their waste. Leachate consisting of organic acids and of high COD concentration from sawdust and woodchips which is undesirable from a water quality

perspective. Woodwaste from treated wood, results in leaching of inorganic chemicals. The extent of unlawful disposal of this waste is not well known and the extent of impact on water quality has not been determined. The impacts include the discharge of leachate with high organic acids (lower pH) and COD which in turn results in low dissolved oxygen and impacts on aquatic ecosystems.

2.3.3.2 Breede-Overberg

Water quality in the headwaters of the Breede River and many of its tributaries are ideal but it becomes progressively poorer in terms of salinity in a downstream direction. The biggest increase occurs in the Middle Breede River due to intensive farming activities. Salinity measured as Ec is in an "acceptable" category in the Upper Breede near Ceres (H1H003Q01) and near Brandvlei Dam (H1H015). Further downstream at Le Chasseur (H4H017) it is still "acceptable". However, downstream of the Zanddrift canal, salinity is "unacceptable" as measured at H5H004 near Secunda, H5H005 near Drew, and H7H006 near Swellendam. Salinity in the Breede River between Brandvlei Dam and the Zanddrift canal near Ashton is managed to meet irrigation water quality requirements through freshening releases from Brandvlei Dam. Downstream of that point salinity is high and farmers can only use water during high flow conditions when there is sufficient dilution of irrigation return flows. Salinities in the lower reaches of tributaries such as the Hex River (H2H010), Nuy River (H4H020), Kogmanskloof River (H3h011), and Riviersonderend River (H6H009) were "unacceptable". The increase in salinity in the Breede River and its tributaries is the result of poor quality irrigation return flows, irrigation and farming practices, and the geology of the region (DWAF, 2002). Sulphate concentrations ranged from "ideal" in the headwaters of the Breede River to "acceptable" in the lower reaches of the river (DWAF, 2011).

Nitrogen concentrations along the Breede River remain "ideal" with little possibility of affecting crop yields.

The water quality in the Buffeljags River near Swellendam with respect to Ec within the irrigation and domestic water use requirements along the entire river reach (DWAF, 2002). The river is also moderately enriched with nutrients and moderately enriched or even eutrophic conditions could exist.

In the Overberg, water in the Palmiet River is "ideal" for all constituents except phosphates. However, in the Klein River (G4H006), upper Sout River (G5H008) and lower Sout River at De Hoopvlei (G5R001) the salinity is naturally high and classified as "unacceptable". The sulphate concentrations and pH in the entire Sout River was "unacceptable".

Elevated phosphate concentrations are a concern throughout the WMA, probably the result of runoff from intensive agricultural activities in the basin and treated effluent return flows.

The Riviersonderend River (H6H009) shows deterioration over time for all constituents. This is a particular concern as this river used to dilute the poor quality in the lower Breede River. Water quality in the lower Breede River near Swellendam (H7H006) also shows a deteriorating trend. The water quality here is poor and it is continuing to deteriorate. In the Klein River (G4H006) there is an improvement in salinity, but not for sulphate and nitrate, even though the water quality in the Klein River is "unacceptable". Salinity and sulphates also showed an improvement in the Sout River (G5H008) although phosphates and ammonia concentrations have increased. In the lower Sout River this improving trend continued but nitrates and pH appeared to have increased.

A number of water quality issues have been identified:

- Salinity in the Breede River - Salinisation of the middle and lower Breede River and its tributaries are the result of the irrigation return flows discharged to the rivers, the geology of the area, and agricultural practices. Of particular concern is the intentional leaching of natural salts where new lands are cleared and soils purposefully leached to prepare those lands for irrigation. Acceptable salinity levels in the Breede River are maintained by freshening releases out of the Greater Brandvlei Dam. Salinity is managed as far downstream as the Zanddrift Canal off-take, just upstream of the Kogmanskloof River confluence. Recommendations have been made regarding possible remedial measures such as the use of interceptor drains to limit the saline return flows entering the river. Another option is the demarcation of saline soils and the issuing of water use licences with conditions as to where new lands can be established. A more extreme (and costly) alternative is the construction of high-level canal systems to convey water directly to irrigators rather than using the river channel. Such an option would expose the river to the effects of saline return flows and place farmers and the ecosystem downstream of the Water Scheme in an even worse position. Impacts are as follows: river water unusable for irrigation users downstream of Zanddrift canal, corrosion of appliances and equipment, and possible inefficient water use.

- Nutrient enrichment in the Breede River - Concerns were expressed about the occurrence of algal blooms under low flow conditions at certain locations within the Middle Breede River as well as the clogging of canals by filamentous algae and aquatic weeds. These concerns were related to nutrient enrichment. This problem can be controlled by ensuring WWTW meet the effluent standards and by controlling fertilizer runoff from diffuse sources. Impacts are as follows: algal blooms in some reaches of Breede, excessive growth of filamentous algae in river and canals.
- Microbiological quality in the WMA - The discharge of inadequately treated wastewater effluent from WWTWs, and irrigation with untreated winery and other industrial effluent are further concerns. Most municipal WWTWs and larger industries are attempting to meet licence conditions but the cumulative effect of many smaller operators irrigating with effluent which does not meet the GA requirement, remains a concern. Diffuse pollution from poorly serviced informal settlements and the use of soak-aways on the banks of the Lower Breede River are also of concern to the microbiological quality of the Breede River and other rivers in the WMA. Impacts are as follows: affect export fruit industry, human health impacts, and recreation impacts.
- Agrochemicals in irrigation return flows - Studies in the Hex River valley have detected pesticide residues in irrigation return flows (London, 1999, London *et al*, 2000). It is probably reasonable to assume that the same patterns of pesticide contamination would occur in the rest of the Breede River Catchment where intensive irrigation agriculture is practised. Impacts are as follows: hormonal imbalances, bioaccumulation of pollutants into fish, aquatic organisms, soils, humans and up and the food chain, and carcinogenic effects.

2.4 Estuaries: ecological state status quo

2.4.1 Approach

A broad level overview of the current state of knowledge of the 26 significant estuaries within the Breede-Gouritz WMA is provided in this review. Detailed descriptions of each estuary, can be found elsewhere, e.g. ecological reserve determination (RDM) studies and situation assessment reports for estuary management plans, with the delineated significant estuaries included in Appendix D. This desktop review provides a comparative account of the different types of estuaries, the biota inhabiting them, anthropogenic impacts, the current ecological health and conservation status of the significant estuaries found within the Breede-Gouritz WMA.

Key resources used in compiling this chapter include the Estuaries of the Cape (Eds: Heydorn & Morant) series published by the CSIR and the South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component (Van Niekerk & Turpie 2012).

2.4.2 Description

There are several classifications of estuaries in terms of their physical characteristics. The geomorphological classification used by Harrison *et al.* (2000) recognises six main types based on mouth condition (open or closed), size and the presence of a bar. Whitfield's (1992) better known classification recognises five types based on size of the tidal prism, mixing process and salinity (Box 1). Of these, estuarine bays, permanently open estuaries and river mouths tend to remain open to the sea on a permanent basis, whereas estuarine lakes and temporarily open/closed systems close periodically, sometimes for periods of years. Temporally open estuaries comprise the largest group of estuaries in South Africa (222 systems, 77%), while the other groups account for a much smaller proportion (23%), (Table 2-19).

Table 2-19. Typical characteristics of the five types of estuaries defined by Whitfield (1992) and their relative prevalence in South Africa (289 estuaries) Turpie *et al.* 2012

Type	Typical size	Typical mouth condition	Number in South Africa	%	Total area (ha)	%
Bay	Large	Open	3	1%	5 118	6%
Permanently open	Med to large	Open	44	15%	17 944	20%
River mouth	Small to large	Open	11	4%	4 947	5%
Lake	Large	Closed	9	3%	56 205	62%
Temporarily open	Small to med	Closed	222	77%	6 631	7%
TOTAL			**289**		**90 844**	

Box 1. Whitfield's (1992) Physical Classification of Estuaries

Type	Tidal prism	Mixing process	Average salinity *
Estuarine Bay	Large (>10 x 10^6 m^3)	Tidal	20 - 35
Permanently Open	Moderate (1-10 x 10^6 m^3)	Tidal/riverine	10 - >35
River Mouth	Small (<1 x 10^6 m^3)	Riverine	<10
Estuarine Lake	Negligible (<0.1 x 10^6 m^3)	Wind	1 - > 35
Temporarily Open	Absent	Wind	1 - > 35

* Total amount of dissolved solids in water in parts per thousand by weight (seawater = ~35)

(a) ***Estuarine bay:*** Water area exceeds 1 200 ha. Natural bays (Knysna) and artificially formed bays (Durban Bay) are permanently linked to the sea and the salinity within them reflects this. Hypersaline conditions are not common and water temperatures are strongly influenced by the sea. Marine and estuarine organisms dominate these systems and extensive wetland/mangrove swamps occur.

(b) ***Permanently open estuaries:*** Vertical and horizontal salinity gradients are present and are modified by the river flow, tidal range and mouth condition. Wetlands (salt marshes), as well as submerged macrophyte beds are common and the fauna is predominantly marine and estuarine. Hypersaline conditions in the upper reaches can occur during times of severe drought. Water temperatures in this estuary type are controlled by the sea during normal conditions and by river input during flood conditions.

(c) ***River mouths:*** Riverine influences dominate the physical processes in these estuaries. Oligohaline conditions are often found. The mouth is generally permanently open but the tidal prism is small and strong riverine outflow prevents marine intrusion. During strong flood conditions the outflow of these mouths can influence the sea salinity for many kilometres. Heavy silt loads are frequent in these estuaries often resulting in shallow mouths (<2m). Water temperatures are strongly influenced by river inflow although the sea can influence bottom waters.

(d) ***Estuarine lakes:*** Water area exceeds 1 200 ha. These are usually drowned river valleys filled in by reworked sediments and separated from the sea by vegetated sand dune systems. The dune can result in complete separation of the lake from the sea that then results in a loss of estuarine characteristics and the system can be referred to as a coastal lake. Estuarine lakes can be either permanently or temporarily linked to the sea and salinity within them is highly variable. Freshwater input, evaporation and the magnitude of the marine connection are the main causes of this large salinity fluctuation. The tidal prism is small, and marine and river input have little influence on water temperatures, which are directly related to solar heating and radiation. Estuarine, marine and freshwater organisms all occur depending on the salinity condition of the system.

(e) ***Temporarily open estuaries:*** Sand bars often form in the mouths of these estuaries blocking off connection with the sea. Sand bars form as a result of a combination of low river flow conditions and longshore sand movement on the adjacent coast. Flooding is frequently the cause of mouth opening, which also results in large amounts of sediment removal. However, infilling from marine and fluvial sediment can be rapid. Hypersaline conditions occur in these estuaries during times of drought. Tidal and riverine inputs control the water temperature in these systems when the mouth is open, but is independent of them when the mouth is closed. Marine, estuarine and freshwater life forms are all found in these systems, depending on the state of the mouth.

Most of the significant estuaries within the Breede-Gouritz WMA have relatively small catchments and are fed by rivers that arise in the coastal mountains (Figure 2-19). These systems tend to be temporarily open, whilst six of the seven permanently open estuaries in the WMA are found between Cape Agulhas and Mossel Bay where the coastal plain is wider. The 25 significant estuaries within the Breede-Gouritz WMA include seven permanently open systems, one estuarine bay (Knysna), four estuarine lakes (Bot, Klein, Wilderness and Swartvlei), 12 temporarily closed estuaries and one river mouth (Bloukrans) (Table 2-20) (Figure 2-19 Figure 2-19).

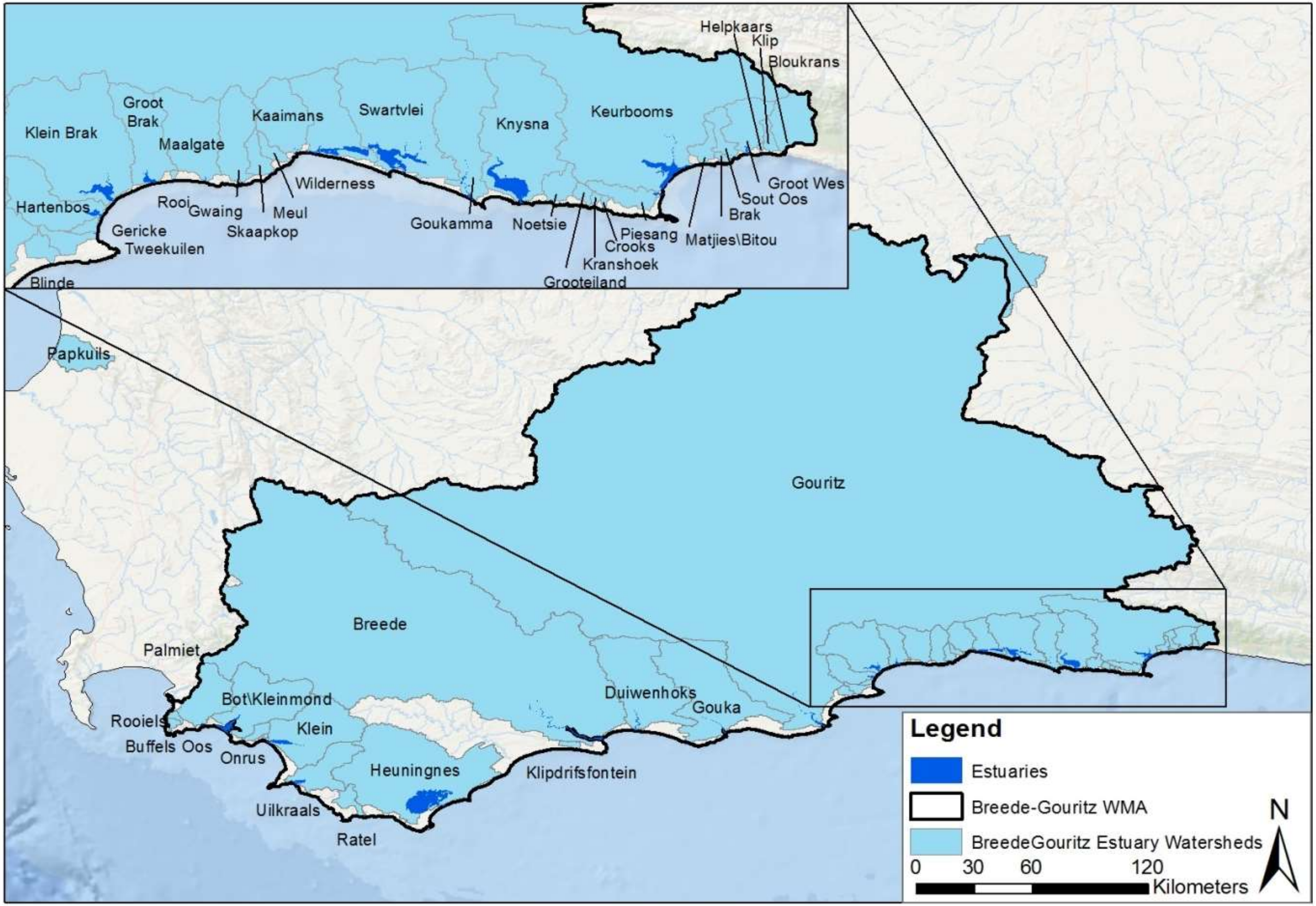


Figure 2-19. The 26 significant estuaries within the Breede-Gouritz WMA showing the catchments

Table 2-20. Catchment and estuary dimensions, mean annual runoff (MAR) and estuary type of the 25 significant estuaries within the Breede-Gouritz WMA

Estuary	Catchment size (km^2)	Present day MAR (million m^3.yr^{-1})	Estuary Functional Zone (ha)	Channel area (ha)	Type (Whitfield 1992)
Palmiet	470	177,94	28.5	26.0	Temporarily closed
Bot/Kleinmond	887	77,67	2 039.0	1229	Estuarine lake
Onrus	58	4,74	15.1	3.5	Temporarily closed
Klein	896	51,21	1 802.0	1339	Estuarine lake
Uilkraals	377	6,82	702.0	55.7	Temporarily closed
Heuningnes	3578	29,53	13 126.0	1451.5	Permanently open
Breede	12 496	1140,69	2 079.0	1147.6	Permanently open
Duiwenhoks	1207	81,62	419.0	108.3	Permanently open
Goukou	1438	89,94	372.0	122.4	Permanently open
Gouritz	45 544	397,85	1 049.0	319.0	Permanently open
Hartenbos	169	3,74	237.0	30.5	Temporarily closed
Klein Brak	556	35,54	977.0	89.4	Temporarily closed
Groot Brak	162	0,92	205.0	65.6	Temporarily closed
Maalgate	185	35,72	22.2	17.0	Temporarily closed
Gwaing	121	51,16	10.6	4.2	Temporarily closed
Kaaimans	132	26,88	20.6	9.0	Permanently open
Wilderness	173	29,01	1 092.0	501.8	Estuarine lake
Swartvlei	419	92,49	2 038.0	114.5	Estuarine lake
Goukamma	252	46,25	213.0	45.3	Temporarily closed
Knysna	419	84,32	2 284.0	1691.7	Estuarine bay
Noetsie	39	5,11	14.8	8.0	Temporarily closed
Piesang	48	6,41	59.5	4.9	Temporarily closed
Keurbooms	1123	104,20	1 523.0	398.2	Permanently open
Groot (Wes)	82	10,88	64.4	30.2	Temporarily closed
Bloukrans	88	31,38	4.2	2.3	River mouth

2.4.3 Status quo assessment

2.4.3.1 Estuarine biota

Estuarine biogeography

South African estuaries fall within three biogeographical zones: the Cool Temperate zone on the west coast, the Warm Temperate zone which extends approximately from Cape Point to the Mbashe River in the Eastern Cape, and the Subtropical Zone on the east coast (Figure 2-20). While relatively high numbers of estuaries are found in both the Warm Temperate and Subtropical zones, dry climatic conditions result in relatively few estuaries in the Cool Temperate zone on the west coast. In general, estuaries increase in density along the coast from west to east. Estuaries within the three zones have been shown to have relatively distinct faunal communities, and have also been found to differ significantly in their physico-chemical characteristics (Harrison 2004). Estuarine water temperatures follow the trend for marine coastal waters, being coldest on the west coast. Warm temperate estuaries are characterised by high salinities and low turbidities due to low rainfall and runoff, high seawater input and evaporative loss, while cool temperate, and especially subtropical, estuaries tend to have lower salinities and higher turbidity, due to relatively high runoff (Harrison 2004). The Breede-Gouritz WMA estuaries straddle the cool temperate and warm temperate zones.

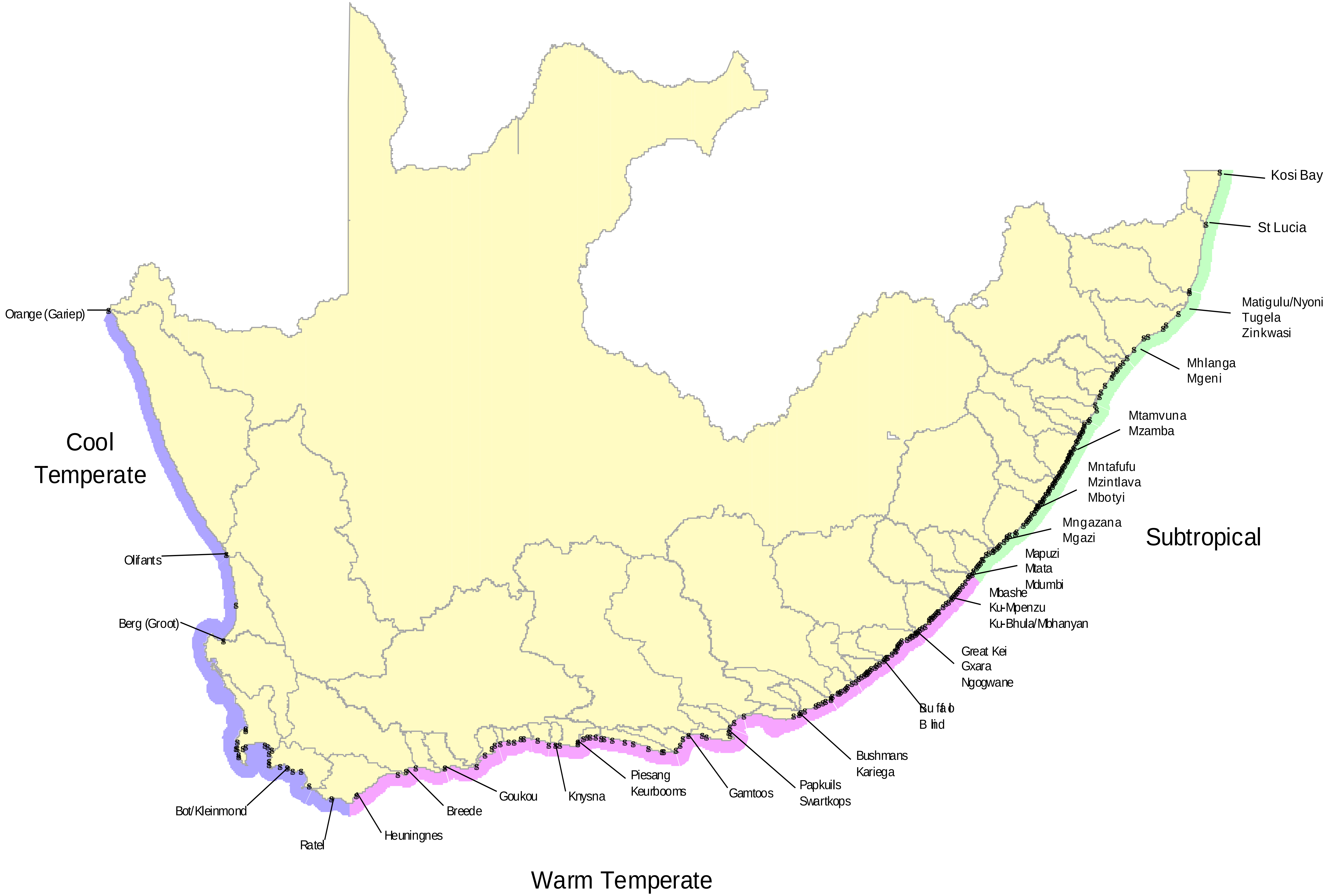


Figure 2-20. **Distribution of estuaries in relation to the three biogeographic zones and secondary catchment areas (Turpie *et al.* 2012)**

Not all estuaries are labelled on this map

Microalgae

With the other primary producers, microalgae are at the base of the food web and they are therefore of major importance to the ecological functioning of every estuary. The important microalgae groups are the micro-phytobenthos (sediment-associated microalgae), phytoplankton (water-column based) and epiphytes (attached to plants). High biomass is generally dependent on stable water and high light conditions and increases in response to nutrient inputs. Phytoplankton biomass in temporarily closed estuaries tends to be lower than in permanently open estuaries whilst the converse is true for benthic microalgae. Large changes in microalgae biomass occur in response to the alternation of open and closed mouth phases in temporarily closed estuaries. Microalgae biomass is controlled by invertebrate and fish grazing. In some temporarily open/closed estuaries, zooplankton can graze up to 70% of the available phytoplankton biomass (Kibirige & Perissinotto 2003). Microalgae distribution and abundance are influenced by a host of factors including salinity, water volume and velocity, sediment type, turbidity (light penetration), nutrient availability and biological interactions (particularly grazing) (Table 2-21).

Limited research has been conducted on microalgae within the estuaries of the Breede-Gouritz WMA. Research by Adams & Bates (1994 & 1999) in a comparative study of phytoplankton and benthic microalgae in estuarine systems in the Eastern and Western Cape sampled the Palmiet, Goukou, Gouritz, Great Brak and Keurbooms estuaries. Diatoms, flagellates, dinoflagellates, euglenoids, green and blue-green algae groups are found in the estuaries. Diatoms are probably the most responsive to changes in water quality, whilst flagellates and dinoflagellates increase in abundance when stratification and lower nutrient levels set in (Adams & Bates 1999). These studies provided evidence that nutrients, flow rates and turbidity are key drivers of microalgae in estuaries (Table 2-21). Phytoplankton biomass is low in most estuaries and this was the case for the estuaries sampled within the Breede-Gouritz WMA with Chlorophyll-a biomass ranging between 0.04 kg Chl-a (per unit estuary area) in the Gouritz, to 0.40 in the Great Brak (Adams & Bates 1999). In these systems, microbenthic biomass exceeded that of phytoplankton by several orders of magnitude and ranged from 16-62 kg Chl-a per unit estuary area (Adams & Bates 1999). This was attributed to the relatively low nutrient load of the inflowing rivers that favoured microphytobenthos over phytoplankton.

Table 2-21. Key drivers influencing the composition and abundance (and biomass) of microalgae in estuarine systems (Source: Clark *et al*. 2014)

Microalgae group	Key drivers			Other influencing factors
Benthic microalgae	Stable sediment *Strong flow (> 5 $m^3 s^{-1}$), water movement from winds or tides will result in suspension of sediment and low biomass.*	Nutrients *High biomass is associated with nutrient rich conditions often indicated by muddy organic rich sediments.*	High light conditions *Turbid waters will limit subtidal benthic microalgae biomass. However this is not a limitation in the intertidal zone.*	Grazing by zooplankton, benthic macrofauna and fish.
Phytoplankton	Water volume *No water means no phytoplankton.*	Nutrients *Biomass increases in response to available nutrients.*	High light conditions *Phytoplankton biomass is higher where irradiance is high.*	Grazing by zooplankton.
Epiphytes	Available host substrate *Submerged macrophyte and inundated emergent vegetation area available for colonization.*	Nutrients *Biomass increases in response to available nutrients.*	High light conditions *Necessary for photosynthesis and growth.*	Grazing by zooplankton, benthic macrofauna and fish.

Macrophytes

Macrophytes are important as primary producers; they produce detritus, modify the physical environment and create a variety of habitats for estuarine biota. Submerged macrophytes provide a substratum for epiphytes, which in turn provide food for invertebrate fauna and refuge for juvenile fish. The extensive reed and sedge habitats that are often associated with estuaries stabilise banks and prevent erosion. Macrophytes also play an important role in carbon sequestration, wave attenuation, shoreline protection, sediment trapping, turbidity reduction, nutrient cycling and nutrient export. Groundwater fed communities consists of reeds, sedges and grasses. Key drivers for the different macrophyte components are salinity, nutrients, sediment type, water level and velocity and grazing (Table 2-22). Major groups of macrophytes found in estuaries include macroalgae, submerged macrophytes, reeds & sedges, grass & shrubs, salt marsh (succulent), swamp forest, and floating macrophytes.

Table 2-22 Key drivers influencing the distribution and abundance (and biomass) of macrophytes in estuarine systems. (Source: Clark *et al*. 2014)

Group	Key drivers			Other influencing factors
Macroalgae	**Depth/ water level** Available habitat decreases in response to drop in water level. Light availability is affected too	**Water velocity** Optimum velocities for growth are between 0.5 and 0.8 m s^{-1}	**Nutrients** Respond rapidly to an increase in nutrients	**Salinity** Occur over a wide range of salinity 0-40
Submerged macrophytes	**Depth / water level** Occur at water depth < 1.2 m and > 0.5 m but dependent on available light, sensitive to exposure and desiccation	**Water velocity / sediment stability** Unstable sediment at > 1 m s^{-1} and no colonization	**Salinity** *Ruppia cirrhosa* (<50) *Stukenia pectinata* (<20) *Zostera capensis* (15-45)	**Turbidity and nutrients** High silt load will reduce light available to the plants. Respond rapidly to an increase in nutrients
Reeds & sedges	**Salinity** Grow best at a salinity <20	**Depth/water level** Will die if permanently inundated > 3 m	**Groundwater seepage and nutrients** Groundwater provides favourable waterlogged habitats	Shading by swamp forest can reduce growth and expansion. Strong waves can reduce cover. Grazing of new shoots as well as fire can cause damage.
Grass & shrubs	**Salinity** < 20 ideal for growth and expansion	**Water level** A water level >1.5 msl will cause die-back. Saline grasses are better adapted to submerged conditions than succulent salt marsh.	**Grazing** Grazing by mammals and aquatic herbivores	Loss of habitat due to invasive plant species.

Salt marsh (succulent)	**Salinity** Grow best in saline soils (10-35). Salt crusts prevent seedling establishment	**Water level** Inundation >3 months will kill salt marsh. Sensitive to desiccation.	**Dry sediment** Adapted to survive saline, dry soils	.
Swamp forest	**Salinity** Prefer low salinity conditions <10	**Water level** Prolonged inundation has negative effect on growth	**Water flow** Prefer flowing water to standing water	Groundwater seepage is important for maintenance of suitable conditions
Floating macrophytes	**Water velocity** Optimum velocities for growth are below 0.5 m s^{-1}	**Salinity** Restricted to areas where < 5	**Water depth** Restricted to shallow waters between 0.5 and 1.2 m	**Nutrients** Invasive aquatics respond rapidly to an increase in nutrients

Macroalgae

Macroalgae in estuaries may be intertidal or subtidal, attached or free floating. Genera such as *Enteromorpha*, *Chaetomorpha* and *Cladophora* are common mat forming algae, although they require a firm substrate for initial cell attachment and filament growth. They have wide salinity tolerance ranges and are often indicative of non-turbulent water (closed mouth conditions) and nutrient enrichment. Inorganic nutrients (especially N and P) are known to stimulate the abundance of ephemeral and epiphytic macroalgae in shallow coastal waters. *Ulva, Enteromorpha* and *Cladophora* often form accumulations due to their filamentous nature and higher nutrient uptake rates than thicker algae (Karez et al. 2004). These accumulations can reduce the water quality of estuaries, not only by depleting the oxygen in the water column upon decomposition but also causing anoxic sediment conditions when large mats rest on the sediment under low flow conditions (Sfriso et al. 1992). Decaying mats of filamentous algae have been shown to adversely impact the social acceptability of water in estuaries and are often the reason for the manipulated opening of estuary mouths (Adams et al. 1999).

During the warmer summer months large macro-algae mats form on mudflats and sandbanks of most cool and warm temperate estuaries, particularly the estuarine lakes and temporary closed systems. These macro-algae mats are generally not problematic in the Breede-Gouritz WMA estuaries and get flushed naturally, except for the few systems that receive excessive nutrients via treated effluent from waste water works e.g. Hartenbos.

Submerged macrophytes

The distribution of submerged macrophytes is controlled by water depth, turbidity and velocity, salinity, nutrients and light availability, substratum and temperature. High water clarity, low sedimentation rates and low water velocity are optimum growing conditions for submerged macrophytes. Two types of growth forms for submerged macrophytes exist: meadows and canopies. Meadows are characterized by basal meristems and biomass that is distributed equally over depth. Examples include *Zostera* and *Ruppia*. Canopies have apical meristems and their biomass is concentrated towards the canopy or surface (e.g. *Stuckenia*) (Madsen *et al.* 2001). The two forms have significantly different effects on water flow and sediments; therefore a distinction between the two is important (Madsen *et al*. 2001). A loss in substratum, refuge, the associated biota and productivity would result if there was a loss of submerged vegetation such as *Ruppia*.

Current velocity also has an effect on suspended sediments and turbidity of the water (Jha 2003). It has been shown that light is limiting to submerged macrophyte growth and turbidity is a significant factor that limits light availability. Re-suspension of sediment is caused by an increase in current velocity, which reduces the amount of light available for growth (Madsen *et al*. 2001) and prevents gas exchange (Burkholder *et al*. 2007). Macrophytes can, however, also decrease the current velocity and therefore turbidity, via sedimentation (Madsen i. 2001). Silt carried in by river flow, phytoplankton blooms and the re-suspension of sediment all cause an increase in turbidity (Boardman 2003). Reductions in submerged macrophyte biomass are expected when high turbidity conditions exist over long periods, however if plant matter remains, regrowth can take place once favourable conditions return (Boardman 2003). Conversely, a decrease in the suspended sediment concentration will increase water clarity and therefore the growth of the submerged macrophyte.

Nutrient sources for uptake by submerged macrophytes include both sedimentary and aqueous solutions (Nichols 1991). The two most important nutrients for the maintenance of growth of submerged macrophytes are nitrogen and phosphorous. Nutrient enrichment may, however, stimulate epiphyte growth and phytoplankton blooms that will shade out light, increase turbidity and compete for nutrients, which will have negative effects on the productivity of the submerged macrophytes. *Stuckenia pectinata* grows in polluted, low oxygen waters with high nitrogen and phosphorus concentrations. The ideal salinity range for the submerged macrophyte *Zostera capensis* is 10 to 46 and 0 to 55 for *Ruppia cirrhosa* (Adams and Bate 1994a, b). *Stuckenia pectinata* grows best in salinities of less than 20 (Gordon et al. 2008). *Ruppia* seeds require a short period of low salinity to germinate, therefore seasonal variation in salinity is necessary for the growth of the species (Boardman 2003). *Stuckenia* species are known to replace *Ruppia* in low salinity habitats if turbidity is high and vice versa in salinities greater than 16.

Submerged macrophyte communities occur in all the Breede-Gouritz WMA estuaries, but are particularly well developed in three of the estuarine lakes (Bot, Klein, and Swartvlei), the permanently open Keurbooms and the estuarine bay (Knysna) (Table 2-23). These macrophytes form important habits for numerous invertebrate and fish species, most notably pipe fish *Syngnathus temminckii* and the endangered Knysna sea horse *Hippocampus capensis*. Sea horses are thought to currently be found only in the Knysna, Swartvlei, and Keurbooms estuaries all in the Breede-Gouritz WMA (Czembor& Bell 2012). Historical and anecdotal records indicate that this species may previously have been present in the Klein Brak, Groot Brak, Goukamma, Groot, Kromme, Kabeljous and Gamtoos estuaries as well (Czembor& Bell 2012).

Reeds and sedges

Reeds and sedges serve as important habitats for bird, invertebrates and fish. Their distribution is dependent on a number of factors such as water depth, salinity, light availability, sediment type and nutrients (Adams & Riddin 2005). The maximum salinity concentration that reeds and sedges can tolerate is 25 psu. *Phragmites australis* is the dominant reed in South African estuaries and grows optimally from 0-15 psu (Adams and Bate 1999) and is found at freshwater seepage sites (Adams 1994, Nondoda 2012). An increase in salinity significantly decreases shoot height and overall plant growth (Adams & Riddin 2005). Waterlogged conditions are necessary for growth for these emergent macrophytes and death is predicted after one month if they do not persist. Conversely, death is also inevitable if plants are completely covered for a month or more (Adams 1994). Wave action also has an effect on growth and distribution of reeds and sedges. Their adaptations to withstand wave action include flexibility (for bending), nodes which add stabilisation, strength of the plant and the formation of dense stands (Adams & Riddin 2005).

Within the Breede-Gouritz WMA, the estuarine Lakes (Bot, Klein and Swartvlei) and the Keurbooms and Heuningnes permanently open estuaries have the majority of the reed and sedge habitats, collectively accounting for 89% of this habitat type (Table 2-23).

Salt marsh

Salt marsh plants provide numerous ecosystem services such as filtering and detoxification, nursery function for fisheries, protection from floods and sea storms and carbon sequestration (Barbier *et al*. 2011). Although it is agreed that abiotic, rather than biotic factors, are responsible for the zonation of salt marsh species, there is disagreement on the level of importance of each factor (Cooper 1982).

Therefore, the eco-physiological responses of estuarine plants are important with regards to predicting their survival and growth under different scenarios (Adams *et al.* 1999). Adams *et al*. (1999) believed that the two most important abiotic factors that determine distribution of salt marsh are inundation and salinity. As the soils of salt marshes are periodically inundated with seawater, causing waterlogging and changes in salinity, a physically stressful environment is created for the angiosperms which grow there (Pennings et al. 2005). Salt marsh plants do not survive in saline conditions over 30 and grow optimally in salinities ranging from 10-35 (Chapman 1974).

Die back of the salt marsh after three months of submergence is predicted and if the sediment dries out, the plants are only expected to survive for six months (Adams 1994). Adams *et al*. (1999) observed that dieback of *Sarcocornia natelensis* was caused by the closure of the mouth of the Great Brak Estuary, which caused inundation for more than 2 months. Reeds and sedges often take over when tidal influence stops (with mouth close) as they are more tolerable of freshwater water and longer inundation conditions (Adams & Riddin 2005).

Knysna estuary has by far the largest intertidal saltmarsh area within the WMA, holding 58% of the total (Table 2-23). Other estuaries in the study area with important intertidal saltmarsh areas include Swartvlei, Keurbooms, Duivenhoks and Goukou (Table 2-23). Most of the subtidal saltmarsh within the Breede WMA is found in three systems, the Klein (17%), Heuningnes (31%) and Klein Brak (29%) estuaries (Table 2-23).

Table 2-23. Estuarine habitat cover of the 26 significant estuaries within the Breede-Gouritz WMA all values in ha. (Source: Van Niekerk & Turpie 2012. Updated channel areas)

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Sand/mud banks	Channel	Rocks	Total
Palmiet	0.1	0.0	0.0	0.0	11.0	26.0	0.5	38
Bot/Kleinmond	0.0	92.4	32.3	373.8	152.3	1229.0	0.0	1880
Onrus	0.0	0.0	0.0	41.1	0.0	3.5	0.0	45
Klein	8.5	161.0	197.5	97.7	164.9	1339.0	5.0	1974
Uilkraals	0.0	0.0	37.7	0.0	46.0	55.7	0.0	139
Heuningnes	5.5	293.0	27.2	96.8	42.6	1451.5	0.0	1917
Breede	20.5	29.6	6.0	4.8	136.0	1147.6	0.0	1344
Duiwenhoks	50.8	0.0	0.0	0.0	79.4	108.3	0.0	238
Goukou	44.2	0.0	0.0	0.0	62.8	122.4	0.0	229
Gouritz	21.1	0.0	0.0	0.0	0.0	319.0	0.0	340
Hartenbos	2.0	13.6	0.0	0.0	9.2	30.5	0.0	55
Klein Brak	17.0	278.0	0.0	2.0	10.0	89.4	0.0	396
Groot Brak	13.0	26.6	0.0	2.5	29.9	65.6	0.0	138
Maalgate	0.0	0.0	0.0	0.0	1.0	17.0	0.0	18
Gwaing	1.6	0.0	0.0	0.1	1.8	4.2	0.3	8
Kaaimans	0.0	0.0	0.0	0.6	5.4	9.0	0.0	15
Wilderness (Touws)	6.3	7.4	4.6	11.2	2.1	501.8	0.0	533
Swartvlei	135.6	0.0	219.4	167.1	133.4	114.5	0.0	770

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Sand/mud banks	Channel	Rocks	Total
Goukamma	1.5	5.2	0.0	4.1	0.2	45.3	0.0	56
Knysna	551.0	?	65.9	38.0	265.5	1691.7	0.0	2612
Noetsie	0.0	0.0	0.1	2.7	0.0	8.0	0.0	11
Piesang	0.0	0.0	0.0	3.1	80.6	4.9	0.0	89
Keurbooms	72.2	41.8	88.7	146.3	166.3	398.2	0.0	914
Groot Wes	0.0	0.8	0.0	2.5	8.1	30.2	0.0	42
Bloukrans	0.0	0.0	0.0	0.0	0.6	2.3	0.0	3
Total	**951.0**	**949.0**	**679.0**	**994.0**	**1409.0**	**8815.0**	**6.0**	**13803**

Invertebrates

Estuarine invertebrates are abundant in productive systems and are the link between primary producers and higher trophic levels such as fish and birds. Estuarine invertebrates include those found in the water column (zooplankton), as well as those that are primarily benthic (benthos). Frequently the larvae of benthic species such as bivalves, gastropods, crabs and polychaetes, and fish are also planktonic (meroplanktonic forms) and seasonally are abundant components of the estuarine zooplankton.

Zooplankton

The zooplankton component that spends its entire cycle in the water column (holoplankton) is, under typically estuarine conditions, dominated by a few genera of copepods and mysid shrimps (Woodridge 1999). These include copepods of the genus *Pseudodiaptomus* and *Acartiella*, and mysid species belonging to the genera *Gastrosaccus, Mesopodopsis, Rhopalophthalmus* and *Tenagomysis.* Copepods tend to dominate estuarine zooplankton numerically but mysids are often more important in terms of biomass (Woodridge 1999). Temperature, salinity, seasonality, mouth state, water depth, resident time and predation are all important drivers of estuarine zooplankton (Woodridge 1999). Copepods tend to be most abundant in the middle and upper estuarine areas where mesohaline conditions exist and abundance is positively linked to freshwater pulses. Zooplankton biomass tends to be higher in estuaries with pronounced axial salinity gradients and estuarine zooplankton are therefore are expected to be more abundant in permanently open systems and positively related to river flow (Woodridge 1999). Studies recording the diversity and occasionally abundance of zooplankton in the Breede-Gouritz WMA estuaries are scarce but include those conducted on the Groot (Grindley unpublished, cited in Morant & Bickerton 1983), Keurbooms and Piesang (Grindley unpublished, cited in Duvenage & Morant 1984), Knysna (Day 1967, Grindley 1985), Swartvlei (Gridley & Wooldridge 1973), Great Brak (Grindley unpublished, cited in Morant 1983), Heuningnes (Grindley unpublished, cited in Bickerton 1984) Bot (Coetzee 1985) and the work of Grindley (1980) on the Gouritz, Goukou, Duiwenhoks Bree and Klein systems (Table 2-24).

Table 2-24. Zooplankton diversity and biomass recorded in five of the significant estuaries within the Breede-Gouritz WMA (Source: Carter 1983)

Estuary	Number of taxa	Biomass mg DW.m^{-3}
Gouritz	17	13.81
Goukou	19	51.88
Duiwenhoks	12	9.98
Breede	22	4.56
Klein	27	22.4

Macrobenthos

Most studies on estuarine invertebrates have focused on the study of macrobenthos, which are invertebrates greater than 0.5 mm or 1 mm. Quantitative studies of estuarine macrobenthic communities are relatively scarce on a national level, with De Villiers *et al.* (1999) reporting that such surveys have only been undertaken on 38 individual systems (13% of 289 estuaries). The macrobenthic fauna of warm temperate estuaries has been relatively well studied compared to that of the subtropical region, and studies have been undertaken on at least 11 of the 26 significant estuaries within the Breede-Gouritz WMA (Table 2-25). The very large range of invertebrate diversity is partly related to geographical area and individual estuary characteristics, but also reflects variation in sampling effort and methodology between the systems. Knysna estuary for example probably does have the highest invertebrate diversity in the region (attributable to its permanently open status, large size and diversity of habitats), but the species count provided includes taxa that are generally too small (meiofauna) to be recorded in macrofaunal surveys that have been undertaken in some of the other systems.

The permanently open estuaries of the Breede-Gouritz WMA tend to have greater species richness than those that are often closed (Table 2-25). Many invertebrate species found in estuaries may have obligate marine larval phases and this explains the relatively low diversity of benthic invertebrate taxa in temporarily open systems (De Villiers *et al.* 1999). Permanently open estuaries that have a high freshwater input also tend to have low invertebrate diversity (e.g. the Groot Wes). Polychaetes and gastropods tend to dominate benthic invertebrate biota in the cool temperate, western part of the WMA, whilst filter feeding and deposit feeding crustaceans comprise the greatest proportion of invertebrate biomass in the warm temperate estuaries (De Villiers *et al*. 1999). These include the sandprawns *Callichirus kraussi* and mud prawns *Upogebia africana* both of which are collected by anglers for bait, and form an important component of the diet of some estuarine associated fish such as spotted grunter and white steenbras. In temporarily open estuaries and in sandy substrata *C. kraussi* is the dominant prawn, partly as larval development is abbreviated and can be completed within the estuary (De Villiers et al 1999). The burrowing activities of the sand prawn have led to the species been referred to as an ecosystem engineer and it has a significant influence on organic turnover with estuaries. Other common crustacean species include brachyuran crabs such as *Hymenosoma orbiculare* that are particularly abundant amongst submerged seagrass beds. Filter feeding bivalves e.g. *Arcuatula capensis* and *Solen capensis* can also attain high densities in warm temperate estuaries estuary (De Villiers et al 1999).

Table 2-25. Invertebrate species diversity in 10 estuaries within the Breede-Gouritz WMA (Source: De Villiers et al 1999)

Estuary	Number of species	Reference
Bot/Kleinmond	25	De Decker & Bailey (1985)
Klein	45	Scott *et al*. (1952)
Uilkraals	15	DWS (2012)
Heuningnes	18	Day (1981)
Breede	149	Carter (1983)
Groot Brak	90	Day (1981)
Swartvlei	44	Whitfield (1989)
Knysna	310	Day (1981)
Piesang	20	Hutchings & Clark (2012)
Keurbooms	42	Duvenhage & Morant (1984)
Groot Wes	10	Morant & Bickerton (1983)

Fish

The warm, productive and sheltered habitats found in estuaries comprise important breeding, nursery and feeding grounds for a large numbers of coastal fish species. Whitfield (1994, 1998) has classified fish species occurring in estuaries based on their origins and life cycle linkages to estuaries. He recognized five major categories of estuary associated fish species and several subcategories (Table 2-26). Category Ia, IIa and V fish species are either entirely, or mostly dependent on estuaries for critical life history phases.

Table 2-26. Estuarine dependence categories for fish (Whitfield 1998)

I.	Estuarine residents: Ia: Resident species not recorded spawning in marine or freshwater environment Ib: Resident species also having marine and/or freshwater breeding populations
II.	Euryhaline marine species usually breeding at sea with juveniles showing varying degrees of dependence on estuaries, further divided into: IIa Juveniles dependent on estuaries as nursery areas IIb Juveniles occurring mainly in estuaries, but also found at sea IIc Juveniles occur mainly at sea, but also found in estuaries
III.	Marine species that occur in estuaries in small numbers but are not dependent on estuaries
IV.	Euryhaline freshwater species whose penetration into estuaries is determined primarily by salinity tolerance. Includes some species which may breed in both freshwater and estuaries
V.	Catadromous species which use estuaries as transit routes between the marine and freshwater environments but may also occupy estuaries in certain regions, further divided into: Va Obligate catadromous species which require a freshwater phase in their development Vb Facultative catadromous species which do not require a freshwater phase in their development but use estuaries as nursery areas

Studies on the ichthyofauna in the estuaries within the Breede- Gouritz WMA date back to the work of Smith (1949) and Day (1981). More comprehensive studies on individual systems include the work on the Bot/Kleinmond and Palmiet systems (Bennett 1985, 1989, Bennett et al 1989), Whitfield's (1982, 1983) research on Swartvlei and Lamberth et al's (2008) work on the Breede. Fish surveys on many of the systems, within the Breede area (including the Bot/Klein, Onrus, Heuningness, Duiwenhoks, Gouritz, Goukou, Malgate, Klein Brak, Groot Brak, Kaaimans, Piesang and Groot W) have been undertaken since the late 1990s (Turpie & Clark 2007).

The estuaries of the Breede-Gouritz WMA have been subjected to a large range of icthyofaunal sampling intensity, from once-off surveys to seasonal sampling over several years. The variation on sampling effort means that the results of these surveys are not easily comparable as species diversity is directly related to sampling effort and species accumulation curves only level off (if at all due to the increased probability of encountering novel marine vagrants over time) after approximately 70 hauls (Turpie & Clark 2007). For example, an overall total of 59 fish species from 30 families has been recorded from the Breede Estuary, but individual surveys have recorded much lower diversity (Day 1981, Ratte 1982, Carter 1983, Coetzee and Pool 1991, Harrison 1999, Hutchings and Lamberth 2002a, 2002b, Lamberth et al 2008). The Harrison (1999) fish surveys produced what is arguably the most useful dataset for comparisons between systems in that his methodology was consistent and sampling effort was scaled according to the size of the estuary. The Harrison (1999) data set was therefore used to compare the relative importance of the different significant estuaries within the Breede-Gouritz WMA in terms of fish habitat (Table 2-27).

A total of 39 fish species were recorded by Harrison (1999) in the estuaries of the Breede-Gouritz WMA. The permanently open Knysna (30), Keurbooms (23) and Breede (21) estuaries had the most diverse icthyofauna, whilst two of the large estuarine lakes, Swartvlei (20) and Wilderness (17) also had comparatively diverse fish communities (Table 2-27). These data concur with the well-established biogeographical trend of decreasing diversity as one moves west along the South African coast (Turpie *et al*. 1999). Permanently open systems also tend to have higher diversity than temporarily closed estuaries as stenohaline marine migrants (category III species) are often found in the lower reaches where salinities approximate seawater. The total number of fish estimated in each estuary was directly related to estuary size (Table 2-27). The two large estuarine lakes in the west of the catchment (the Klein & Bot) had the highest total abundance, following the biogeographical pattern of low diversity, high abundance in the cool temperate region (Table 2-27). Based on the Harrison (1999) data, the Bot, Klein, Knysna, Swartvlei, Goukamma, Breede, Keurbooms and Piesang estuaries contained an estimated 95% of the fish in the Breed-Gouritz WMA. Estuaries containing a high number of estuarine dependent species (Categories Ia, IIa and V) include the, Klein, Heuningnes, Goukou, Gouritz, Swartvlei, Goukamma, Knysna, Noetzie, Piesang and Keurbooms the Klein estuaries (Table 2-28).

The Breede-Gouritz WMA estuaries comprise nursery or feeding habitat for two endangered fishes (Knysna sea horse *Hippocampus capensis* and white steenbras *Lithognathus lithognathus*) as well as several important fishery species (Table 2-27). The populations of three estuarine dependent fishery species, white steenbras, Leervis *Lichia amia* and dusky kob *Argyrosomus japonicas* are collapsed, whilst the iconic estuarine angling species spotted grunter *Pomadasys commersonnii* is considered overexploited (Mann 2013). The Breede estuary was recently identified as an important habitat for Zambezi (bull) sharks *Carcharhinus leucas* (Mc Cord & Lamberth 2009, Van Niekerk & Turpie 2012). The 2011 NSBA identified 13 of the 26 estuaries within the Breede-Gouritz WMA as very important fish nurseries (Van Niekerk & Turpie 2012).

Table 2-27. Estimated total number, number of species and percentage of the Breede-Gouritz WMA population of fish found in 23 of the 26 significant estuaries. EDC = estuarine dependence category after Whitfield (1998). Fish data from Harrison (1999). Species of fisheries importance are in bold font.*: Estuaries ranked as very important fish nurseries by Van Niekerk & Turpie (2012)

Species/Estuary	EDC	Palmiet	Bot/Kleinmond	Onrus	Klein	Uilkraals	Heuningnes	Breede	Duiwenhoks	Goukou	Gouritz	Hartenbos	Klein Brak	Groot Brak	Maalgate	Kaaimans	WildernessTouw	Swartvlei	Goukamma	Knysna	Noetsie	Piesang	Keurbooms	Groot (W)	Total Number
		Percentage of estimated total number found in 23 significant estuaries within the Breede-Gouritz WMA																							
Hippocampus capensis	IA																			100.0					13 592
Gilchristella aestuaria	IA			0.0	0.2		4.0	0.3	0.6	0.6	2.5	1.1	0.1	1.6	3.0		0.0	0.7	22.1	51.7	0.0	11.5		0.0	4 591 555
Atherina breviceps	IB				88.5	0.1	0.04		0.4	0.1		0.1					0.0	5.0	0.0	5.8			0.0		43 958 541
Caffrogobius gilchristi	IB				14.0		1.3	20.2	0.3	0.9	7.3		5.1	0.5		0.0	0.5	36.7	3.6	6.4		3.0	0.4		1059 557
Caffrogobius natalensis	IB							9.6	1.0				3.3						0.7	84.5		0.3	0.6		252 077
Caffrogobius nudiceps	IB							74.7	1.3											21.6			2.4		62 998
Clinus superciliosus	IB		0.7		43.5								0.1					50.2		4.6			1.0		793 583
Glossogobius callidus	IB		100																						4 149 348
Psammogobius knysnaensis	IB	0.6		0.6	32.2	0.3	2.0	5.2	0.6	0.7	2.2	0.2	1.5	0.3	0.5	0.1	0.8	20.7	8.1	19.6	0.0	1.0	2.3	0.3	1041 953
Syngnathus termminckii	IB		13.2		58.6			0.2	0.4								0.0	12.0		15.4			0.3		707 490
Mugillogobius merteni	IB		100																						93 059
Argyrosomus japonicus	IIA						1.5	21.6	8.0	7.0	7.1		4.3	1.0					17.1	10.7		5.5	16.1		42 195
Lithognathus lithognathus	IIA						0.2	0.9	0.3	0.3		0.6	2.2	4.3		0.2	0.3	4.6	61.9	20.5	0.1	0.5	2.2	0.7	639 442
Pomadasys commersonnii	IIA							6.2		0.4	2.2	0.9	3.8	0.8			0.1	11.5	3.2	69.1		1.4	0.4		170 501
Rhabdosargus holubi	IIA				0.3		0.1	0.3		0.9	0.2		2.2	1.1	0.0	0.0	0.6	16.9	11.3	44.8	0.0	1.3	19.9	0.0	3621 256
Elops machnata	IIA							13.4												79.9			6.7		11 336
Lichia amia	IIA							4.3	4.7		2.1		7.7	3.7			0.7	9.1		63.4			4.2		35 704
Monodactylus falciformis	IIA							5.3	13.3	10.3					0.3	0.2	0.4	39.8		15.8		9.4	5.3		57 352
Mugil cephalus	IIA	0.2		2.1	19.7	0.1	0.6	2.5		20.1	0.1	0.4	0.5	1.7	5.0	0.3	0.6	0.5	14.7	12.8	6.9	7.6	3.4		600 669
Galeichthys feliceps	IIB	0.1			58.0			17.1	5.0	1.8	9.2		1.3	1.9	0.1	0.5		3.2	0.9			0.4	0.4		203 908

Species/Estuary	EDC	Palmiet	Bot/Kleinmond	Onrus	Klein	Uilkraals	Heuningnes	Breede	Duiwenhoks	Goukou	Gouritz	Hartenbos	Klein Brak	Groot Brak	Maalgate	Kaaimans	WildernessTouw	Swartvlei	Goukamma	Knysna	Noetsie	Piesang	Keurbooms	Groot (W)	Total Number
Liza dumerilii	IIB						1.2	18.9	0.5	0.4	14.9	0.5	2.4	9.6	0.1		1.5	1.0	0.3	33.6		14.3	0.8		674 085
Liza tricuspidens	IIB		91				0.1	0.6	1.9	0.0	0.5			0.0			0.2	3.3		1.2		0.4	0.4		1889 383
Heteromycteris capensis	IIB						3.9	36.9			18.3				0.5	5.7	6.1		10.9			7.0	9.2	1.6	32 900
Solea bleekeri	IIB							73.6			22.3		1.8		0.1	0.1	0.2		1.8						100 998
Diplodus capensis	IIC									0.5								25.2		57.9			16.5		869 045
Pomatomus saltatrix	IIC				52.6								4.9							24.1		16.4		2.1	18 768
Rhabdosargus globiceps	IIC						0.6													95.9		1.2	2.3		198 417
Liza richardsonii	IIC	3.7		2.6	21.0	7.3	6.0	8.1	4.6	4.6	1.2	0.4	0.1	2.3	0.0	0.0	0.7	11.2	2.9	18.6	0.1	2.5	2.1	0.1	6709 665
Sarpa salpa	IIC									0.6								67.1		32.4					2534 426
Hemiramphus far	IIC																			100					126 862
Lithognathus mormyrus	III																			100					9 062
Diplodus hottentotus	III												5.5					39.6		54.9					8 252
Pomadasys olivaceum	III							100																	6 070
Amblyrhynchotes honckenii	III								1.8											98.2					46 154
Chaetodon marleyi	III																			100					4 531
Dasyatis kuhlii	III		100																						38 319
Awaous aeneofuscus	IV		100																						19 992 956
Pseudocrenilabrus philander	IV		100																						21 4941
Myxus capensis	VB			0.2							1.0	0.4	0.6	11.9			0.3	2.1	10.4	37.8	33.3	0.5	1.5		155 726
Total		0.3	27.5	0.2	43.7	0.6	0.7	1.3	0.6	0.6	0.5	0.1	0.2	0.4	0.2	0.0	0.1	7.1	2.4	11.3	0.1	1.0	1.2	0.0	95 736 674
Number species		4	8	5	11	4	13	21	16	16	15	9	18	14	10	10	17	20	16	30	7	18	23	7	39

Table 2-28. Relative proportion (%) of fish by Estuarine Dependence Category (EDC) found in 23 of the 26 significant estuaries within the Breede-Gouritz WMA

Estuary/EDC	IA	IB	IIA	IIB	IIC	III	IV	VB
Palmiet		0.01	0.03	0.01	2.35			
Bot/Kleinmond		8.33		59.47		34.10	100.00	
Onrus	0.04	0.01	0.24		1.69			0.22
Klein	0.21	77.00	2.48	4.08	13.58			
Uilkraals		0.13	0.02		4.66			
Heuningnes	3.97	0.07	0.21	0.40	3.88			
Breede	0.30	0.66	1.11	8.94	5.18	5.40		
Duiwenhoks	0.55	0.38	0.28	1.69	2.92	0.75		
Goukou	0.58	0.08	3.20	0.25	3.13			
Gouritz	2.53	0.19	0.29	5.43	0.75			0.96
Hartenbos	1.10	0.09	0.16	0.11	0.25			0.43
Klein Brak	0.12	0.15	2.09	0.72	0.10	0.41		0.59
Groot Brak	1.59	0.02	1.59	2.39	1.45			11.85
Maalgate	3.00	0.01	0.59	0.03	0.01			
Kaaimans		0.00	0.07	0.10	0.00			
WildernessTouw	0.01	0.03	0.54	0.57	0.42			0.32
Swartvlei	0.71	6.31	13.30	2.59	25.56	2.90		2.10
Goukamma	22.01	0.24	17.52	0.31	1.88			10.40
Knysna	51.85	6.11	38.50	8.59	27.69	56.44		37.82
Noetsie	0.03	0.00	0.82		0.04			33.35
Piesang	11.42	0.08	2.06	3.71	1.65			0.49
Keurbooms		0.09	14.83	0.57	2.76			1.46
Groot (W)	0.00	0.01	0.09	0.02	0.04			
Total	100	100	100	100	100	100	100	100

Birds

Very few data were collected on South Africa's estuarine birds before the 1970s. In the summers of 1979-81, a count was undertaken of all estuaries and lagoons of the entire South African coast apart from the former Ciskei and Transkei coasts (Ryan & Cooper 1985, Ryan et al. 1986, Underhill & Cooper 1984). The gaps were filled in later counts (Turpie 2004, Turpie *et al.* 2014). Although a complete count has never been repeated, an increasing number of estuaries has been monitored since the 1990s through the Co-ordinated Waterbird Counts (CWAC) programme managed by the Avian Demography Unit at the University of Cape Town. In addition, Ryan (2012) partially repeated the coastal count in the Western Cape.

The 1979-81 counts, augmented by counts from other studies where they existed, were used by Turpie (1995) in an analysis of the importance of estuaries for waterfowl, and subsequently in the computation of the conservation importance of estuaries (Turpie et al. 2002). Turpie & Clark (2007) collated all available CWAC data on temperate estuaries for a conservation plan for temperate South African estuaries as part of the CAPE Project. Turpie *et al*. (2012) updated these data and added additional estuaries in their national-scale estuary conservation plan for the country as part of the National Biodiversity Assessment. There are still many estuaries for which there are no recent data or no data at all.

Based on available data, some 81 species have been recorded in the estuaries of the Breede-Gouritz WMA, representing most species recorded in temperate South African estuaries. The number of bird species and individuals found in individual systems varies greatly, and is determined primarily by the size and physical habitat diversity of the systems, which in turn influence food availability, foraging, resting and breeding opportunities for birds.

Bird communities in South Africa's temperate estuaries suggest four main groupings for birds (Figure 2-21; Turpie & Clark 2007). Type A estuaries are large open systems that support diverse waterbird communities and are characterised by high numbers of waders. Type B estuaries are systems that have restricted or closed mouths, frequently have brackish lake characteristics, and support large waterfowl communities. Some systems (A/B) can have a mixture of these characteristics. Type C are typically medium to large sandy estuaries, often support gull and tern roosts, but have relatively low overall diversity. Type D systems are depauperate and are generally small and nutrient poor.

However, it is also important to distinguish between subset communities and distinct communities. In effect, types A and B are relatively distinct, whereas types C and D support subsets of the communities found in type A (Figure 2-22). This suggests that for birds it would be best to concentrate conservation efforts on type A and B systems. Furthermore, since type B communities are likely to bear some resemblance to freshwater wetland systems, the main effort should be on type A systems. Thus, Whitfield's (2002) estuary typology, though widely used, does not necessarily make sense as an ecosystem typology from a biodiversity perspective. Neither fish nor bird communities group according to this classification (Turpie & Clark 2007).

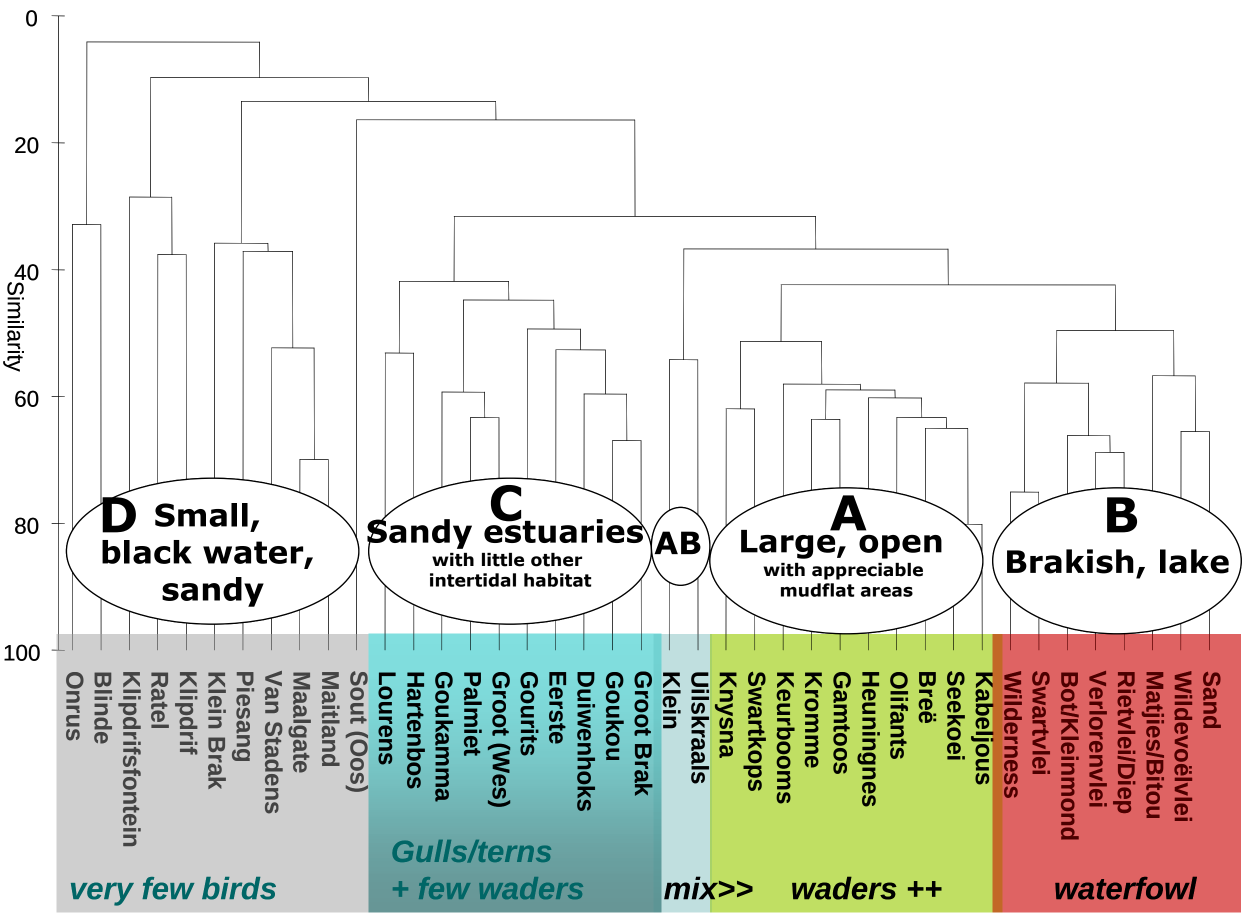


Figure 2-21. Cluster diagram showing groupings of estuaries on the basis of bird community structure (Source: Turpie & Clark 2007)

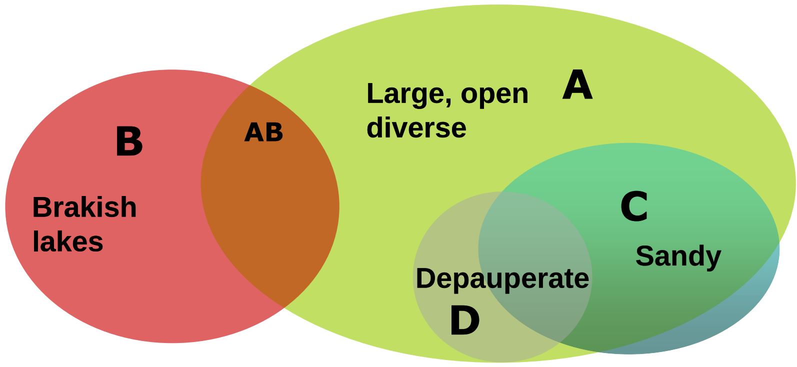


Figure 2-22. Schematic of the overlap between bird communities of the different estuary types (Source: Turpie & Clark 2007)

Terns and coots are the most numerous group on the estuaries of this WMA (Table 2-19). Several estuaries support very large tern roosts, while Redknobbed Coots favour the freshwater conditions and associated macrophyte productivity offered by the large estuarine lakes which are a prominent feature of this region compared with most other parts of the South African coast. Ducks make up the next most dominant group, which is also consistent with the prevalence of freshwater habitat in this region. Waders are the next most numerous, though they tend to favour quite different, strongly tidal estuaries, where there are large shallow intertidal areas.

The community composition of the estuaries in the Breede-Gouritz WMA is compared in Table 2-29. Data are missing for several of the smallest estuaries. Nevertheless, small systems such as these tend to support very few birds. Indeed, 20 of the area's 41 estuaries each have fewer than 1% of the region's waterbirds. The Klein estuary has historically supported the highest proportion of the region's birds, followed by the Bot/Kleinmond system, Uilkraals, Wilderness, Swartvlei and Knysna estuaries. A similar pattern is found if just estuary-dependent species are taken into consideration (see Turpie *et al.* 2012), but with Klein, Uilkraals and Knysna being most important.

Table 2-29. Percentage distribution of estuarine waterbirds, by group, among the estuaries of the Breede-Gouritz WMA. Total number of birds in each group is given in the last column

	Grebes	Pelicans	Cormorants	Darters	Herons & egrets	Ibis & spoonbill	Flamingos	Ducks	Birds of prey	Skulking rallids	Coots	Waders	Gulls	Terns	Kingfishers	Wagtails	All
WMA Total	700	6	1 336	79	783	108	398	5 927	45	83	12 477	8 613	2 214	12 774	120	162	45 826
Palmiet	-	-	3	-	-	-	-	< 1	-	-	-	< 1	1	-	-	-	< 1
Bot/Kleinmond	18	100	23	43	9	15	94	19	32	6	18	12	17	5	21	29	14
Onrus	-	-	-	-	-	-	-	-	-	-	< 1	< 1	< 1	-	-	1	< 1
Klein	5	-	3	1	8	45	3	18	4	-	22	14	6	36	17	19	22
Uilkraals	-	-	< 1	-	2	-	-	< 1	2	-	-	4	8	44	5	2	14
Heuningnes	-	-	3	-	< 1	< 1	< 1	-	1	-	-	6	1	5	1	1	3
Klipdrifsfontein	< 1	-	-	-	-	-	-	-	-	-	-	< 1	-	-	-	2	< 1
Breede	< 1	-	2	3	3	1	-	3	3	1	< 1	5	6	< 1	4	5	2
Duiwenhoks	-	-	1	2	1	-	-	1	-	-	-	< 1	2	2	4	1	1

	Grebes	Pelicans	Cormorants	Darters	Herons & egrets	Ibis & spoonbill	Flamingos	Ducks	Birds of prey	Skulking rallids	Coots	Waders	Gulls	Terns	Kingfishers	Wagtails	All
Goukou	< 1	-	2	1	5	-	-	< 1	1	-	< 1	1	2	< 1	1	4	1
Gouritz	-	-	1	-	1	-	-	2	4	-	-	2	6	< 1	3	1	1
Blinde	-	-	-	-	-	-	-	< 1	-	-	< 1	< 1	-	-	-	2	< 1
Hartenbos	-	-	3	8	4	-	-	< 1	2	-	< 1	< 1	5	2	2	1	1
Klein Brak	-	-	1	1	1	-	-	< 1	-	-	-	< 1	1	< 1	-	-	< 1
Groot Brak	-	-	1	1	9	-	-	1	1	-	< 1	< 1	2	< 1	2	6	1
Maalgate	-	-	< 1	-	-	-	-	< 1	-	-	-	< 1	5	-	-	-	< 1
Gwaing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kaaimans	-	-	-	-	-	-	-	-	-	-	-	-	< 1	-	1	-	<1
Touw	53	-	11	9	7	28	2	30	16	74	25	2	1	< 1	9	3	13
Swartvlei	21	-	15	28	17	7	< 1	16	15	11	34	3	1	< 1	4	2	13
Goukamma	-	-	2	-	< 1	-	-	< 1	2	-	-	< 1	3	< 1	1	< 1	< 1
Knysna	< 1	-	15	1	16	3	-	7	7	3	< 1	42	15	2	12	10	11
Noetsie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piesang	-	-	-	-	< 1	-	-	-	-	-	-	< 1	1	-	1	-	< 1
Keurbooms	< 1	-	7	2	4	-	-	< 1	3	-	-	6	14	2	3	2	3
Groot (W)	-	-	2	-	< 1	-	-	< 1	1	-	-	< 1	2	< 1	2	< 1	< 1
Bloukrans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Most recent assessments of birds in the study area suggest that estuarine waterbird numbers have declined significantly over the past three decades. Ryan (2012) found that while certain larger species had increased in number, including Egyptian Goose and three species of ibises, most small birds had decreased in abundance, apart from African Black Oystercatcher. These included both resident and migratory waders. Numbers of the four most abundant migrant waders had decreased by more than 50% and in two cases over 90%. These are likely attributed to external conservation issues such as hunting and loss of breeding areas in the northern hemisphere. However, declines in the numbers of resident waders suggest that local level disturbance also plays a role. This has been shown to be the case in Knysna estuary, where human disturbance reduces bird numbers by up to 40% during peak holiday season (Love & Turpie 2005). The impacts associated with changes in the quality and quantity of freshwater inflows have also played a significant role in determining the present ecological status of bird communities on estuaries (DWS 2012, DWS 2015 a, b).

2.4.3.2 Conservation importance and levels of protection

The 2011 NBA included the National Estuary Biodiversity Plan which identifies which South African estuaries require full or partial protection. This plan represented a significant milestone in that it is the first biodiversity planning study to include all the estuaries of South Africa. Nearly 300 estuaries from the Cool Temperate, Warm Temperate and Subtropical regions were included. The overall goals of the core Estuarine Protected Area network to be developed here were as follows (Turpie & Clark 2007):

- Representativeness: all estuary-dependent species should be represented in viable numbers in the protected areas network;
- Maintenance of ecological processes: the protected area network should allow for connectivity and interaction with other adjoining ecosystems;

- Maintenance of fishery stocks: the protected area network should provide enough protection to exploited species that they are able to act as source areas for surrounding exploited areas; and
- Feasibility of implementation: consideration should be given to the practicalities of protection in each estuary. This was taken into account through decisions about whether the estuary was able to achieve full or partial protection and by favouring, where possible, healthier estuaries that offer a lower rehabilitation and opportunity cost of protection.

The estuaries within the Breede-Gouritz WMA identified by this exercise as requiring full or partial protection are shown in Table 2-30. A number of these estuaries within the WMA already have some protection falling within provincial (Cape Nature) or National (SANParks) reserves. Protection of living marine/estuarine resources is, however, limited, with only two estuaries having some no-take marine protected area (MPA) status (Table 2-30). The NSBA ranked 13 estuaries within the WMA as very important fish nurseries, of these, only the Goukou has some no-take MPA protection.

Table 2-30. Estuaries within the Breede-Gouritz WMA that were identified as requiring partial or full protection as well as the current protection status by the NSBA 2011 (Van Niekerk & Turpie 2012)

Estuary	Recommended extent of protection	Recommended degree of undeveloped margin	Current degree of protection
Palmiet	Full	50%	None
Bot / Kleinmond	Partial	50%	None
Klein	Partial	50%	None
Uilkraals	Partial	75%	None
Heuningnes	Full	75%	Lower estuary is within Cape Nature Reserve. Not MPA.
Goukou	Partial	50%	Lower estuary is within Cape Nature Reserve. Part is a no-take MPA
Gouritz	Partial	50%	None
Kaaimans	Full	50%	None
Wilderness (Touws)	Partial	50%	Part of the estuary falls within the Wilderness Lakes National Park.
Swartvlei	Partial	50%	Part of the estuary falls within the Wilderness Lakes National Park.
Goukamma	Full	75%	Lower estuary is within Cape Nature Reserve. Partial MPA protection (angling is allowed).
Knysna	Partial	50%	Part of the estuary falls within the Knysna National Park. Not MPA.
Piesang	Partial	50%	None
Keurbooms	Partial	50%	Part of the estuary falls within the Keurbooms Nature

Estuary	Recommended extent of protection	Recommended degree of undeveloped margin	Current degree of protection
			reserve (Cape Nature). Not MPA.
Groot (Wes)	Full	75%	Entire estuary falls within the Tsitsikamma National Park. Not MPA.
Bloukrans	Full	100%	Entire estuary falls within the Tsitsikamma National Park. No take MPA.

2.4.3.3 Impacts on estuaries

Changes in catchment land use/cover

In general, the rivers that feed estuaries within the Breede-Gouritz WMA have catchments in which at least half of the total catchment area is untransformed as indigenous vegetation, natural vegetation, waterbodies or wetlands (Table 2-31). Much of the remaining land area in the catchments that is not untransformed is either cultivated lands (mostly in the west of the WMA) or commercial forestry (particularly in the Garden Route area) (Table 2-31). Urban development of estuary catchments is low throughout the region, the exceptions been Piesang, Gwaing, Knysna and Onrus systems (Table 2-31). Despite low levels of urban development as a proportion catchment size, however, where there is urban development it is almost always concentrated on the coast, and surrounds, or in many case extends into the estuary functional zones.

Table 2-31. Habitat types and developments in the catchments of the 26 significant estuaries within the Breede-Gouritz WMA

Catchment Description	Commercial Forestry (%)	Cultivated land (%)	Indigenous vegetation (%)	Mines (%)	Natural Vegetation\ Forest (%)	Urban (%)	Waterbodies (%)	Wetlands (%)
Palmiet	6.8	17.0	50.8	0.0	21.0	1.0	2.1	1.1
Bot\Kleinmond	1.3	39.4	45.9	0.0	9.9	0.9	1.4	1.2
Onrus	0.9	17.0	52.2	0.0	22.0	3.7	1.1	3.1
Klein	0.6	40.7	38.4	0.0	17.5	0.2	1.1	1.5
Uilkraals	0.0	14.6	54.1	0.0	27.4	0.0	0.4	3.7
Heuningnes	0.6	48.9	40.2	0.0	7.6	0.2	0.8	1.9
Breede	0.4	30.7	48.8	0.0	16.1	0.5	1.3	1.7
Duiwenhoks	0.5	43.4	31.8	0.0	21.8	0.2	0.2	1.9
Gouka	1.8	27.0	38.9	0.0	30.0	0.6	0.2	1.4
Gouritz	0.0	3.6	47.5	0.0	46.9	0.1	0.1	0.4
Hartenbos	0.1	41.2	26.3	0.2	28.8	1.3	0.8	1.1
Klein Brak	4.5	20.7	26.6	0.0	45.2	0.4	0.2	2.0
Groot Brak	11.3	21.1	21.6	0.1	40.3	2.5	0.9	1.9

Catchment Description	Commercial Forestry (%)	Cultivated land (%)	Indigenous vegetation (%)	Mines (%)	Natural Vegetation\ Forest (%)	Urban (%)	Waterbodies (%)	Wetlands (%)
Maalgate	3.0	42.4	14.4	0.0	35.7	0.8	0.8	2.6
Gwaing	5.7	18.7	17.3	0.0	40.5	14.9	0.3	2.1
Kaaimans	8.7	1.3	33.0	0.0	49.5	6.2	0.6	0.3
Wilderness	6.3	12.4	30.4	0.0	42.3	2.4	2.7	3.1
Swartvlei	32.7	7.9	25.3	0.0	27.9	1.0	3.2	1.5
Goukamma	24.2	6.5	37.0	0.0	31.1	0.5	0.2	0.1
Knysna	22.9	2.4	36.3	0.0	28.9	5.0	2.8	1.3
Noetsie	43.3	0.0	46.0	0.0	8.7	1.2	0.0	0.4
Piesang	21.6	8.4	24.9	0.1	28.8	14.5	1.4	0.0
Keurbooms	5.9	4.8	39.2	0.0	48.3	0.4	0.2	0.6
Groot Wes	6.2	0.7	35.8	0.0	56.0	0.2	0.2	0.4
Bloukrans	6.0	0.0	43.5	0.0	49.3	0.4	0.0	0.3

Changes in quantity and quality of flows

The majority of the estuaries have not experienced large reductions in natural flows compared to reference conditions (Table 2-32). The estuaries where significant dams have been built in the catchments or substantial water extraction for irrigation or other purposes takes place, have however, experienced quite dramatic reductions in natural runoff (Table 2-32). These include Palmiet, Onrus, Uilkraals, Heuningness, Breede and Gouritz. Four systems receive treated wastewater directly into the estuary and in two of these, the Gwaing and the Keurbooms this has elevated present day flows to above the reference level. Wastewater discharge into the Hartenbos and the Knysna has also been known to cause water quality problems. Stormwater inputs from surrounding urban areas (that are likely to contain contaminants) are qualitatively rated as high for three systems (Onrus, Knysna and Piesang), medium for five estuaries (Bot, Uilkraals, Hartenbos, Klein Brak & Groot Brak), and low or negligible for the remaining 18 estuaries' within the WMA (Table 2-32).

Table 2-32. Modelled changes in MAR from reference to present including direct wastewater treatment works (WWTW) input for the identified 26 significant estuaries in the Breede-Gouritz WMA

Estuary	Reference MAR (million $m^3.yr^{-1}$)	Current MAR (million $m^3.yr^{-1}$)	Current as (% reference)	WWTW input (million $m^3.yr^{-1}$)	Current (% Reference Incld .WW)	Stormwater N. L M H
Palmiet	253.72	177.94	70.13			N
Bot/Kleinmond	94.97	77.67	81.78			M
Onrus	9.16	4.74	51.75			H
Klein	63.75	51.21	80.33			L
Uilkraals	15.53	6.82	43.93			M
Heuningnes	42.94	29.53	68.78			N
Breede	1855.60	1140.69	61.47			L
Duiwenhoks	88.82	81.62	91.89			N
Goukou	110.48	89.94	81.41			L
Gouritz	612.38	397.85	64.97			L

Estuary	Reference MAR (million $m^3.yr^{-1}$)	Current MAR (million $m^3.yr^{-1}$)	Current as (% reference)	WWTW input (million $m^3.yr^{-1}$)	Current (% Reference Incld .WW)	Stormwater N. L M H
Hartenbos	5.14	3.74	72.66	0.54	83	M
Klein Brak	39.34	35.54	90.35			M
Groot Brak	1.00	0.92	91.71			M
Maalgate	37.38	35.72	95.57			N
Gwaing	53.76	51.16	95.16	96.61	275	L
Kaaimans	36.70	26.88	73.26			L
Wilderness	32.75	29.01	88.59			L
Swartvlei	101.62	92.49	91.02			L
Goukamma	52.88	46.25	87.46			N
Knysna	90.48	84.32	93.19	2.20	96	H
Noetsie	5.52	5.11	92.45			L
Piesang	6.94	6.41	92.46			H
Keurbooms	121.73	104.20	85.60	43.57	121	L
Groot (Wes)	11.87	10.88	91.70			N
Bloukrans	34.12	31.38	91.97			N

Levels of human disturbance within functional zone

Developments in the estuary functional zones of the 26 significant estuaries within the Breede-Gouritz WMA have been qualitatively assessed in broad categories using Google Earth (Table 2-33). The larger estuaries throughout the WMA have the most anthropogenic developments and impacts, with nearly all the permanently open systems and the four estuarine lakes subject to a range of activities and developments. Knysna estuary has the greatest range of development within the EFZ, whilst the Piesang is the only other system to have “industrial” activity within the EFZ (Reverse Osmosis Desalination Plant). Fishing and/bait collecting are undertaken in nearly all the estuaries where permitted. Permanently open systems experience the highest levels of fishing pressure due to the availability of marine species and the immigration of fish into the estuaries sustaining catches (to a degree). Illegal fishing using gillnets is known to be rife in the Bot & Klein estuaries, and has been reported from several other estuaries in the west of the WMA (e.g. Breede & Duiwenhoks).

Table 2-33. Qualitative assessment of developments within or abutting the estuary functional zones of the 26 significant estuaries in the Breede-Gouritz WMA

Estuary	Residential	Industrial	Roads /Railways	Bridges	Footpaths	Jetties	Marinas/boat mooring	Launch sites	Fishing/bait collecting	Recreational area s
Palmiet			X	X	X				X	X
Bot\Kleinmond	X		X	X	X	X		X	X	X
Onrus	X		X		X					X
Klein	X		X		X	X	X	X	X	
Uilkraals	X		X	X	X				X	X
Haelkraal			X						?	
Heuningnes			X	X	X	X			X	X

Estuary	Residential	Industrial	Roads /Railways	Bridges	Footpaths	Jetties	Marinas/boat mooring	Launch sites	Fishing/bait collecting	Recreational area s
Breede	X		X		X	X	X	X	X	X
Duiwenhoks	X		X		X	X		X	X	X
Gouka	X		X	X	X	X		X	X	
Gouritz	X		X		X			X	X	
Hartenbos	X		X	X	X				X	X
Klein Brak	X		X	X	X	X		X	X	X
Groot Brak	X		X	X	X				X	
Maalgate					X					
Gwaing			X		X				?	X
Kaaimans	X		X	X	X	X			X	X
Wilderness	X		X	X	X	X		X	X	X
Swartvlei	X		X	X	X	X	X	X	X	X
Goukamma			X	X	X				X	X
Knysna	X	X	X	X	X	X	X	X	X	X
Noetsie	X				X				?	
Piesang	X	X	X	X	X				X	X
Keurbooms	X		X	X	X	X	X	X	X	X
Groot Wes	X		X	X	X				X	X
Bloukrans					X					

Invasion by alien organisms

Invasive alien species pose a significant threat to estuaries where they cause both ecological and economic damage. Alien species can exert a significant impact upon community structure and functions, by modifying spatial and food chain resources, with direct or indirect effects on the occurrence of indigenous species (Van Niekerk & Turpie 2012). The combination of brackish waters colonised by physiologically generalist species and potentially unsaturated ecological niches leads to the highest potential infection rate for any aquatic system. In addition, estuaries are also subjected to a two-sided invasion pressure by alien species, via the ocean and via inland waters (Van Niekerk & Turpie 2012).

Invasive alien plants in estuaries include aquatic (e.g. water hyacinth, water fern, parrot's feather) and terrestrial species such as *Sesbania* and Australian *Acacia* species (Adams *et al*. 1999). The extent of aquatic alien plants in the estuaries of the Breede-Gouritz WMA is not well known, but they do not appear to be problematic in many systems. Terrestrial alien plant species, particularly Australian *Acacia* species have however, colonised the estuary margins of many systems in the WMA. An invasive intertidal salt marsh grass, *Spartina alterniflora*, has been recorded at the Groot Brak Estuary since 2004. It is a perennial, deciduous, salt tolerant grass that can grow up to 2 m tall and is found in the intertidal areas of estuaries. *Spartina alterniflora* has spread at an alarming rate of 0.15 ha yr-1 since 2004 to occupy a cover of 0.87 ha by 2010, spreading laterally at a rate of 1.1 m yr-1 (Adams et al 2012). An eradication programme via Working for Water was initiated in 2011 with foliar herbicide application proving effective (Adams et al 2012).

At least 10 freshwater alien fish species are likely to be found in most of the Breede-Gouritz WMA estuaries. Most of these were introduced from the northern hemisphere in the late 1800s until the 1970s either to enhance freshwater angling, or as fodder fish to feed the larger introduced species or as mosquito control. In addition to these alien species, translocations of southern African species either as angling fish or in the hope of establishing an aquaculture industry have also taken place. Extra-limital Tilapia species *Tilapia sparrmanii* and *Oreochromis mossambicus* now occur in the upper reaches of most of the Breede-Gouritz WMA estuaries. Range expansion of both introduced and translocated species throughout South Africa was further facilitated by interbasin transfer schemes, irrigation and stormwater networks as well as intentionally or inadvertently by recreational anglers and other water users as they moved between water bodies (Van Niekerk & Turpie 2012). Migration of catadromous eels or mullet, recruitment of the larvae and juveniles of estuary-dependent marine species, and the survival of the eggs and young of estuary residents, may be severely compromised through predation by introduced fish in estuarine headwaters (Van Niekerk & Turpie 2012).

Table 2-34. Freshwater alien fish species likely to occur in estuaries within the Breede-Gouritz WMA (Source Van Niekerk & Turpie 2012)

Species name	Common name	% occurrence (130 estuaries)	SA range
Micropterus salmoides	Largemouth bass	31	Olifants -Mhlathuze
Micropterus dolomieu	Smallmouth bass	24	Olifants - Thukela
Cyprinus carpio	Carp	23	Orange - Thukela
Lepomis macrochirus	Bluegill sunfish	14	Olifants - Thukela
Micropterus punctulatus	Spotted bass	14	Olifants - Thukela
Oncorhynchus mykiss	Rainbow trout	10	Sand - Thukela
Gambusia affinis	Mosquitofish	9	Berg - Knysna
Salmo trutta	Brown trout	3	Olifants - Thukela
Tinca	Tench	2	Lourens - Breede
Ctenopharyngodon idella	Grass carp	2	Zeekoei - Thukela

A total of 86 introduced alien marine invertebrates species are known from South African waters with the highest numbers of species within the Ascidiacea (18), Amphipoda (17) and Cnidaria (15) (Mead *et al.* 2011). Not all alien marine species however, have been found in estuaries in the different biogeographic regions. The majority of alien species are restricted to harbours (e.g. *Ciona intestinalis, Carcinus maenas, Metridium senile*) and sheltered estuaries (Robinson *et al*. 2005). The Pacific oyster *Crassostrea gigas* was introduced to the Knysna Estuary in South Africa in the 1950s with the intention to farm. In 2001, through the use of DNA sequencing, established populations of *C. gigas* were found in the Breede, Duiwenhoks, Goukou, Knysna, Kromme and Keiskamma estuaries (Robinson *et al*. 2005) .The latter three populations are likely to have formed from aquaculture activities in the area. On the other hand, oyster farms have never existed in the former three estuaries, so the source of introduction is unclear. In 2001, the highest densities of individuals were found in the Breede Estuary (8.3 individuals per m^2, with a population size of approximately 184,000 individuals) (Robinson *et al*. 2005).

2.4.3.4 Present ecological status

The 2011 NBA conducted a desktop assessment of the health of nearly 300 South African estuaries (Van Niekerk & Turpie 2012). The ecological health category was determined by an ecological water requirement study in cases where one had been completed; alternatively the assessment was based on expert knowledge. This health assessment is presented in Table 2-35 with updated information for systems that have subsequently had an ecological reserve determination study completed, namely the Goukou (DWS 2015a), Keurbooms (DWS 2015b), Gouritz (DWS 2015c), Klein (AEC 2015) and Uilkraals (DWS 2012).

Table 2-35. Desktop National Health Assessment (NBA 2011), with individual ecological components graded

Estuary	Health Condition											
	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Palmiet													C
Bot/Kleinmond													C
Onrus													E
Klein													C
Uilkraals													D
Haelkraal													C
Heuningnes													D
Breede													B
Duiwenhoks													B
Goukou													C
Gouritz													C/D
Hartenbos													D
Klein Brak													C
Groot Brak													D
Maalgate													B
Gwaing													B
Kaaimans													B
Wilderness (Touws)													B
Swartvlei													B
Goukamma													B
Knysna													B
Noetsie													B
Piesang													C
Keurbooms													A/B
Groot (Wes)													B
Bloukrans													A

Graded from Excellent (dark blue), good (blue), fair (green) to poor (brown). Present Ecological Status is also provided. Sources: Van Niekerk & Turpie (2012), DWS (2012), (DWS 2015 a, b), AEC (2015)

2.4.3.5 Recommended ecological status based on health and importance

The conservation importance of South African estuaries was scored based on their size, habitat importance score, zonal type rarity score and biodiversity importance score (Turpie & Clark 2007). The significant estuaries ranked in terms of these conservation scores as well as the present ecological status and recommended ecological class as reported in the 2011 NBA or updated RDM studies are shown in Table 2-36 (Van Niekerk & Turpie 2012). The estuarine Bay, Knysna, is ranked as the most important estuary for conservation within the Breede-Gouritz WMA, whilst the four estuarine lakes and the larger permanently open estuaries are also ranked highly (Table 2-36).

Table 2-36. PES, conservation importance (scale of 1-100) and REC of the 26 significant estuaries within the Breede-Gouritz WMA

Sources: Turpie and Clark 2007, Van Niekerk & Turpie (2012), DWS (2012), (DWS 2015 a, b), AEC (2015).

Estuary	PES	Importance	REC
Knysna	B	100	B
Bot/Kleinmond	C	97	B
Klein	C	97	B
Swartvlei	B	97	B
Gouritz	C/D	88	B
Keurbooms	A/B	88	A
Breede	B	87	B/C
Duiwenhoks	B	84	B
Heuningnes	D	83	A or BAS*
Wilderness (Touws)	B	83	A or BAS*
Goukou	C	80	B
Groot Brak	D	77	C
Uilkraals	D	76	B
Piesang	C	73	B
Goukamma	B	72	A
Hartenbos	D	66	D
Palmiet	C	63	B
Groot (Wes)	B	63	A or BAS*
Onrus	E	59	B
Klein Brak	C	53	C
Bloukrans	A	51	A or BAS*
Maalgate	B	38	B
Kaaimans	B	28	B
Noetsie	B	28	B
Gwaing	B	10	B
Haelkraal	C	Not rated	B
BAS* – Best Attainable State			

2.5 Wetlands: ecological state status quo

An assessment was made to identify wetland resource units (WRUs) in the study area. The assessment was conducted as a desktop exercise, making use of the National Freshwater Ecosystems Priority Areas (NFEPA) wetlands map (Nel et al., 2008), the Cape Nature CAPE Fine-Scale Biodiversity Planning Project FSP maps (Pence, 2008; Job et al., 2008a; Job et al., 2008b) and the DWAF Ecoregion maps (Kleynhans et al., 2005). This assessment, as described in the *Resource Unit Delineation and Integrated Units of Analysis* Report (DWS, 2016b), allowed for the determination of WRUs in the study area. Additional background information for WRUs was also collated from the Wetland Report for the Gouritz Reserve study (DWS, 2015) and Malan et al. (2015).

2.5.1 Approach

As described above the description of the delineation of the wetlands is outlined in the *Resource Unit Delineation and Integrated Units of Analysis* Report (DWS, 2016b). The steps followed to defined priority wetlands in the study area were as follows:

- NFEPA wetland dataset as defined for the Breede-Gouritz WMA (FEPA wetland GIS layer from BGIS: http://bgis.sanbi.org/)
  - Removal of the artificial wetlands and estuaries
  - Removal of NFEPA non-priority wetlands
  - Removal of Heavily to critically modified wetlands (NFEPA condition DEF and Z1-3)
  - Removal of wetlands smaller than 500m^2
- Level I and Level II Ecoregions (from http://www.dwaf.gov.za/iwqs/gis_data/RHPdata.htm)
  - Defined Wetland Resource Units according to the Ecoregions
  - Also used Simplified Geology map from AGIS (http://www.agis.agric.za/agisweb/agis.html)
- FSP maps for Cape Winelands, Overberg and Eden District Municipalities
  - Used for detailed description of the status quo of each wetland system
  - Removal of FSP wetlands with Integrity of wetland being less than 80% (INTEG80_all condition of Z).

This methodology was followed to define the WRUs within the study area. The WRUs were defined according to the underlying Ecoregion, in order to provide an understanding of the biophysical constraints on wetland formation. This methodology is consistent with the methodology used in the determination of priority wetlands for the Gouritz Reserve Determination Study (DWS, 2015). Following this assessment the WRUs were defined according to Hydrogeomorphic Unit (HGM) in order to determine the different wetland types within each WRU.

The status quo descriptions relied on both the NFEPA PES data, as well as the Wetland Integrity data from the FSP maps where applicable. The status quo of the WRUs were described in more detail within each IUA.

2.5.2 Description

In terms of the National Water Act (Act No. 36, 1998) a wetland may be defined as:

"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

This indicates that wetlands must have one or more of the following characteristics:

- *Hydromorphic soils*: characteristic soils of prolonged saturation;
- *Hydrophytes*, at least occasionally: highly saturated plants;

- *High water table*: a high water table that results in saturation at or near the surface, leading to anaerobic conditions.

These characteristics are indicative of the relationship between hydrology, topography and vegetation in determining the characteristics of a wetland in the landscape. Considering the long term controls that topography exerts on wetland occurrence and behaviour, Ecoregions were considered a useful way to interpret wetland occurrence in the study area.

The Level I Ecoregions associated with the study area are mainly the Western and Southern Folded Mountains, Overberg Southern Folded Mountains, Southern Coastal Belt, South Eastern Coastal Belt and Great Karoo regions (Figure 2-23). The Level II Ecoregions reflect the underlying geology to a large degree (Figure 2-24), therefore when overlaid with a simplified geological map the Level II Ecoregions are given appropriate context (Figure 2-25).

Across the WMA there are numerous wetlands, with many of the wetlands in the study area being considered conservation priorities (Figure 2-26). As there are numerous wetlands within the WMA, wetland RUs were defined according to the Ecoregion classification, taking cognisance of the controls exerted by underlying geology (Figure 2-27 Figure 2-27). There were 11 WRUs defined for the WMA, with priority wetlands occurring within the wetland RUs and IUAs of the study area (Figure 2-29).

The WRUs accorded a top-down approach to defining the wetland characteristics within the WMA. These provided an overview of the typical characteristics of wetlands and the associated HGM type within each WRU (Figure 2-27 and Figure 2-29). The IUAs within each WRUs were also defined, as were the important wetlands within each IUA (Figure 2-29). Following from this assessment, important wetlands were defined and assessed in terms of ecological state per IUA. Certain important wetlands are considerd to be a part of river or estuary systems, in which case will have associated nodes in each case. Further details in terms of the ecological condition of these wetlands is therefore related to the assessment of these river and estuary systems.

Wetland types that occur in the study area are the following:

- *Floodplain wetlands*: occur on mostly flat areas adjacent to and formed by an alluvial river channel.
- *Valley-bottom wetlands*: occurs mostly on flat areas located along the valley floor. A channelled valley-bottom wetland has a channel running through it; with an un-channelled valley-bottom wetland having no channel running through it.
- *Depressions*: a wetland or aquatic ecosystem with closed (or near closed) elevation contours within which water accumulates. Depressions may be flat-bottomed (often described as pans), or extend over large areas, whereby they may be termed “wetland flats” or “floodplain flats”.
- *Seeps*: a wetland area located on gentle to steeply sloping land, dominated by colluvial, uni-directional movement of water and material down-slope.

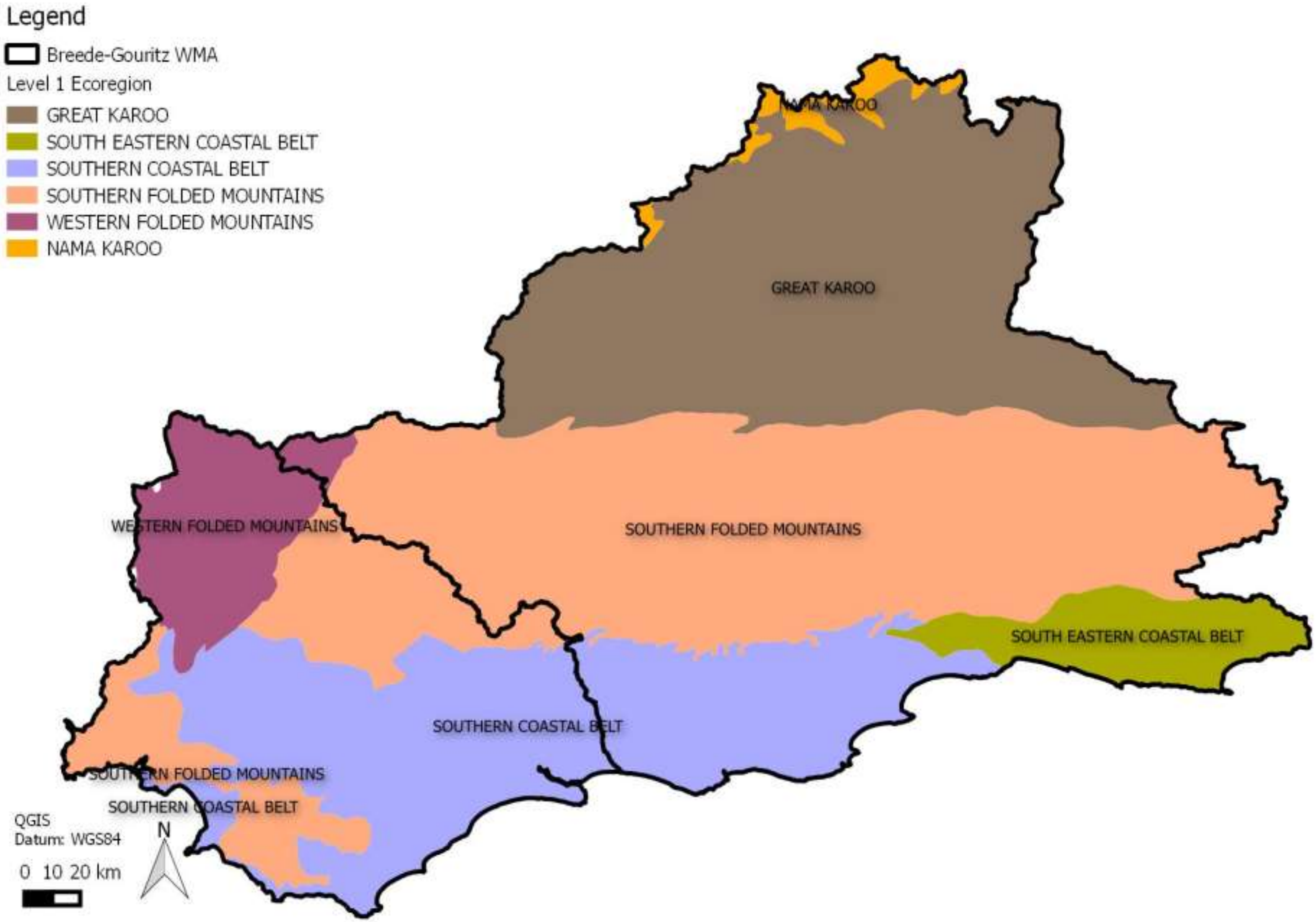


Figure 2-23. Level I Ecoregions within the study area (after Kleynhans et al., 2005)

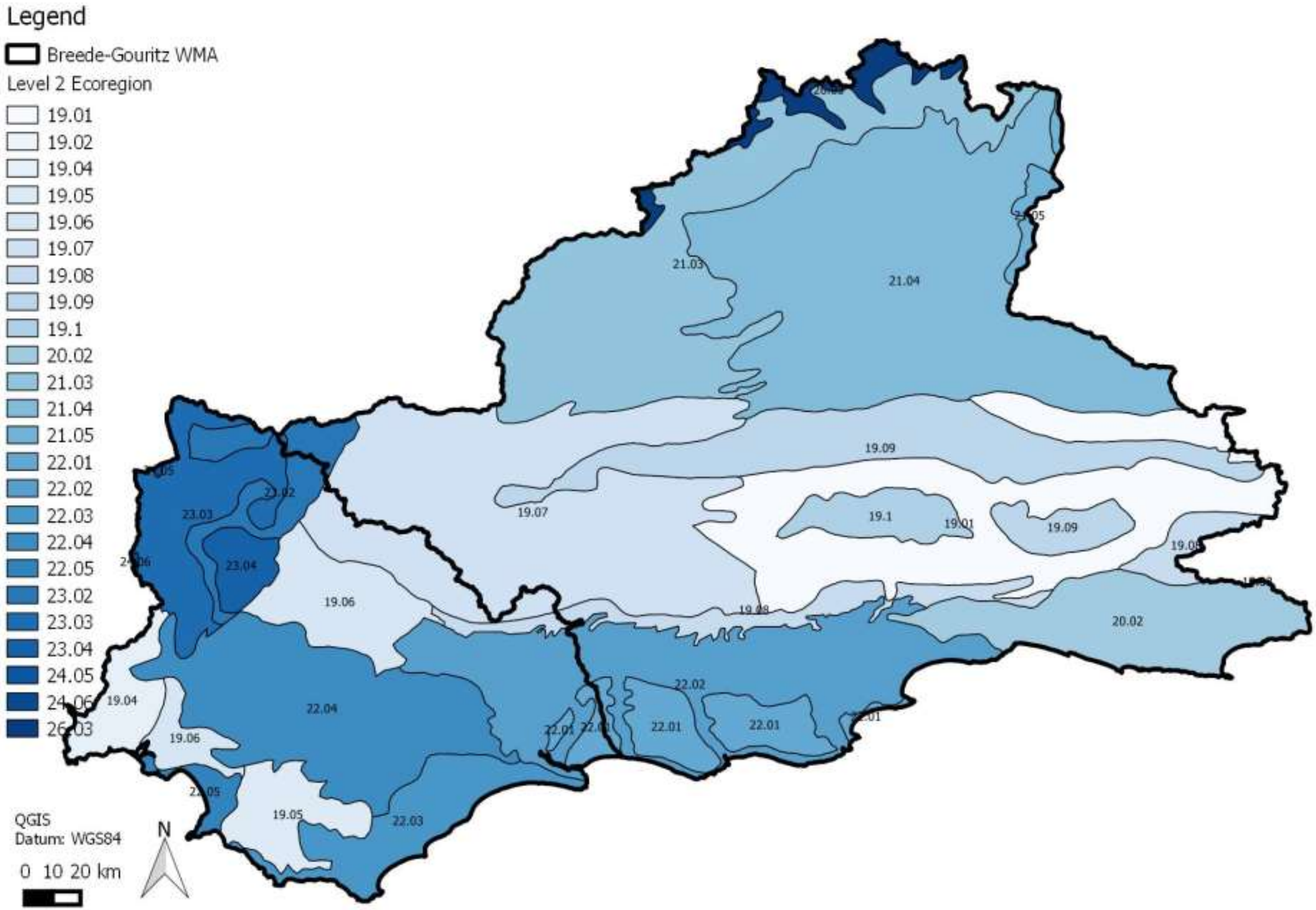


Figure 2-24. Level II Ecoregions within the study area (After Kleynhans et al., 2005)

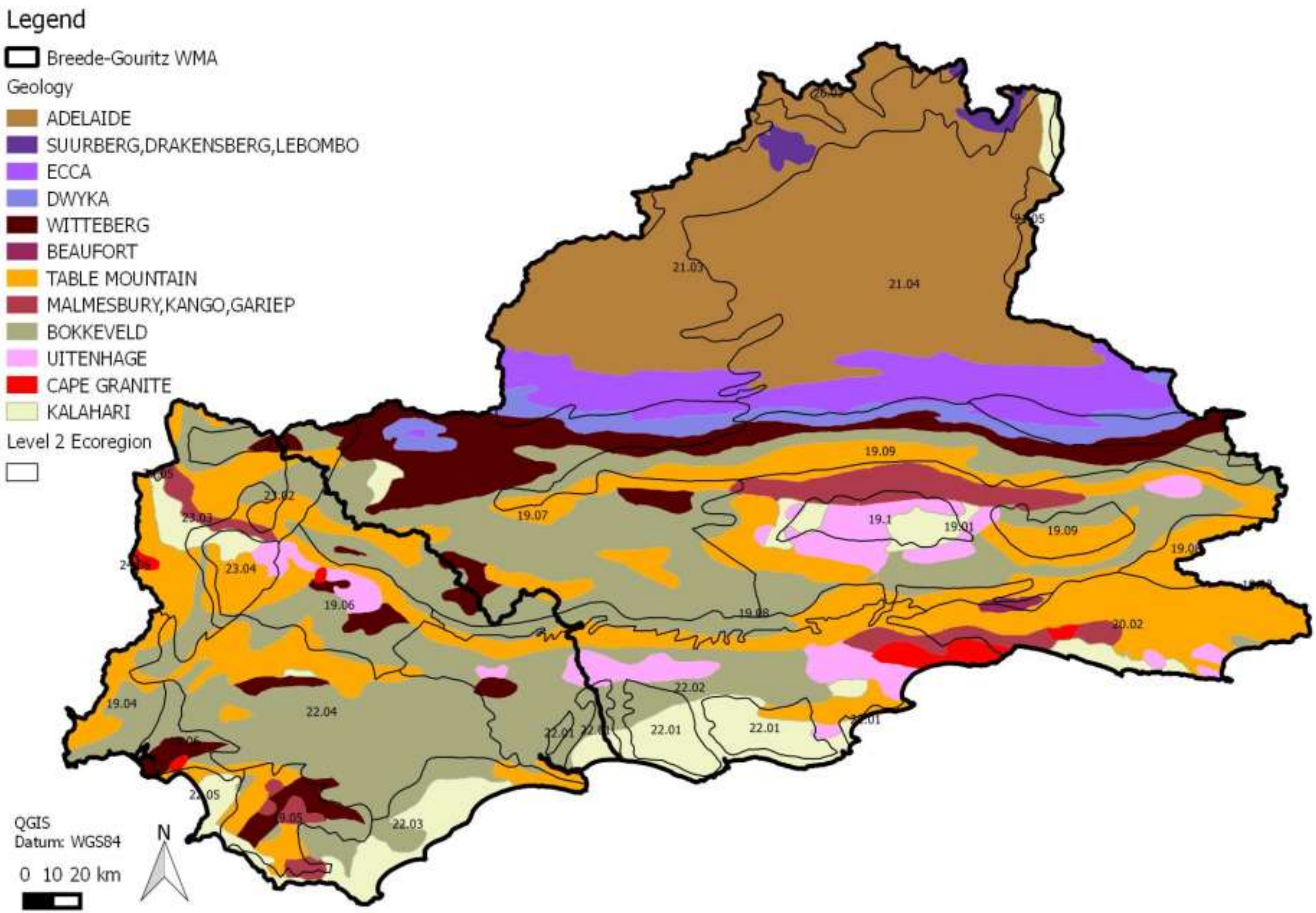


Figure 2-25. Simplified geology overlaid with Level II Ecoregions within the study area (BGIS and Kleynhans et al., 2005)

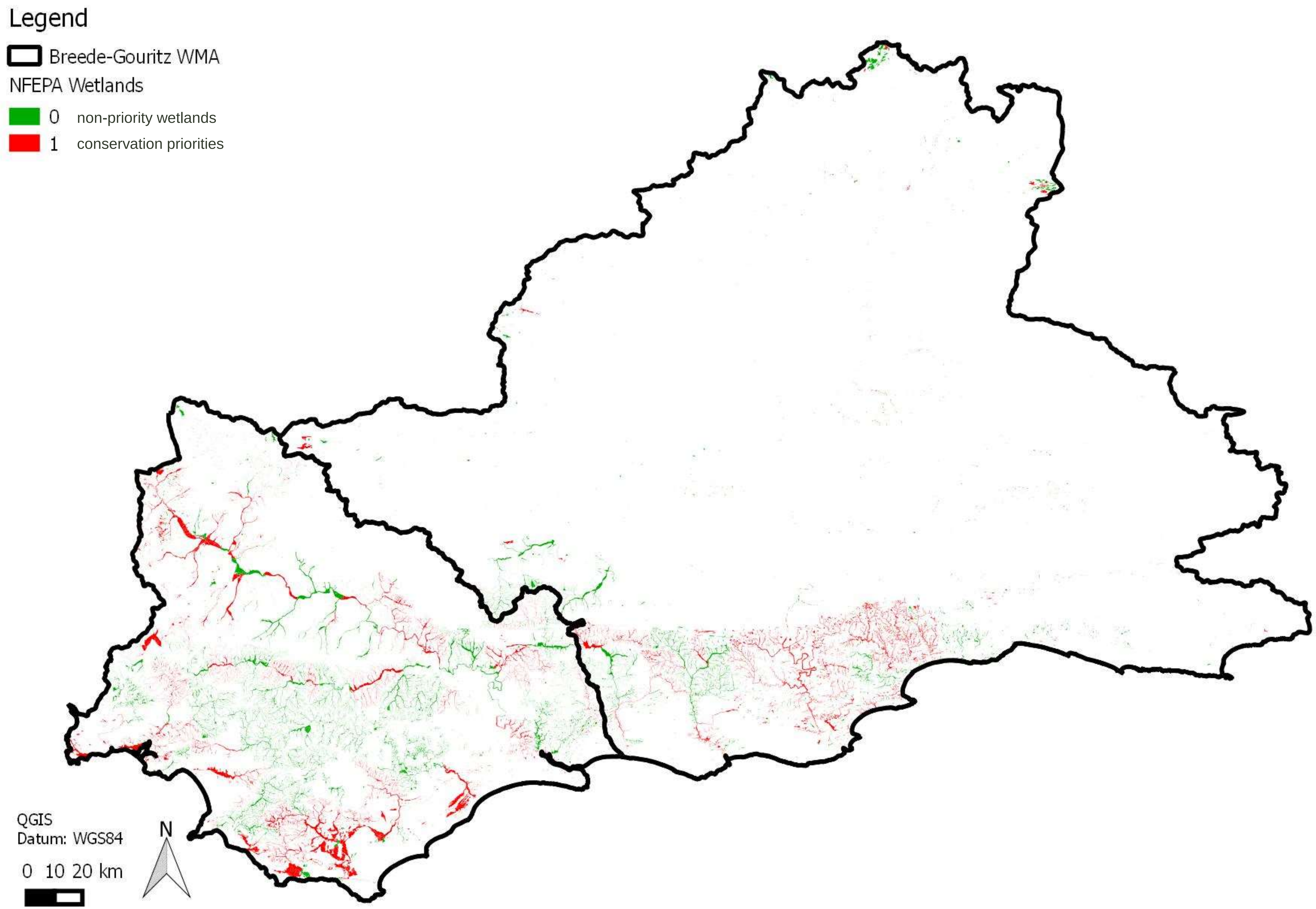


Figure 2-26. **The extent and density of wetlands across the study area, as indicated by NFEPA wetland layer (Driver *et al*, 2012)**

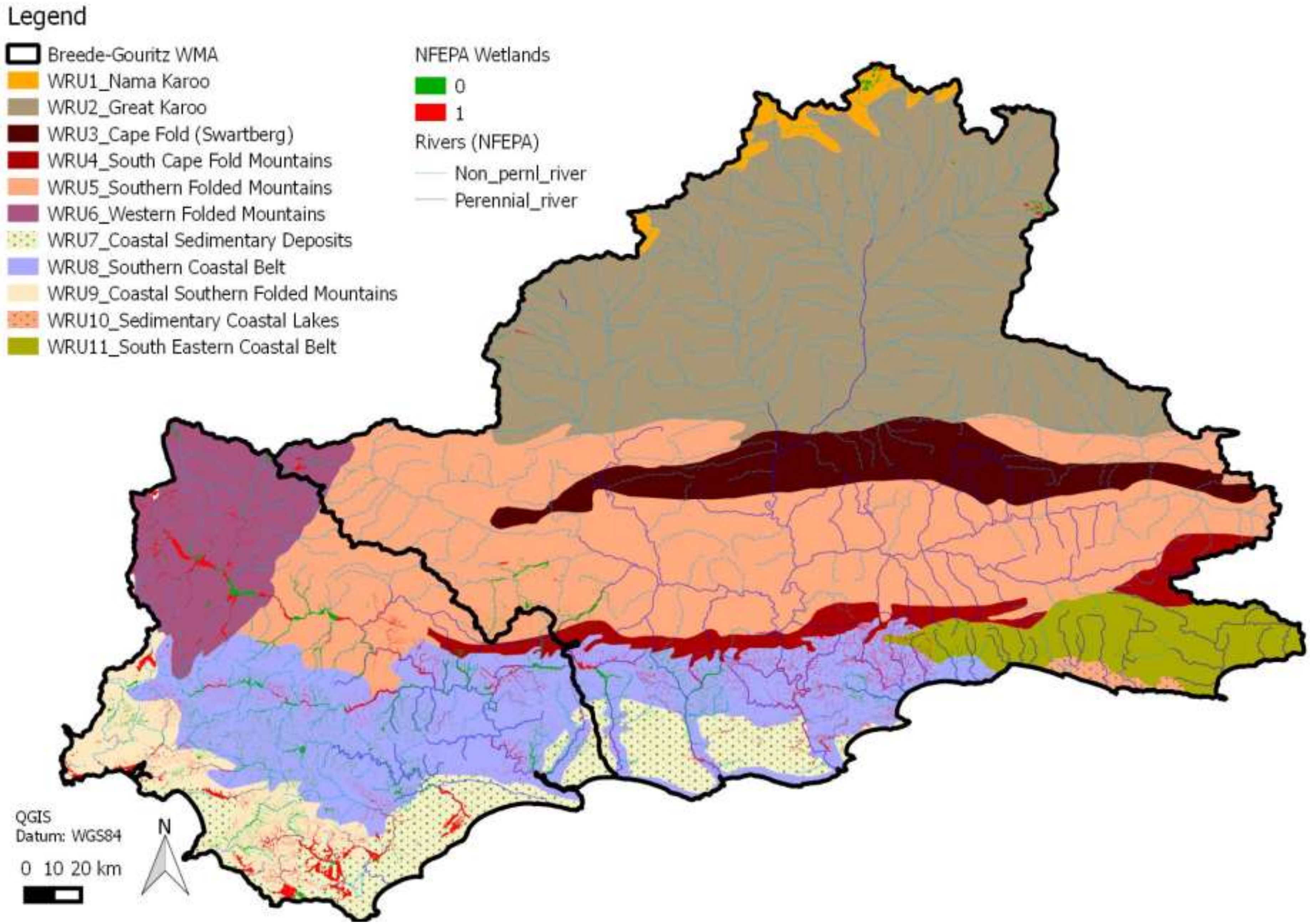


Figure 2-27. The WRUs across the study area, with NFEPA wetlands and rivers overlain.

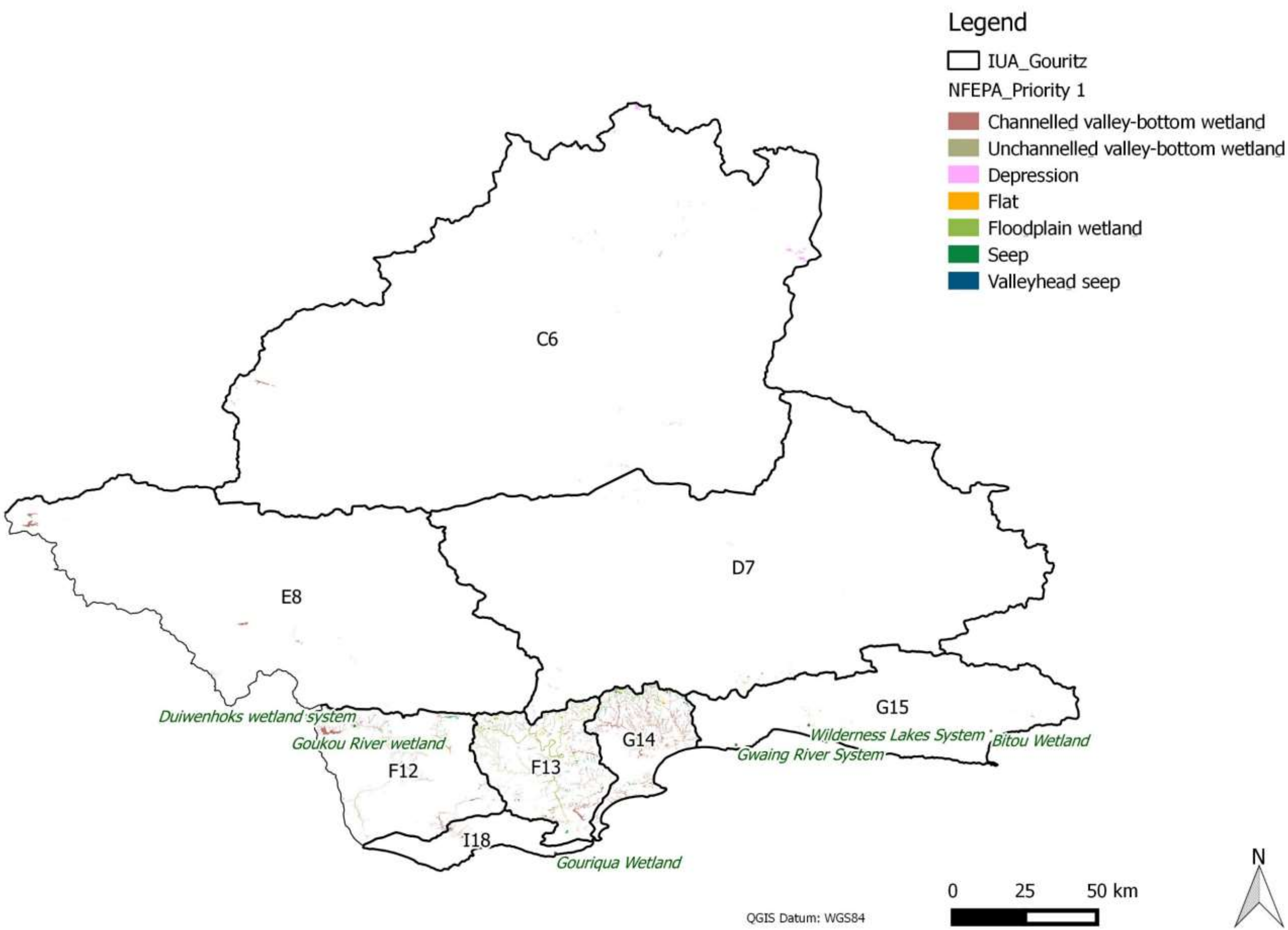


Figure 2-28. **The important wetlands within the Gouritz IUAs**

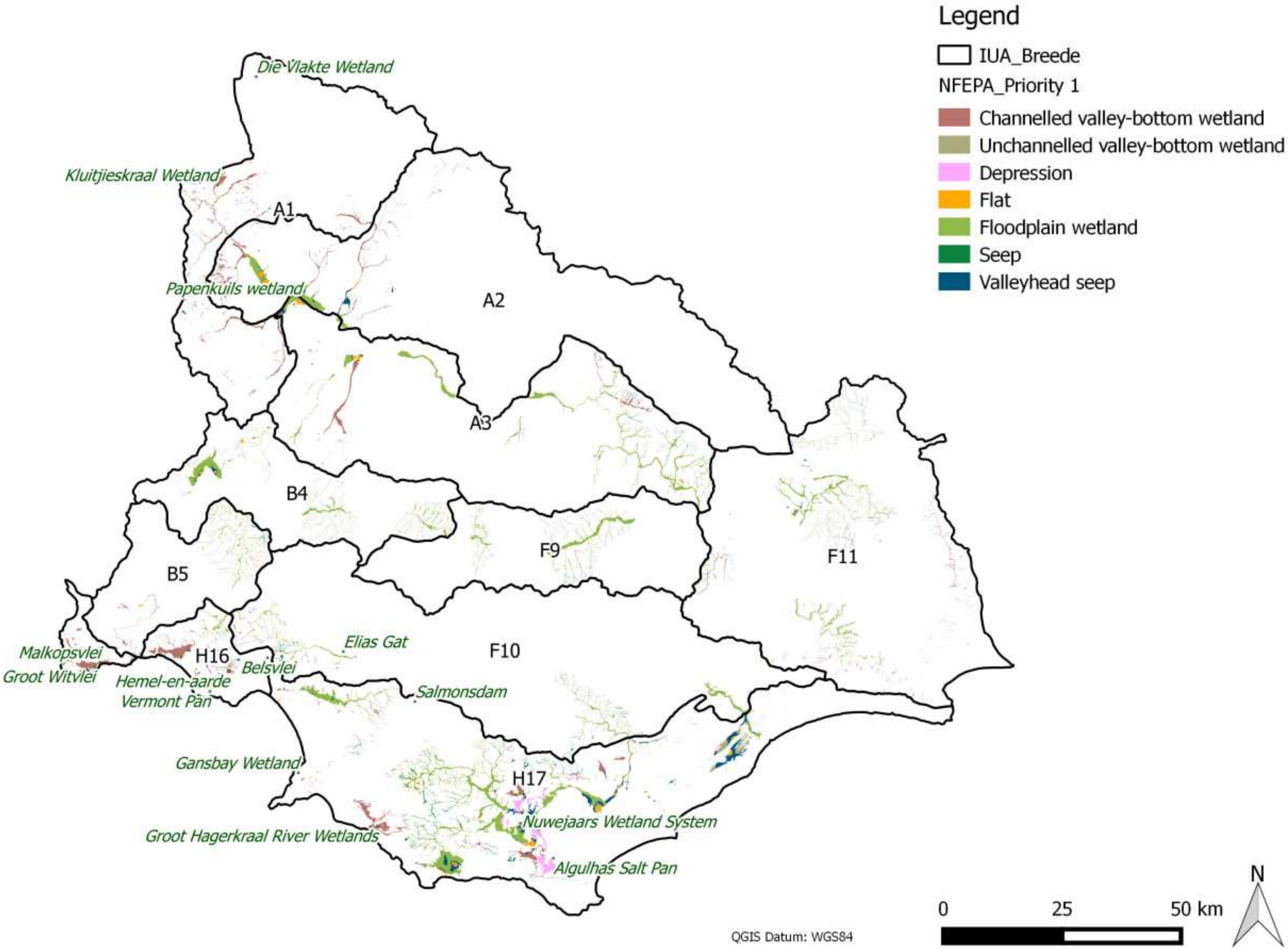


Figure 2-29. The important wetlands within the Breede IUAs

Table 2-37. The typical wetland types, IUA and important wetlands within each WRU across the study area (highlighted wetlands may require additional EWR nodes)

WRU name	Typical wetlands	HGM types	IUA code	IUA	Important Wetlands
WRU1_Nama Karoo	Seeps with a likely high degree of groundwater dependence.	Depression Seep	**C6**	Gamka-Buffels	
WRU2_Great Karoo	Small seeps and river-linked wetlands.	Depression Seep Valley bottom	**C6**	Gamka-Buffels	
WRU3_Cape Fold (Swartberg)	Small seeps associated with groundwater-fed springs	Seep	**D7** **E8**	Gouritz-Olifants Touws	
WRU4_South Cape Fold Mountains	Small seeps associated with groundwater-fed springs	Seep	**D7** **E8** **A2**	Gouritz-Olifants Touws Breede Working Tributaries	
WRU5_Southern Folded Mountains	Small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence respectively.	Depression Seep Valley bottom	**D7** **E8** **A2** **A3**	Gouritz-Olifants Touws Breede Working Tributaries Middle Breede Renosterveld	
WRU6_Western Folded Mountains	Valley bottom and floodplain wetlands.	Flat Seep Valley bottom Floodplain	**A1**	Upper Breede Tributaries	**Die Vlakte Wetland** **Kluitjieskraal Wetland**
			A2	Breede Working Tributaries	Papenkuils Wetland (part of the Breede River)
			A3	Middle Breede Renosterveld	
WRU7_Coastal Sedimentary Deposits	Desktop information shows wetlands are very infrequent - possible due to deep infiltrating soils and a lack of shallow/perched water tables. Inter-dune depressional wetlands are present, suggesting	Flat Seep Valley bottom	**H16**	Overberg West Coastal	**Vermont Pan**
			H17	Overberg East Fynbos	Gansbay Wetland Algulhas Salt Pan; Nuwejaars Wetland System (part of the Heuningnes Estuary system)
			F11	Lower Breede Renosterveld	
			F12	Duiwenhoks	
			I18	Hessequa	Gouriqua Wetland
			F13	Lower Gouritz	
			G14	Groot Brak	

	groundwater contributions (DWS, 2015)				
WRU8_Southern Coastal Belt	Valley bottom wetlands, seepage wetlands	Flat Depression Seep Valley bottom Floodplain	**B4**	Riviersonderend Theewaters	
			F9	Lower Riviersonderend	
			F11	Lower Breede Renosterveld	
			F10	Overberg East Renosterveld	
			F12	Duiwenhoks	Duiwenhoks Wetland System (part of the Goukou River system)
					Goukou River Wetland (part of the Goukou River system)
			I18	Hessequa	
			F13	Lower Gouritz	
			G14	Groot Brak	
			G15	Coastal	Gwaing River System (part of the Gwaing Estuary system)
WRU9_Coastal Southern Folded Mountains	Seeps and depression wetlands as well as valley bottom and floodplain wetlands	Flat Depression Seep Valley bottom Floodplain	**B4**	Riviersonderend Theewaters	
			B5	Overberg West	
			H16	Overberg West Coastal	**Groot Witvlei**
					Malkopsvlei
					Hemel-en-Aarde
					Blesvlei
			F10	Overberg East Renosterveld	**Diepte Gatt**
					Elias Gat
					Salmonsdam
			H17	Overberg East Fynbos	Groot Hagerkraal Wetlands (part of the Haelkraal Estuary system)
WRU10_Sedimentary Coastal Lakes	Lakes and wetland flats	Depressions	**G15**	Coastal	Wilderness Lakes System (part of the Wilderness, Swartvlei, Goukamma and Knysna estuary systems)
WRU11_South Eastern Coastal Belt	Channelled and unchannelled valley bottom wetlands	Seep Valley bottom	**G15**	Coastal	Bitou Wetland (part of the Keurbooms estuary system)

2.5.3 Status quo assessment

Most Gouritz sub-area rivers originate in the Great Karoo bioregion, where rivers are predominantly perennial. This region is also semi-arid, with limited rainfall, and consists of flat plains and low hills formed by Karoo sediments and dolerite intrusions of the Adelaide Group. These characteristics influence the type and distribution of wetlands over the **WRU1 Nama Karoo** and large **WRU2 Great Karoo.** WRU1 is associated with depression or seep wetlands. Tributaries of the Gamka River are associated with depression wetlands in the high lying areas to the east and unchannelled valley-bottom wetlands near the Leeu river of WRU2. The headlands of the Buffels River, to the west of WRU2, also host flat, seep and channelled valley-bottom wetlands. Most of the wetlands within WRU2 occur in high lying areas, with other wetlands in low lying areas being associated to main channels (valley bottom wetlands). Wetlands within this catchment zone are likely to be associated with the vegetation type Muscadel Riviere valley bottom wetlands and drainage lines (Mucina & Rutherford, 2006) which are sporadically flooded, flat, broad alluvial deposits dominated by *Acacia karoo* and *Salsola* species (DWS, 2015).

Below the Great Karoo the Swartberg Mountains extend to separate the Klein Karoo from the Great Karoo. The Klein Karoo lies to the north of the Langeberg Mountains and belongs to the Bokkeveld Group, consisting of mainly sandstones and shales. The Table Mountain sedimentary group gives rise to the Langeberg Mountains which separates the inland Klein Karoo from the coastal regions (DWS, 2015). The Cape Supergroup consists of sandstones, quartzite and conglomerates of the Malmesbury Group, overlain in the valley floors by alluvial deposits (DWS, 2015). This diverse topogrpahy of the Southern Folded Mountains Ecoregion traverse the middle of the Gouritz sub-area, and a small section of the Breede sub-area. The **WRU5 Southern Folded Mountains** are surrounded by the **WRU3 Cape Fold Swartberg** to the north and **WRU4 South Cape Fold Mountains** to the south. Within the Gouritz sub-area there are limited wetlands, with most occuring near the tributaries of the Groot River in the east, with seep wetlands occuring in the high lying areas. Within the Breede sub-area the floodplain wetlands associated with the Touws River near Barrydale and the floodplain wetlands associated with the Breede River below Montague are the main wetland systems. Along the coast of the Breede sub-area **WRU9 Coastal Southern Folded Mountains** extends from the west of the WMA towards Bredasdorp. This region is associated with the Cape Supergroup and consists of extensive valley bottom and floodplain wetland systems as well as seep and depression wetlands due to the varying topography of the area.

The South Eastern Coastal Belt occurs in a region with very different climate and topography to the Great Karoo region. This area is characterised by closed hills and mountains, with a moderate to high mean annual precipitation (MAP) (Kleynhans et al., 2005). The **WRU11 Southern Eastern Coastal Belt** is therefore quite different to the Karoo wetlands. In terms of characteristics linked to wetland occurrence the closed hills and high rainfall provide favourable conditions for channelled valley-bottom wetlands, and in particular the occurrence of inland lake systems at the outlet of steep coastal rivers. Sections of Granite, Conglomerate and Quartzite are dominant, whilst adjacent to the coast old quaternary sediments have been deposited in places (DWS, 2015). These areas are associated with the **WRU10 Sedimentary Coastal Lakes** and **WRU7 Coastal Sedimentary Deposits.** The wetlands associated with WRU10 occur along the coastal areas of the WMA which are underlain by limestone. The deep-free draining soils and absence of perched water tables reduces the incidence of wetlands in this area, with wetland habitats being more vulnerable to degradation due to higher agriculture potential (DWS, 2015). These wetlands may also contain peat deposits.

The Upper Breede River occurs within the **WRU6 Western Folded Mountains**. This region is characterised by tablelands and plains, but has distinctive closed hills and mountains with high elevations (Kleynhans et al., 2005). The significant wetlands in this region are cape alluvial floodplain wetlands associated with the upper Breede River (Job et al., 2008). These wetlands are characterised by wide river valleys, where periodic inundation of the floodplain sustains the habitat. Valley bottom wetlands are associated with rivers between the towns of Worcester and Robertson.

WRU8 Southern Coastal Belt extends over the Breede and Gouritz sub-areas. Wetlands of the WRU8 are expected to be dominated by extensive seepage wetlands (especially in granitic areas) and valley bottom wetlands (DWS, 2015). Permanently wet valley bottom wetlands are typically located at the base of the sandstone mountain range and are likely fed by a combination of overland flow from the mountains as well as constant groundwater contribution from the adjacent quartzitic sandstone (DWS, 2015).

2.5.3.1 Major threats and impacts

In natural capital terms wetlands may be seen as a significant economic investment. This monetary value is rooted to the fact that the primary functioning of a wetland are to process water and regulate runoff. The inherent value of wetlands is that they protect and regulate this water source by acting like sponges, soaking up water during flood events and releasing it during dry periods (DWAF, 2005). By regulating water flows during floods, wetlands may reduce flood damage and help prevent soil erosion. As natural filters wetlands also help to purify water by trapping pollutants, heavy metals and disease causing organisms. These ecosystem services are provided at very little cost but with significant payback for the economy.

Aside from the socio-economic benefits of wetlands, they also serve an important role as a stepping stone for birds, reptiles, invertebrates and amphibians moving across the landscape. This role as a stepping stone is dependent on the degree of permeability in the surrounding area, generally decreasing as the landscape becomes more degraded (Job et al., 2008). Development of the surrounding area also limits the movements of animals, in effect reducing the functioning of a wetland.

Although wetlands provide important ecosystem services many are at risk, with the main issues being draining wetlands for crops and pastures, poorly managed burning and grazing resulting in headcut and donga erosion, planting alien invasive vegetation, mining, pollution and urban development. These have been significant as they alter the natural flow of water in wetlands and as water is the driver of wetland formation it follows that any changes would be damaging. Furthermore, groundwater use reduces natural discharge, the extent and timing of which is dependent on the position of abstraction compared to discharge point, and the aquifer water balance. Hence use of an aquifer (by direct abstraction, or potentially by afforestation) that has some natural discharge to a wetland, has the potential to reduce this natural discharge, which in turn may impact on the wetland ecosystem. It is standard practice to identify groundwater dependent wetlands in the vicinity of planned abstraction and quantify a potential reduction in discharge.

Key threats per WRU in the study area are as follows:

- **WRU1 Nama-Karoo:** Transformation into dams and transformation through cultivation; invasive alien *Prosopis glandulosa* infestations; mining for salt; and trampling and overgrazing.
- **WRU2 Great Karoo:** Direct transformation of the wetlands due to grazing pressure, cultivation and building of dams and other infrastructure; increased nutrient inputs; and invasive alien plants.
- **WRU3 Cape Fold (Swartberg):** Limited threats which include physical alterations from agriculture; trampling and grazing.
- **WRU4 South Cape Mountains:** Too frequent fires; cultivation within wetland areas; expansion of afforestation; and invasive alien woody species into wetlands.
- **WRU5 Southern Folded Mountains:** Transformation for cultivation and building of roads; increased nutrient inputs; and invasive alien plants.
- **WRU6 Western Folded Mountains:** Agriculture impacts, wetland drainage, encroachment of cultivation and transformation to farm dams. (WfW working in the area)
- **WRU7 Coastal Sedimentary Deposits:** Clearing of natural vegetation, cultivation and alien invasive plants; too frequent or infrequent fire; and alien plant invasion. (WfW working in the area)
- **WRU8 Southern Coastal Belt:** Erosion of peat wetlands (WfW working in the area)

- **WRU9 Coastal Southern Folded Mountains:** Urban development and nutrient enrichment.
- **WRU10 Sedimentary Coastal Lakes:** Change in hydrology and salinity, high nutrient and sediment inputs; harvesting of flora and fauna; development within demarcated wetland area; coastal development; cultivation and draining.
- **WRU11 South Eastern Coastal Belt**: Encroachment from forestry and agriculture (central and upper catchments); encroachment from low cost housing and urban areas (coastal); clearing of natural vegetation and cultivation around and in wetlands; invasive alien vegetation and changes in hydrology.

2.5.3.2 Baseline assessment of wetlands ecological state

The ecological condition of wetlands within the study area is difficult to define due to limited baseline data. Although the NFEPA wetland maps provide EIS and PES factors, these were done on a coarse national scale and require critical evaluation. It is proposed for this study that the NFEPA wetland maps be used as a first attempt when determining the status of wetland systems, but that fine-scale studies be referred to where available. The FSP maps provide detailed assessment for certain areas across the study area, the Gouritz Reserve Determination Study provides additional information for the Gouritz region and the Malan et al. (2015) report on the “Trajectory of change in wetlands of the Fynbos Biome from the late 1980s to 2014” provide additional information for priority wetlands within the Breede region.

The FSP maps (Job et al., 2008) specified significant wetland clusters by identifying any wetland cluster which was greater than 500Ha in size and with more than 80 percent natural vegetation as a significant wetland cluster. The FSP maps are available for the Upper Breede area (IUA A1; IUA A2; IUA A3) and for the Riversdale area (IUA F12; IUA F13; IUA I18).

The Gouritz Reserve Determination Study (DWS, 2015) identified that there were too many wetlands to evaluate on an individual basis. The study therefore provided a desktop level quaternary scale catchment assessment of the wetlands across the Gouritz region. This information was used to determine the average EIS and PES categories of wetlands within assessed quaternary catchments. The prioritised wetland names, and associated Ecological Condition assessments, are available for the Gouritz region (IUA C6; IUA D7; IUA E8; IUA F12; IUA F13; IUA G14; IUA G15; IUA I18).

The wetlands of the Riviersonderend (IUA B4; IUA F9), Overberg (IUA B5; IUA F10; IUA H16; IUA H17) and the Lower Breede regions (IUA F11) do not have detailed studies associated with them therefore the NFEPA ecological condition was used, with critical examination in terms of specific wetlands. Reports such as Malan et al. (2015) for wetlands in the Fynbos region and various Working for Wetlands Reports provide an overview of the ecological condition of certain wetlands in this area. PES for Malan et al. (2015) were assessed using the Duthie (1999) scoresheet.

Table 2-38. The typical wetland types, IUA and priority wetlands within each WRU across the study area

IUA code	IUA	Priority Wetlands	EIS	PES	Importance
C6	Gamka-Buffels		Mod	B	
D7	Gouritz-Olifants		Low	C	
E8	Touws		Low	C	
F12	Duiwenhoks	Duiwenhoks Wetland System	Mod	D	Flood attenuation and sediment trapping. Donga erosion. Invasive woody vegetation.
		Goukou River Wetland	7.1		Rare vegetation type. WQ amelioration. Prevention of flooding. Refer to section 2.4.
F13	Lower Gouritz		Mod	C/D	
G14	Groot Brak		Mod	C	
G15	Coastal	Gwaing River System			Refer to section 2.4.
		Wilderness Lakes System			Refer to section 2.4.
		Bitou Wetland	Mod	C	Moderate EIS as flows limited to Keurbooms Estuary. Already transformed by agriculture. Birds. Flood attenuation. Refer to section 2.4.
I18	Hessequa	Gouriqua Wetland	5		Possible new snail species. Refer to section 2.4.
A1	Upper Breede Tributaries	Die Vlakte Wetland	5.9		WQ amelioration and provision for river.
		Kluitjieskraal Wetland	N/A		WQ amelioration, provision of water, ecotourism (cycling). Lower wetland destroyed
A2	Breede Working Tributaries	Papenkuils Wetland	8.3		Rare veg type. Scarce wetland type. WQ amelioration. Flood prevention.
A3	Middle Breede Renosterveld				
B4	Riviersonderend Theewaters				
B5	Overberg West				

F10	Overberg East Renosterveld	Diepte Gatt	5.4	B	Large seep wetland. Rare plant species. Water source area.
		Elias Gat	4.1	C	WQ amelioration, provision of water.
		Salmonsdam	6.5	A	High EIS. Water source area.
F11	Lower Breede Renosterveld				
H16	Overberg West Coastal	Vermont Pan	5.3	B/C	High EIS due to waterbirds.
		Groot Witvlei	6.2	B	High EIS due to rare plant species and amphibians. Recreation.
		Malkopsvlei	6	B	
		Hemel-en-Aarde	5.6	B/C	WQ amelioration, provision of water, flood prevention.
		Belsvlei	5	E	Scarce wetland type, WQ amelioration, flood prevention. Lower very little functioning remains.
H17	Overberg East Fynbos	Gansbay Wetland	3.8		Distinct wetland due to Milkwood trees.
		Algulhas Salt Pan	6.2	B	High EIS due to endemic veg, birds, amphibians. Tourism important. Refer to section 2.4.
		Soetendalsvlei	9.1		Unique aquatic system. Flood prevention. WQ amelioration and tourism. Refer to section 2.4.
		Voelvlei	6.2		Rare wetland type with unique hydrology. Refer to section 2.4.
		Groot Hagerkraal Wetlands	7.3	A/B	High EIS due to vegetation. Refer to section 2.4.

2.6 Rivers: ecological state status quo

2.6.1 Approach

Some information pertinent to describing the status quo of rivers has already been summarised in previous reports, namely the data gathered and interrogated during the delineation of biophysical and allocation nodes and that used to *type* the rivers toward IUA delineation. That useful from these data toward status quo description are summarised here.

The following information and GIS layers were required to complete the procedure of selecting nodes:

- Quaternary, secondary and primary catchment boundaries (from http://www.dwaf.gov.za/iwqs/gis_data/RHPdata.htm)
- Rivers on a 1:500 000 scale (from http://www.dwaf.gov.za/iwqs/gis_data/RHP data.htm)
- Level I Ecoregions (from http://www.dwaf.gov.za/iwqs/gis_data/RHPdata.htm)
- Gauging weirs – from Department of Water Affairs and Forestry (DWAF)
- Geomorphic zones by Rowntree and Wadeson (1999) (from Chief Directorate Resource Quality Services, Department of Water Affairs (DWA)
- Environmental Water Requirements (EWR) sites (from relevant Reserve studies).
- Hydrological Index Classes based on the hydrological index of Hughes and Hannart (2003) as modified by Dollar *et al*. (2006) and Brown *et al*. (2006).
- Ecological Importance and Sensitivity categories and Present Ecological Status (or habitat integrity) (from various reports, DWA database, updated and augmented with fieldwork in WCWSS).

River IUAs were decided upon by considering a range of information about biophysical drivers known to determine river type and condition, namely flow (perennial or non-perennial), geomorphological zonation, riparian vegetation and adjacent terrestrial vegetation type.

Two DWS data sets describe river ecological condition (Table 2-39, PES 1999 and PES 2014). Change from the former to the latter were used to describe trends and where possible, using other data, to infer reasons for change. This must be interpreted with some caution since the 1999 dataset was compiled via a desktop analysis and the 2014 data were compiled from field assessments and so are inherently more accurate and are reported at a finer scale.

Finally the status quo descriptions were focussed at PES 2014, the most comprehensive data set gathered about river ecological condition using a range of biophysical data to date, including that for vegetation, invertebrates, amphibians and fish. Consideration was also paid to the presence and location of conservation priority areas, summarised by National Freshwater Ecosystem Protected Areas (NFEPA, Nel and Driver 2011). Where possible, causes and sources for the ecological condition 2014 were described as being flow or non-flow related.

Examples of the data categorised used in the descriptions are provided next.

Table 2-39 Scores for Ecological condition and habitat descriptions (Kleynhans and Louw 2007)

Ecological Category	Ecological condition % Score	Description of the habitat
A A/B	92-100% 87-92%	Still in a Reference Condition.
B B/C	82-87% 77-82%	Slightly modified from the Reference Condition. A small change in natural habitats and biota has taken place but the ecosystem functions are essentially unchanged.
C C/D	62-77% 57-62%	Moderately modified from the Reference Condition. Loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged.
D D/E	42-57% 37-42%	Largely modified from the Reference Condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E E/F	22-37% 17-22	Seriously modified from the Reference Condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	0-17%	Critically/Extremely modified from the Reference Condition. The system has been critically modified with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.

2.6.2 Description

The four main data categories used to determine river *type* were flow being perennial or non-perennial, geomorphological zonation, riparian vegetation and adjacent terrestrial vegetation types.

2.6.2.1 Gouritz

Most Gouritz sub-area Rivers are non-perennial; most perennially flowing rivers are located in the southern and south-Eastern region of the sub-area (Figure 2-30). These non-perennial rivers are relatively steep as Upper Foothills drain into Lower Foothills (Figure 2-31), the two most prominent zones sub-area wide.

The most prominent riparian vegetation types are the Southern Karoo Rivers and Muscadel Alluvial Vegetation, both along non-perennial rivers, and freshwater lakes, located along the coast. Various others types are found elsewhere and are less prominent (Figure 2-32).

Upper, Lower and Rainshadow Valley Karoo dominate the northern and central sub-area (Figure 2-33) with Western-Fynbos Renosterveld also prominent in the central region. The eastern-coastal region comprises Eastern-Fynbos-Renosterveld while the western-coastal region comprises Southern Fynbos, East Coast Renosterveld or South Coast Fynbos. There are smaller areas of various other types elsewhere.

2.6.2.2 Breede

Most of the rivers in the Breede sub-area flow perennially, the few non-perennial rivers flow into the Riviersonderend River and others are located in the Overberg region (Figure 2-34).

Upper and Lower Foothills are most prominent (Figure 2-35) throughout the sub-area with some steeper Mountain Streams and Transitional zones being located higher up the tributaries of the Breede, Riviersonderend and Palmiet Rivers respectively.

Cape Lowland Alluvial Vegetation is most prominent along the perennial rivers with smaller patches of Muscadel Alluvial Vegetation along some of the non-perennial rivers (Figure 2-36). Along the coast there are Cape Coastal Lagoons, Cape Lowland Freshwater Wetlands and Cape Estuarine Saltmarshes. There are also scattered Cape Inland Salt Pans.

Fynbos dominates the northern, western and southern parts of the sub-area while Renosterveld dominates central regions (Figure 2-37Figure 2-37). A thin patch of Strandveld occurs linearly along the coast.

Figure 2-30. Perennial and non-perennially flowing rivers in the Gouritz

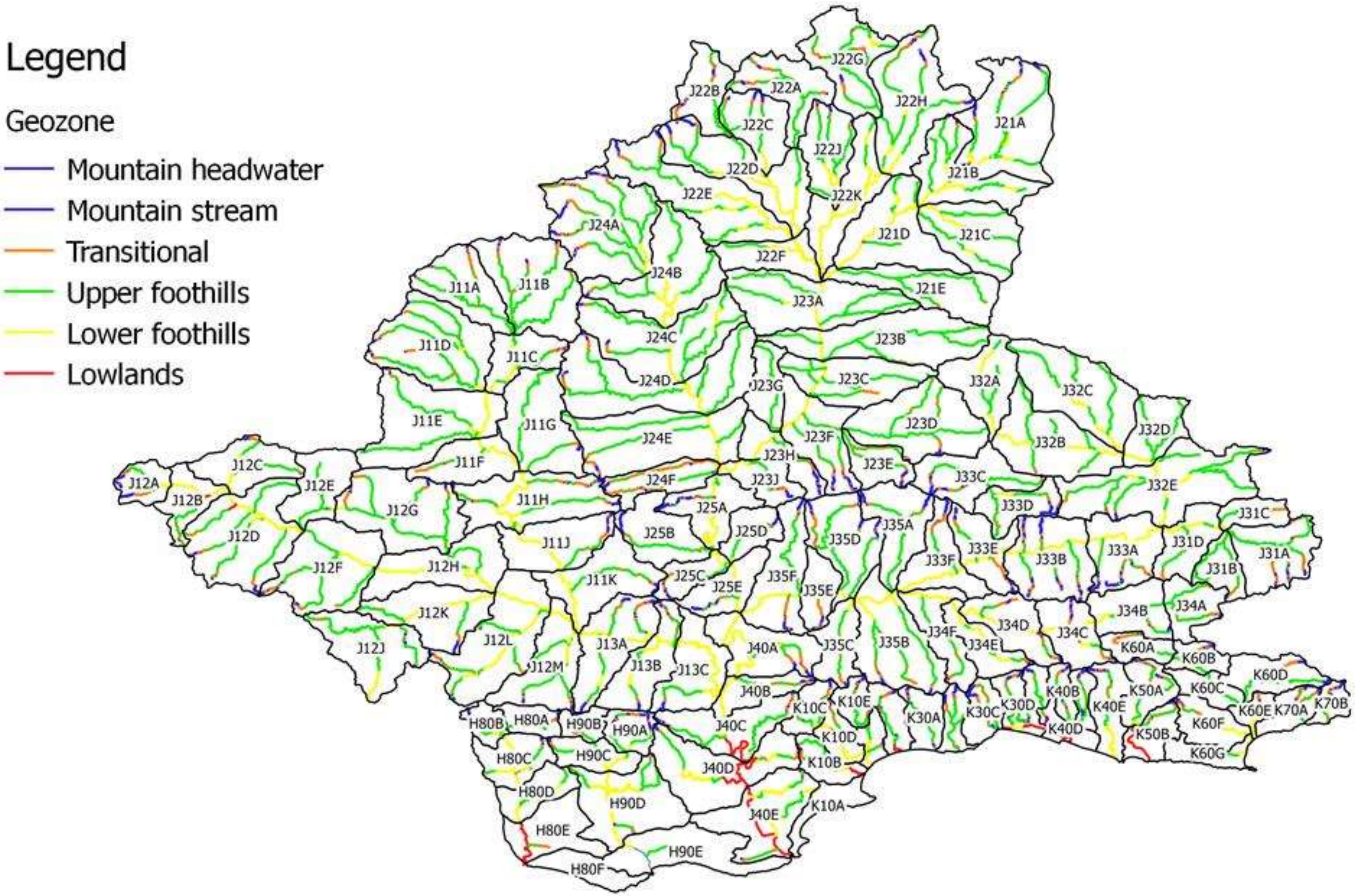


Figure 2-31. Geomorphological zones of the Gouritz

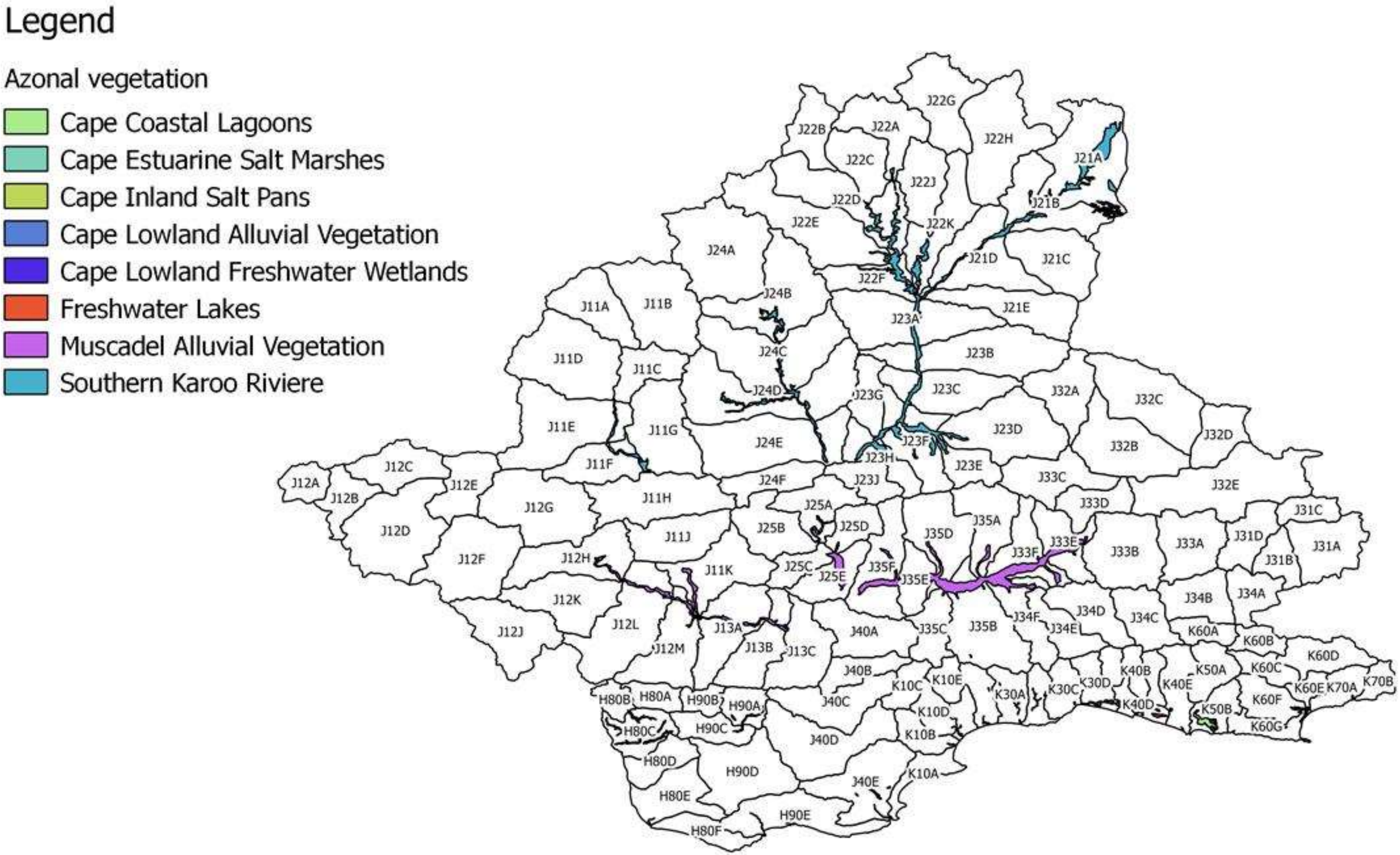


Figure 2-32. Riparian vegetation types of the Gouritz

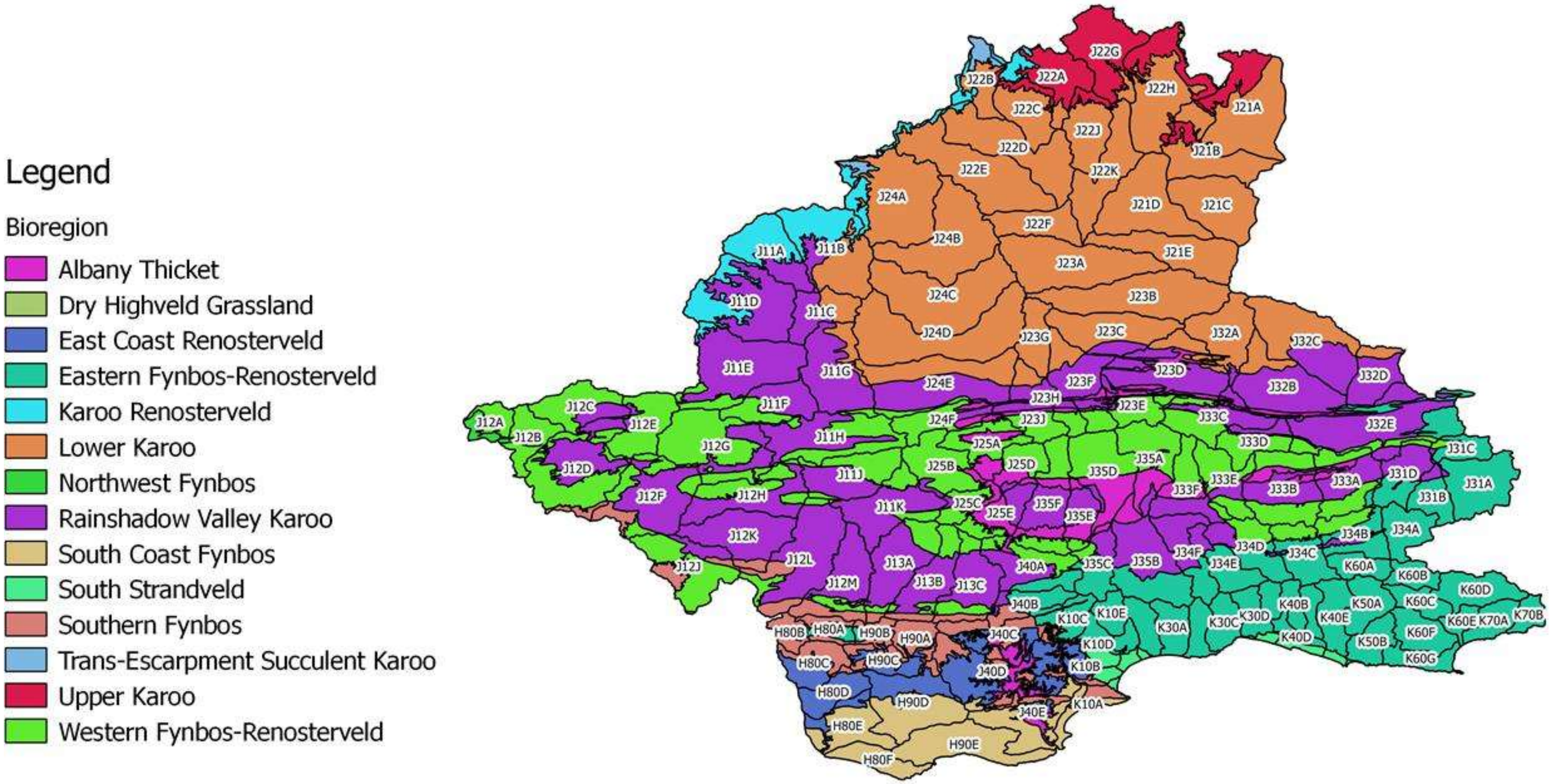


Figure 2-33. Terrestrial vegetation types of the Gouritz

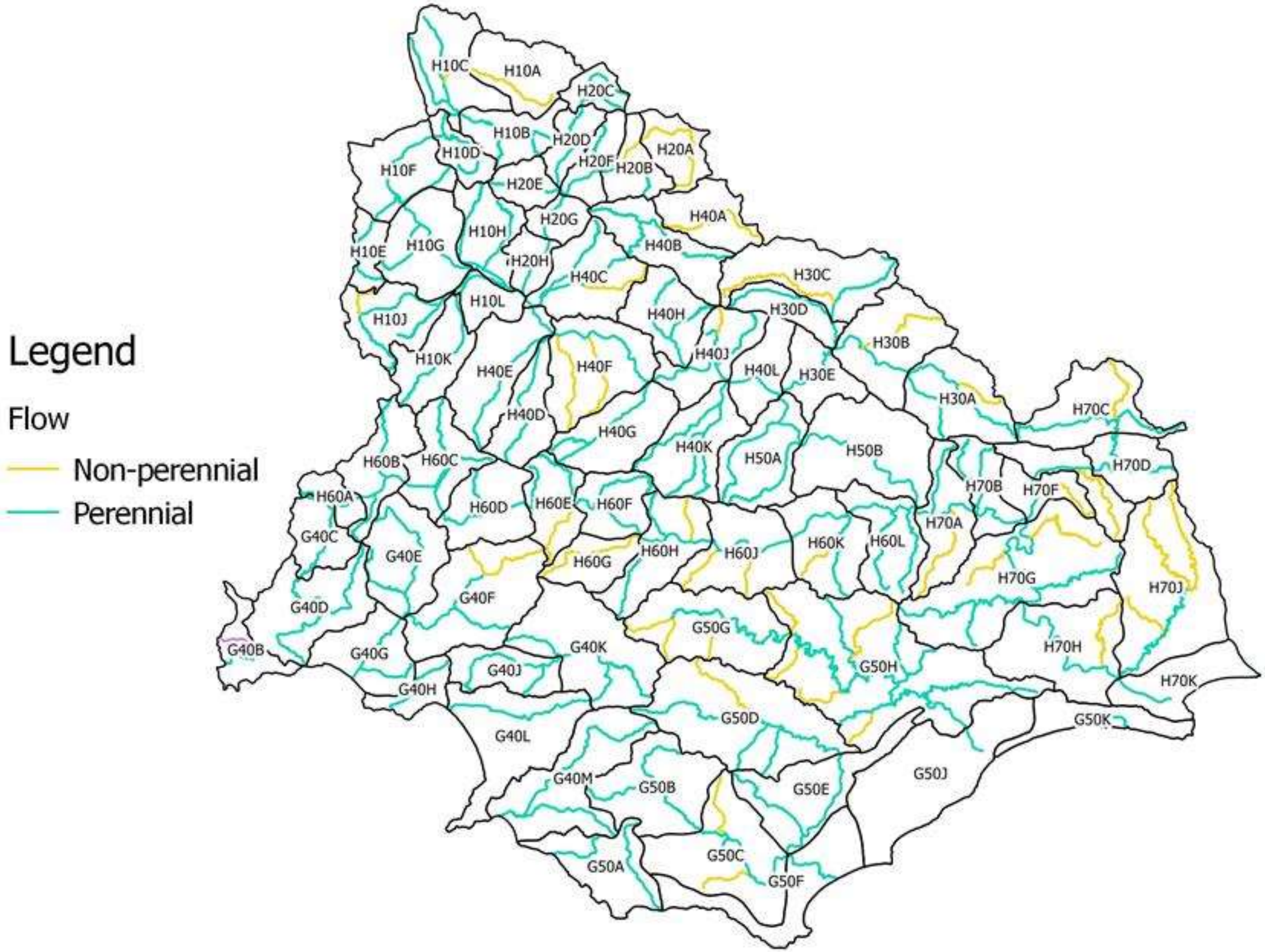


Figure 2-34. Perennial and non-perennially flowing rivers in the Breede

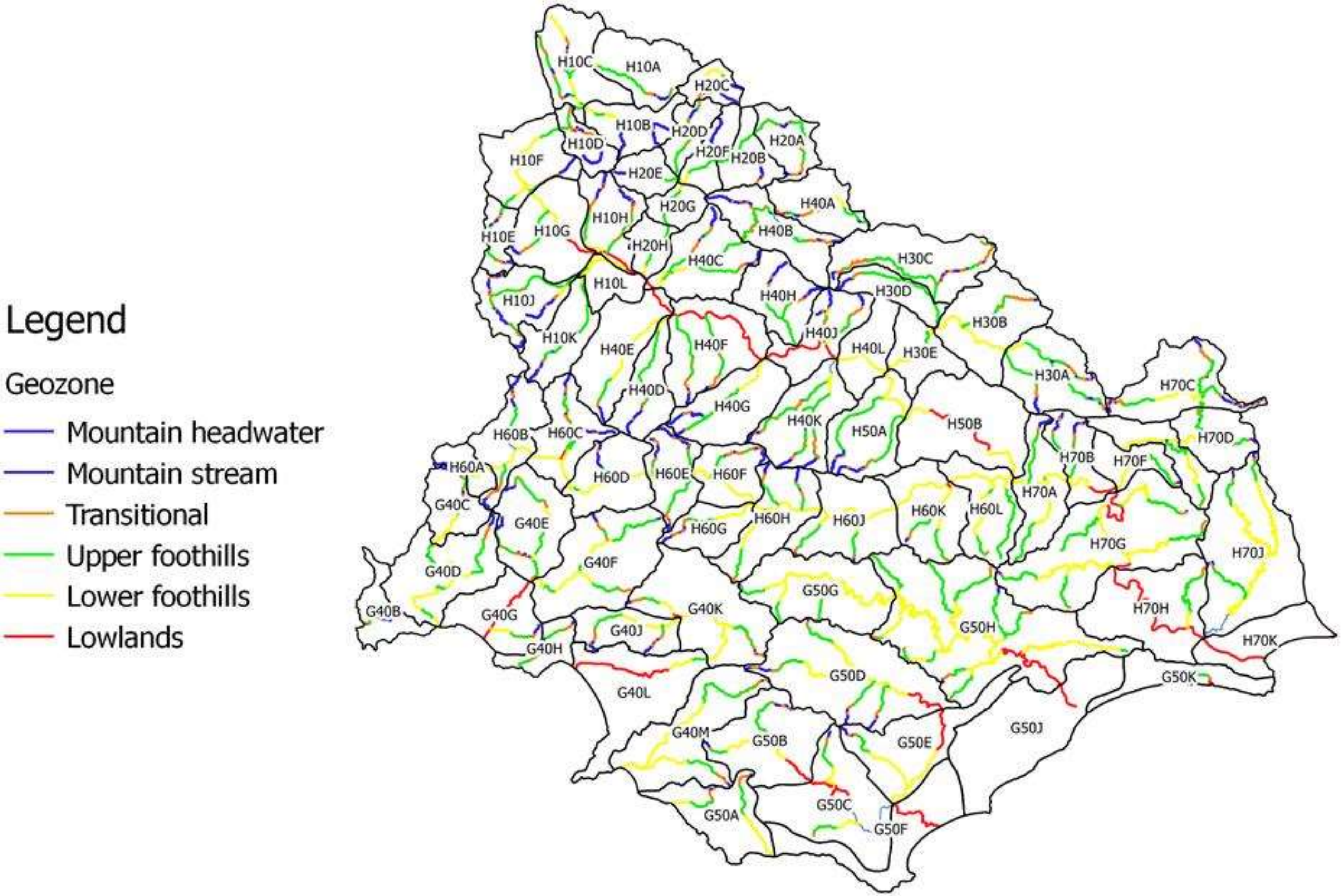


Figure 2-35. Geomorphological zones of the Breede River

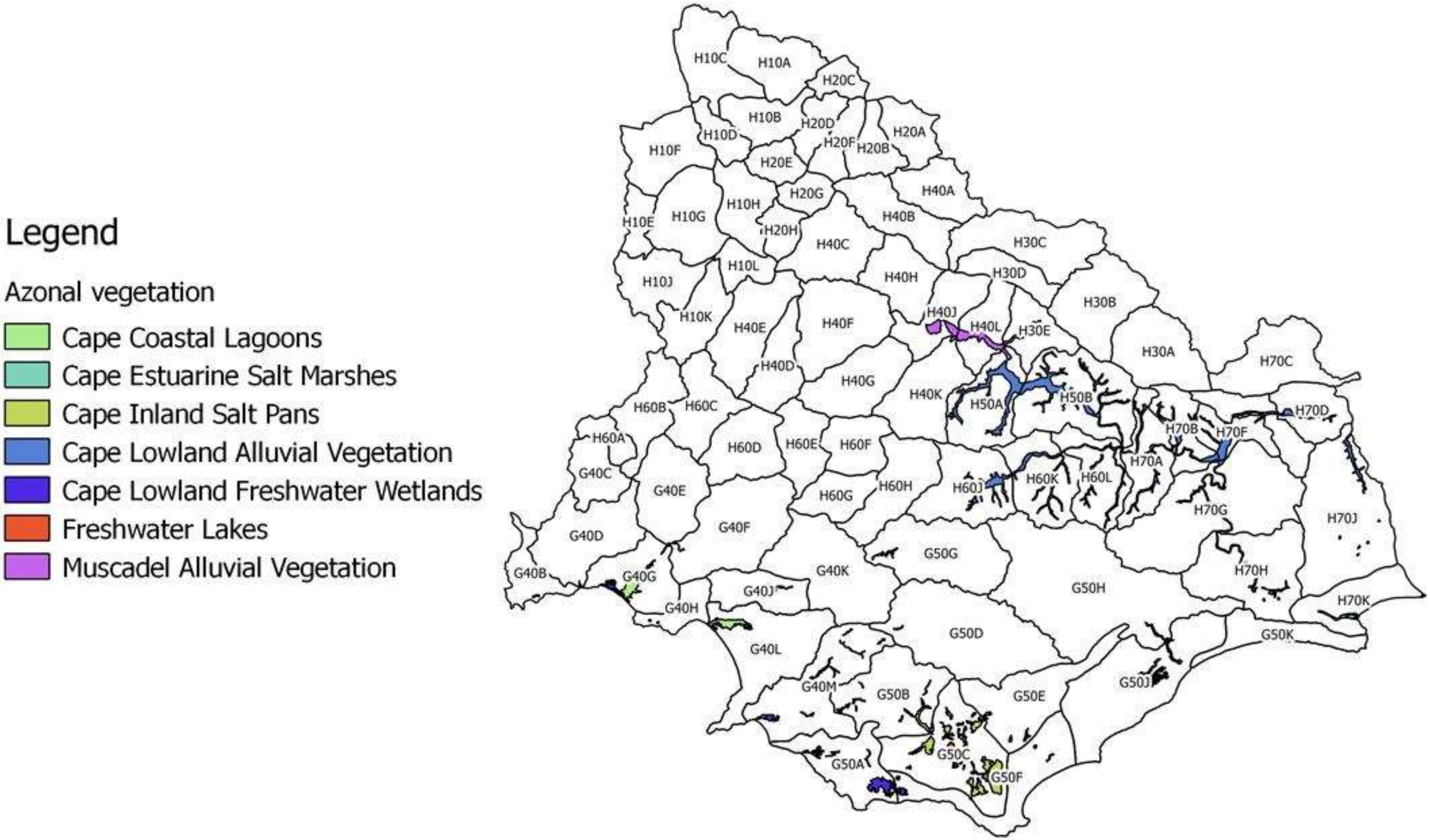


Figure 2-36. Riparian vegetation types of the Breede

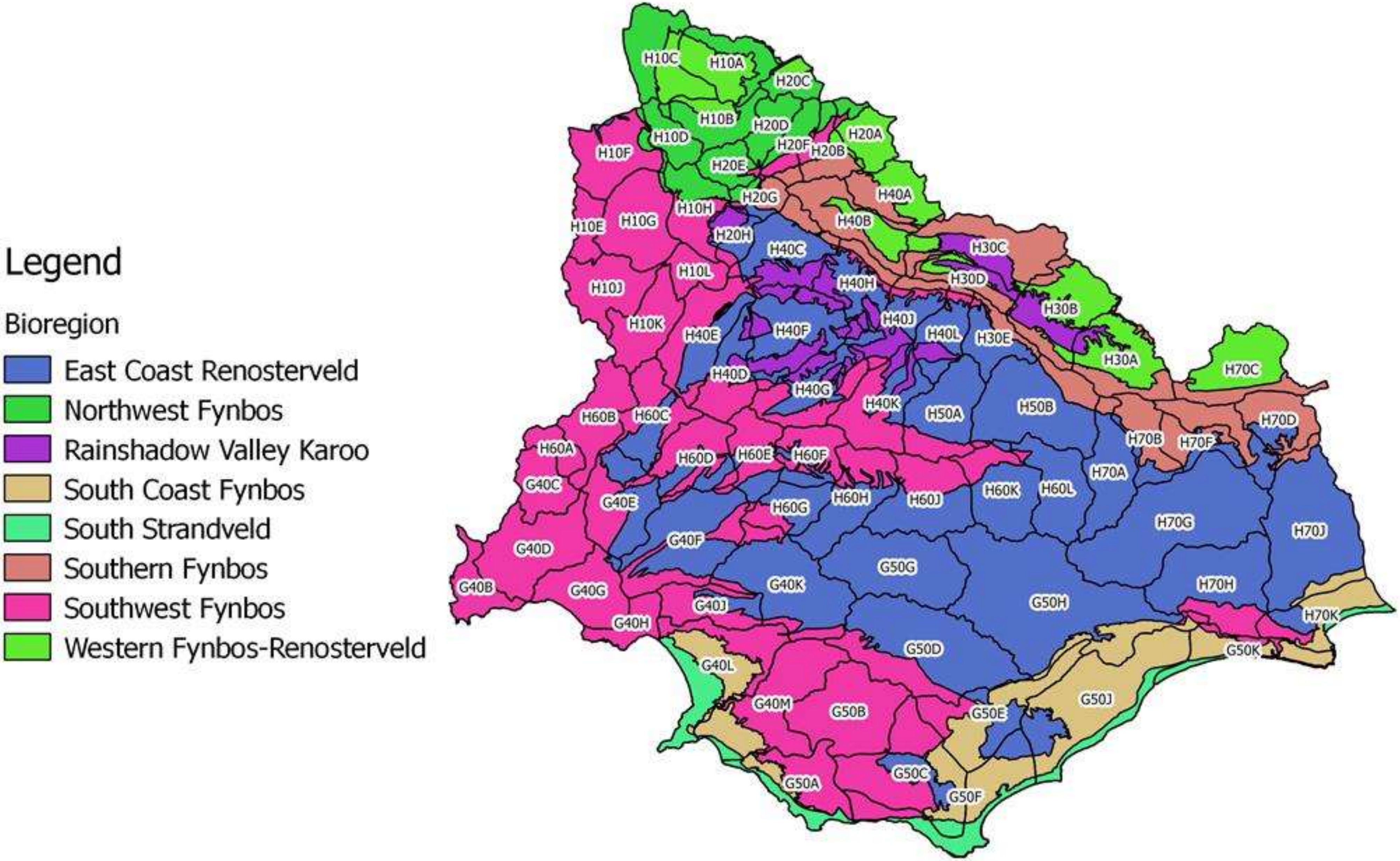


Figure 2-37. Terrestrial vegetation types of the Breede

2.6.3 Status quo assessment

The 1999 and 2014 DWS PES data sets were the main inputs into the status quo descriptions. In what follows the terms ***Present Ecological Status*** are misleading and therefore not used in the context of these status quo descriptions; PES 1999 was based on data gathered prior to 1999 and is no longer *PRESENT.* PES 2014 is also dated thus no longer considered present. Therefore, the term ecological condition, with the post-script dates 1999 or 2014, was used.

2.6.3.1 Gouritz

The ecological condition 1999 of the majority of the sub-area was a C-category, considered to be moderately modified (Figure 2-38). The Olifants River Catchment was largely modified, condition category D, the Lower Gouritz seriously modified, condition category E/F and the coastal rivers slightly modified, condition category B.

Following the more detailed field-based assessment, and potentially with changes over time for various reasons, the northern and western karoid regions of the sub-area were in a better condition 2014, more condition classes A and B for the sub-quaternaries than were scored C (Figure 2-39). The Olifants River Catchment remained largely modified with D-category condition scores but not throughout and not for all sub-quaternaries present. Some parts of the Touws River Catchment, including the main stem river were now largely modified 2014, previously in a moderately modified condition 1999. The same can be said for the Duiwenhoks River Catchment. The condition of the Lower Gouritz has improved from being seriously modified 1999 to largely modified (D-category) with some C or B-category sub-quaternaries. The coastal rivers remained in a slightly modified condition not changing much 1999-2014.

2.6.3.2 Breede

The majority of the Breede sub-area was in a moderately modified condition 1999, condition category C, with some quaternaries in an A, B, or E/F category and the upper tributaries of the Breede River being largely modified, condition category D (Figure 2-40).

Following the more detailed field-based assessment, and potentially with changes over time for various reasons, much of what was moderately modified (C-category) now was shown to be largely (D-category) to seriously modified (E-category). In general, most of the rivers across the Breede River sub-area were in a largely to seriously modified condition 2014, apart from a few of the upper tributaries and some of the coastal estuary inflowing rivers (Figure 2-41Figure 2-41).

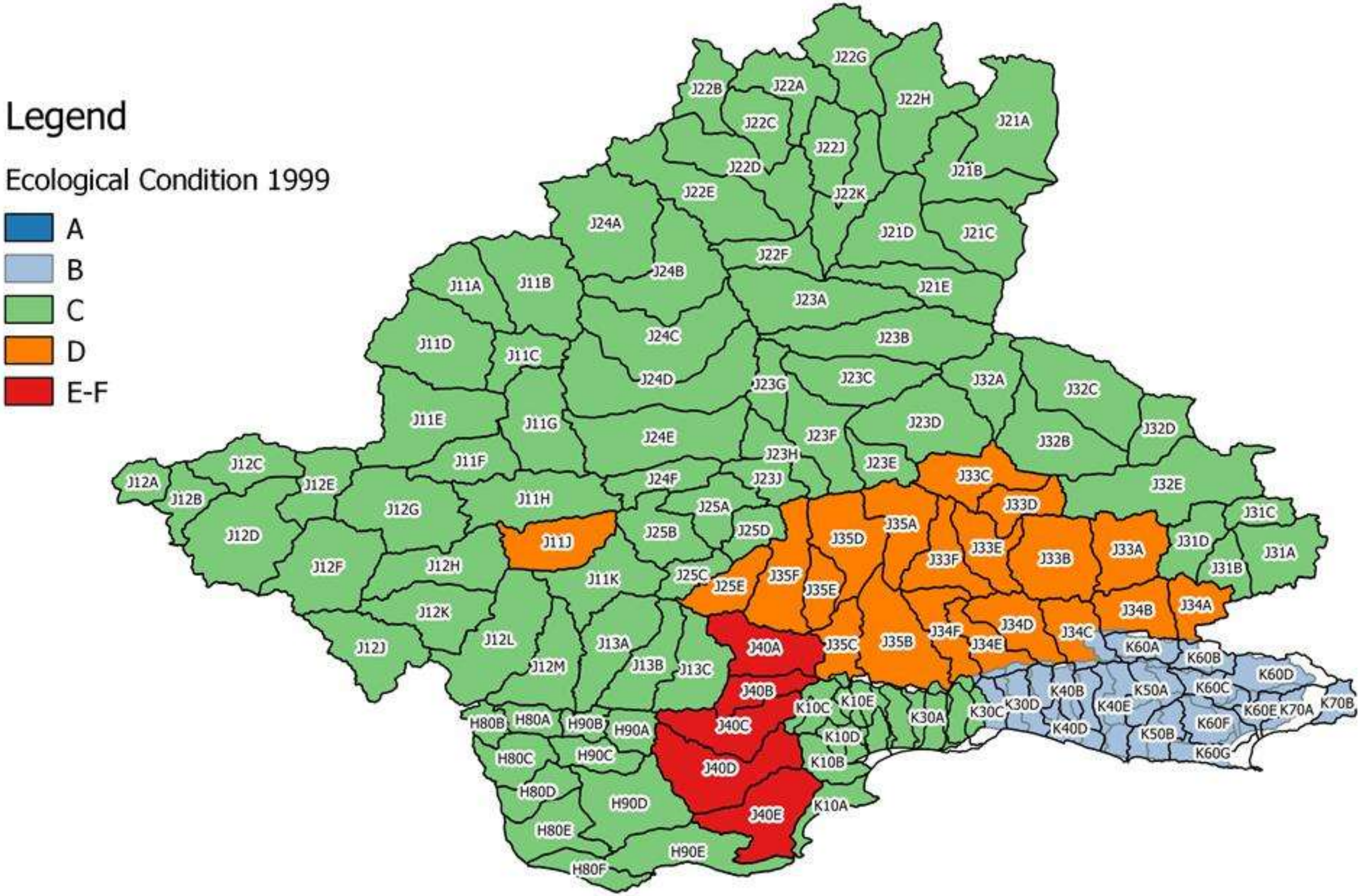


Figure 2-38. Gouritz ecological condition 1999 at quaternary level

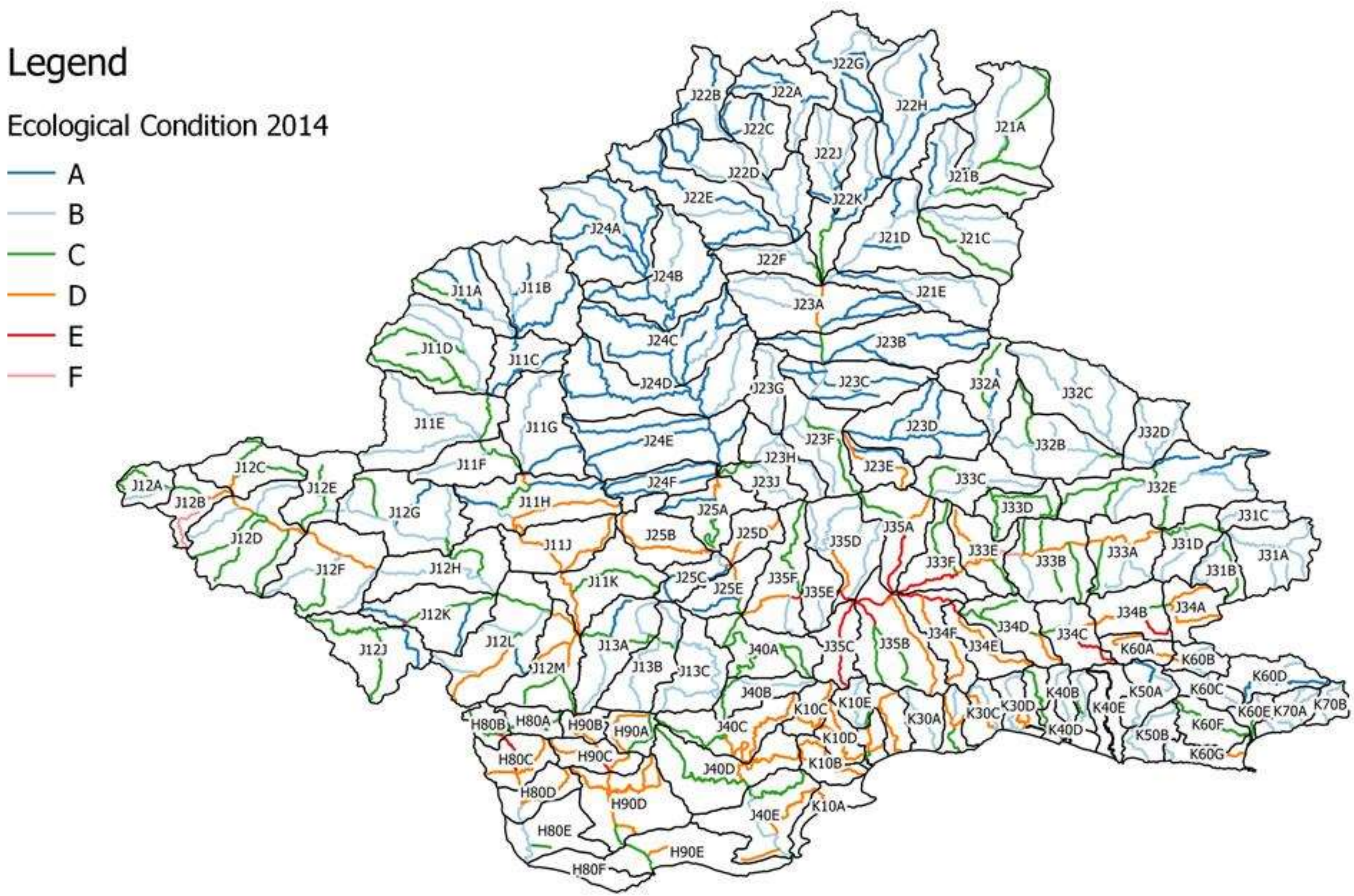


Figure 2-39. Gouritz ecological condition 2014 at a sub-quaternary level

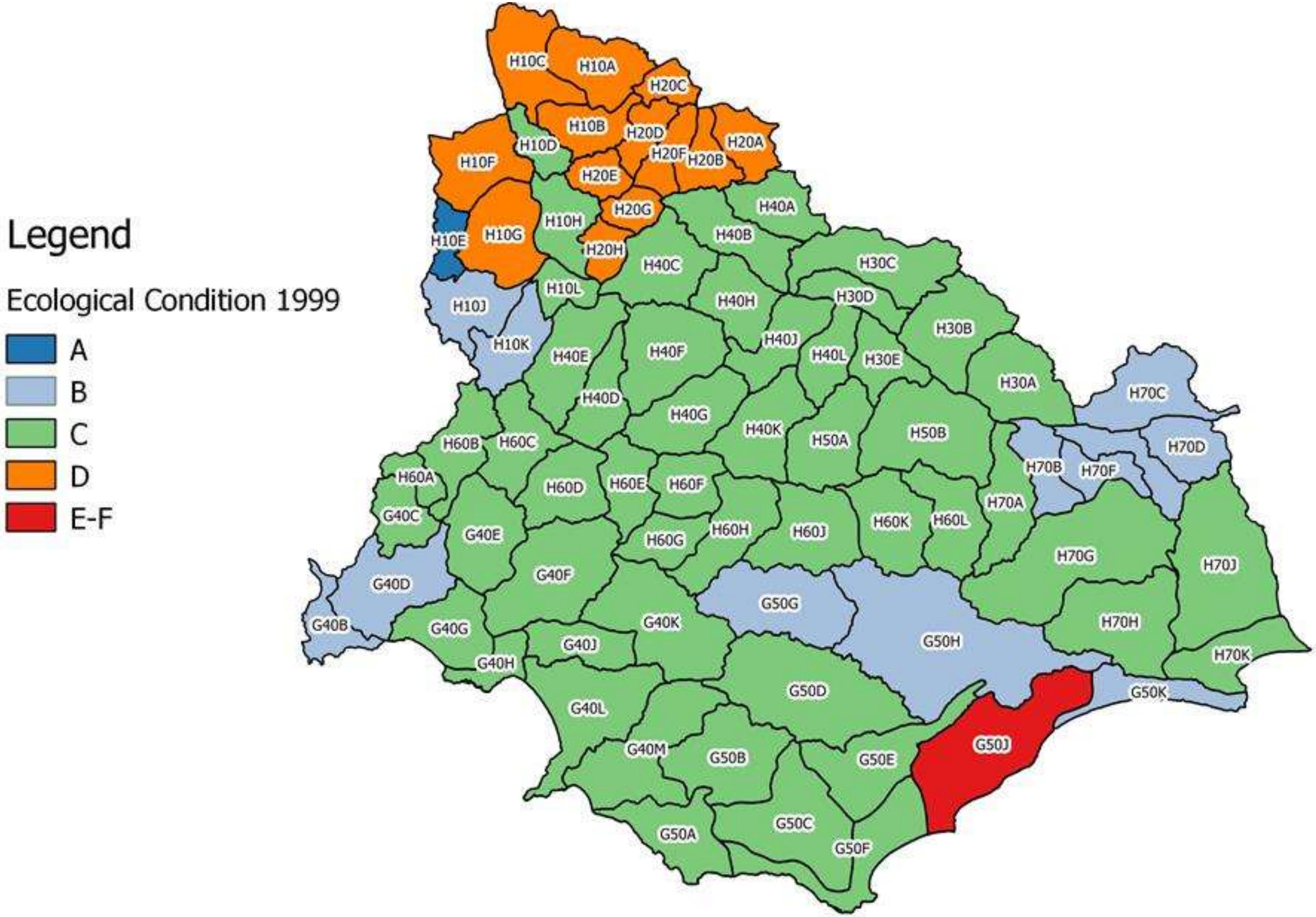


Figure 2-40. Breede ecological condition 1999 at a quaternary level

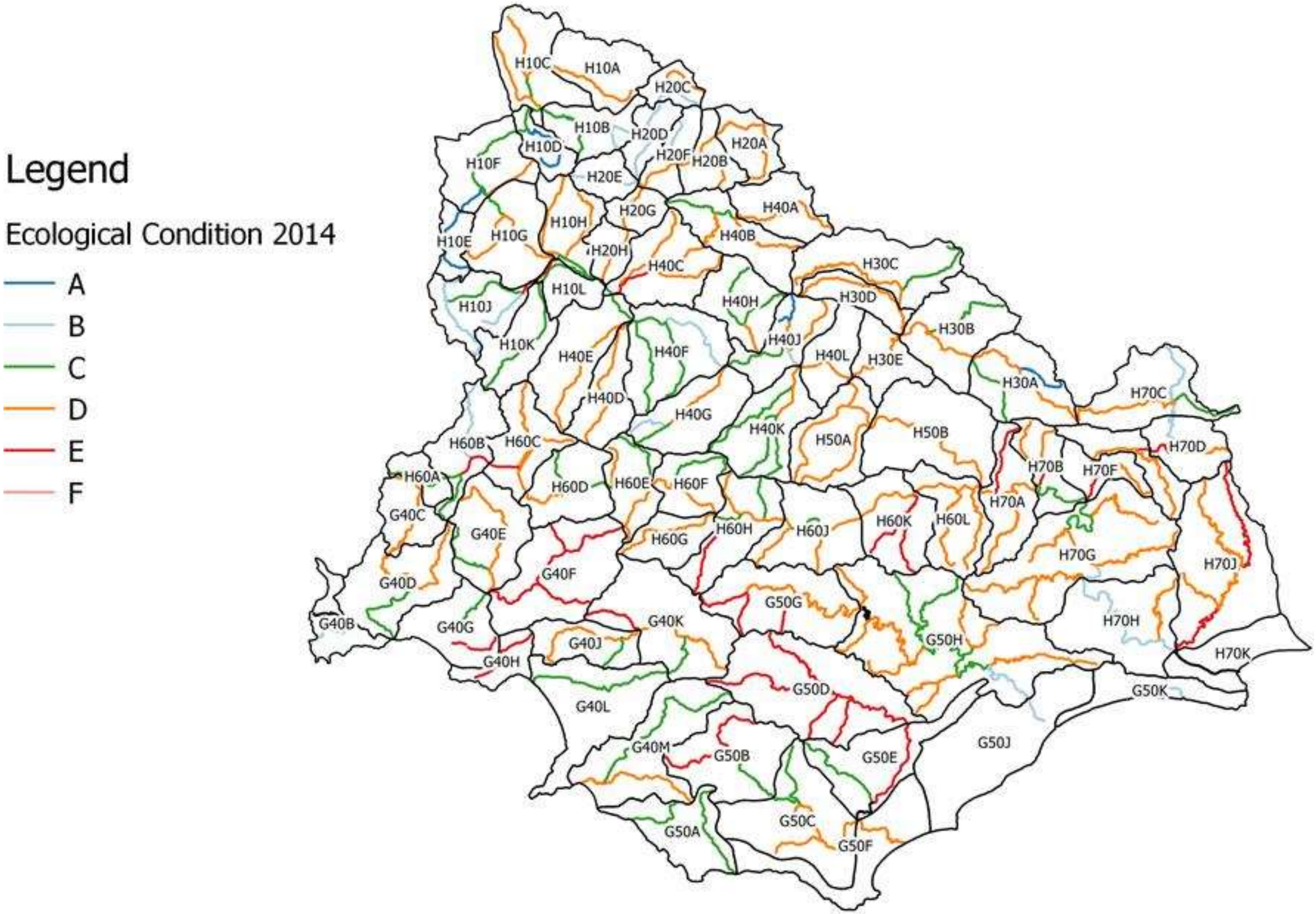


Figure 2-41. Breede ecological condition 2014 at a sub-quaternary level

3 BIOPHYSICAL & ALLOCATION NODES

3.1 General approach

For River Nodes we defined the biophysical and allocation river nodes for the study area according to the procedures described in WRCS (Dollar et al. 2006). Eleven “tiers” of information were sequentially assessed, and rules applied, in order to establish nodes for each tier. Nodes for all significant dams are included as part of River Nodes.

For Estuary Nodes we followed the National Biodiversity Assessment approach in which the estuarine functional zone (EFZ) was formulated as the lateral boundaries of an estuary up to the 5 m contour, with the downstream node taken as the estuary mouth and the upstream node taken as the limits of tidal variation or salinity penetration, whichever penetrates furthest.

3.2 River and Estuary nodes

There are 147 biophysical and allocation nodes in the Gouritz sub-area (Figure 3-1, Table 3-1) and there are 114 biophysical and allocation nodes in the Breede sub-area (Figure 3-2, Table 3-2 and Table 3-3).

The locations of the estuary nodes for the Gouritz component of the WMA are presented in Table 3-2 and the locations of the estuary nodes for the Breede sub-area are presented in Table 3-4.

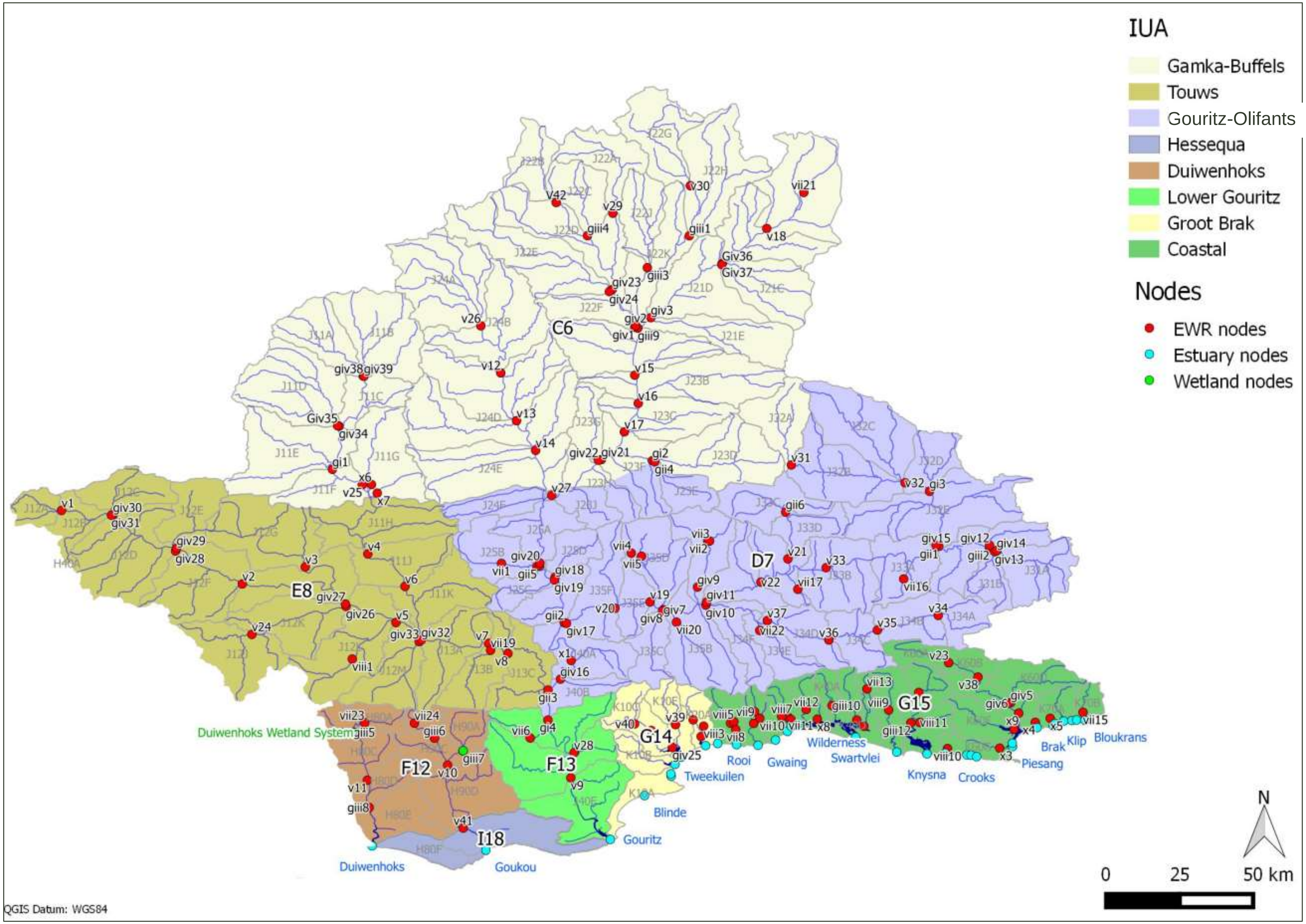


Figure 3-1. Biophysical and allocation nodes in the Gouritz

Table 3-1 Biophysical and allocation nodes in the Gouritz

IUA	SQ CODE	CODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
Tou	J12B-08556	gv1	U/s of Verkeerdevlei reservoir, d/s of confluence Smalblaar Bok	Donkies	19.8480	-33.3309	J12B	WFM	3	UF	H	C	C		NP
Tou	J12B-08605	giv31	U/s confluence Donkies Ysterdams	Donkies	20.0333	-33.3455	J12B	SFM	3	UF	M	C	D	FishCorrid	NP
Tou	J12C-08526	giv30	U/s confluence Ysterdams Donkies	Ysterdams	20.0394	-33.3451	J12C	SFM	3	UF	H	C	D		NP
Tou	J12D-08735	giv28	U/s confluence Touws Kragga	Touws	20.2714	-33.4567	J12D	SFM	3	UF	H	C	D	FishFSA	NP
Tou	J12E-08645	giv29	U/s confluence Kragga Touws	Kragga	20.2753	-33.4477	J12E	SFM	3	UF	H	C	C	FishCorrid	NP
Tou	J12F-08751	gv2	d/s of confluence Touws Stinkfontein se	Touws	20.5192	-33.5584	J12H	SFM	3	UF	H	C	B	FishFSA	NP
Tou	J12H-0871	gv3	u/s of reservoir	Prins	20.7529	-33.5059	J12G	SFM	3	UF	H	C	C	FishCorrid	NP
Tou	J12H-08834	giv27	U/s confluence Touws Brak	Touws	20.9021	-33.6208	J12H	SFM	3	UF	M	C	B	FishCorrid	P
Tou	J12J-08970	gv24	Placed u/s of Bellair reservoir	Gatkraal se	20.5545	-33.7146	J12J	SFM	3	UF	H	C	C	Upstream	NP
Tou	J12K-08887	giv26	U/s confluence Brak Touws	Brak	20.9042	-33.6280	J12K	SFM	3	UF	H	C	C	FishCorrid	NP
Tou	J12L-08985	gviii1		Doring	20.9274	33.7904	J12L	SFM	3	UF	H	C	D	FishFSA	P
Tou	J12M-08904	gv5	D/s confluence Touws Doring	Touws	21.0896	-33.6779	J12M	SFM	3	UF	H	C	D	FEPA	P
Tou	J12M-08976	giv33	U/s confluence Touws Groot	Touws	21.1757	-33.7367	J12M	SFM	3	UF	H	C	D	FishFSA	P
Tou	J11J-08686	gv4		Groot	20.9852	-33.4657	J11J	SFM	3	UF	H	D	D		P
Tou	J11K-08828	gv6	D/s confluence Groot Swartberg	Groot	21.1232	-33.5662	J11K	SFM	3	UF	H	C	D	Upstream	P
Tou	J11K-08860	giv32	U/s confluence Groot Touws	Groot	21.1842	-33.7316	J11K	SFM	3	UF	H	C	D	Upstream	P
Tou	J13B-08923	gv7	D/s confluence Groot Huis	Groot	21.4334	-33.7421	J13B	SFM	3	UF	H	C	C		NP
Tou	J13B-08993	gvii19	gauge J1H017	Derde	21.4408	-33.7636	J13B	SFM	3	UF	VH	C	B	FEPA	NP
Tou	J13C-08915	gv8	D/s confluence Groot Bos	Groot	21.5054	-33.7736	J13C	SFM	3	L	VH	C	B	FEPA	NP
Tou	J13C-09099	gii3	u/s confluence Groot Gouritz	Groot	21.6543	-33.8861	J13C	SFM	3	UF	H	C	B	Phase2FEPA	P
G B	J11A-07923	giv38	U/s confluence Buffels Swaerskraal se	Buffels	20.9683	-32.913	J11A	GK	3	UF	H	C	B	Upstream	NP
G B	J11B-08099	giv39	U/s confluence Swaerkraal se Buffels	Swaerkraal se	20.9710	-32.9136	J11B	GK	3	UF	H	C	A	Upstream	NP
G B	J11C-08151	giv34	U/s confluence Buffels Meintjiesplaas	Buffels	20.8783	-33.0691	J11C	GK	3	UF	H	C	B	FishFSA	NP
G B	J11D-08269	giv35	U/s confluence Meintjiesplaas Buffels	Meintjiesplaas	20.8730	-33.0676	J11D	GK	3	UF	H	C	A	Upstream	NP
G B	J11F-08460	gi1	d/s confluence Wilgehout Buffels	Buffels	20.8536	-33.2033	J11F	GK	3	UF	H	C	C	FishFSA	NP
G B	J11F-08427	gv25	Placed u/s of Floriskraal reservoir	Buffels	20.9646	-33.2511	J11F	SFM	3	UF	H	C	C	FEPA	NP
G B	J11G-08230	gx6	U/s reservoir, inflow J11G	Geelbek	20.9987	-33.2505	J11G	SFM	3	UF	H	C	B	Upstream	NP
G B	J11G-08407	gx7	U/s reservoir inflows from J11G	Hartbeesspruit	21.0202	-33.2771	J11G	SFM	3	UF	H	C	A	Upstream	P
G B	J21A-07211	gvii21	Springfontein reservoir	Kuils	22.6041	-32.3389	J21A	GK	3	UF	H	C	C	FishFSA	NP
G B	J21B-07533	gv18	D/s confluence Gamka Stols	Gamka	22.4664	-32.4519	J21B	GK	3	LF	VH	C	B	FishFSA	NP
G B	J21B-07611	giv36	U/s confluence Gamka Put	Gamka	22.3005	-32.5616	J21B	GK	3	LF	VH	C	B	Upstream	NP
G B	J21C-07664	giv37	U/s confluence Put Gamka	Put	22.3000	-32.5655	J21D	GK	3	LF	H	C	B	Upstream	NP
G B	J21D-07700	giv3	U/s confluence Gamka Veldmans	Gamka	22.0363	-32.7307	J21D	GK	3	LF	H	C	B	FEPA	NP
G B	J21E-07830	giii9	u/s confluence Gamka Leeu	Gamka	21.9877	-32.7635	J21E	GK	3	LF	VH	C	B	FEPA	NP
G B	J22B-07311	gV42		Teekloof	21.6846	-32.37056	J22D	GK	3	UF	VH	C	B		NP
G B	J21C-07446	giii4	u/s confluence Waaikraal Teekloof	Waaikraal	21.8007	-32.4744	J22C	GK	3	LF	VH	C	B	Upstream	NP
G B	J22A-07343	gv29		Koekemoers	21.8949	-32.4040	J22D	GK	3	UF	H	C	B	FEPA	NP
G B	J22D-07656	giv23	U/s confluence Koekemoers Wilgerbos	Koekemoer	21.8927	-32.6427	J22D	GK	3	LF	H	C	A	Upstream	NP
G B	J22E-07694	giv24	U/s confluence Wilgerbos Koekemoers	Wilgerbos	21.8820	-32.6493	J22E	GK	3	LF	VH	C	B	Upstream	NP
G B	J22F-07805	giv1	U/s confluence Koekemoer Leeu	Koekemoers	21.9763	-32.7606	J22F	GK	3	LF	VH	C	C	Phase2FEPA	NP
G B	J22H-07280	gv30		Leeu	22.1829	-32.3178	J22H	GK	3	UF	VH	C	A	Upstream	NP
G B	J22K-07551	giii1	d/s confluence Leeu Sand	Leeu	22.1788	-32.4747	J22K	GK	3	LF	VH	C	A	Upstream	NP
G B	J22J-07529	giii3	u/s confluence Hottentots Leeu	Hottentots	22.0231	-32.5745	J22K	GK	3	LF	H	C	A		NP
G B	J22K-07655	giv2	U/s confluence Leeu Koekemoers	Leeu	21.9798	-32.7559	J22K	GK	3	LF	VH	C	C	Upstream	P
G B	J23B-08017	gv15		Gamka	21.9762	-32.9104	J23B	GK	3	LF	H	C	C	Upstream	NP

IUA	SQ CODE	CODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
G B	J23C-08176	gv16	D/s confluence Gamka Groot	Gamka	21.9894	-32.9980	J23C	GK	3	LF	H	C	B	Upstream	P
G B	J23F-08268	gv17	D/s confluence Gamka Gedenksteen se leegte	Gamka	21.93780	-33.0868	J23F	GK	3	LF	H	C	B	FishFSA	P
G B	J23E-08400	gii4	u/s confluence Cordiers Sand	Cordiers	22.0506	-33.1798	J23E	GK	2	T	H	C	D	Upstream	NP
G B	J23F-08328	gi2	d/s confluence Sand Cordiers	Sand	22.0420	-33.1761	J23F	GK	3	UF	H	C	B	Upstream	NP
G B	J23F-08334	giv21	U/s confluence Gamka Kat	Gamka	21.8524	-33.1729	J23F	GK	3	LF	H	C	B	Upstream	P
G B	J23G-08124	giv22	U/s confluence Kat Gamka	Kat	21.8412	-33.1749	J23G	GK	3	UF	H	C	B	Upstream	NP
G B	J23J-08497	gv27	Placed u/s of Gamkapoort reservoir	Gamka	21.6679	-33.2840	J23J	SFM	3	LF	H	C	C	Upstream	P
G B	J24B-07905	gv26	D/s confluence Dwyka Juk	Dwyka	21.4048	-32.7563	J24B	GK	3	UF	H	C	A	FEPA	NP
G B	J24C-08051	gv12	D/s confluence Dwyka Frieshoek	Dwyka	21.4788	-32.9032	J24C	GK	3	LF	H	C	A	FishFSA	NP
G B	J24D-08234	gv13	D/s confluence Dwyka Bad	Dwyka	21.5375	-33.0520	J24D	GK	3	LF	H	C	A	FEPA	NP
G B	J24E-08292	gv14	D/s Dwyka Jakkals/Vlakkraal	Dwyka	21.6083	-33.1444	J24E	GK	3	LF	H	C	A	FishFSA	P
G O	J25A-08567	giv20	U/s confluence Gamka Kobus	Gamka	21.6243	-33.4941	J25A	SFM	3	LF	H	C	C	Upstream	P
G O	J25B-08591	gvii1	gauge H2H005	Kobus	21.4812	-33.4948	J25B	SFM	2	UF	H	C	D	FEPA	NP
G O	J25B-08591	gii5	u/s confluence Kobus Gamka	Kobus	21.6131	-33.5043	J25B	SFM	2	UF	H	C	D	FishFSA	P
G O	J25C-08776	gvii18	gauge J2H010	Gamka	21.6231	-33.5022	J25A	SFM	3	LF	H	C	B	FEPA	P
G O	J25C-08795	giv19	U/s confluence Gamka Nels	Gamka	21.6783	-33.5460	J25C	SFM	3	LF	H	C	D		P
G O	J25D-08626	giv18	U/s confluence Nels Gamka	Nels	21.6808	-33.5376	J25D	SFM	2	LF	H	C	D		P
G O	J25E-08884	gii2	u/s confluence Gamka Olifants/Gouritz	Gamka	21.7142	-33.6784	J25E	SFM	3	LF	H	D	C	FishFSA	P
G O	J31A-08654	giv14	U/s confluence Olifants Hartbees	Olifants	23.3206	-33.4549	J31A	SFM	2	UF	M	C	B	Phase2FEPA	NP
G O	J31B-08675	giv13	U/s confluence Hartbees Olifants	Hartbees	23.3134	-33.4589	J31B	SFM	2	UF	M	C	B	Phase2FEPA	NP
G O	J31C-08569	giv12	U/s confluence Kammanassie Olifants	Kammanassie	23.2937	-33.4389	J31C	SFM	2	UF	H	C	B	FishCorrid	NP
G O	J31D-08592	giii2	d/s confluence NoName Olifants	Olifants	23.2932	-33.4469	J31C	SFM	2	LF	H	C	C	FEPA	NP
G O	J31D-08650	gii1	u/s confluence Olifants Traka	Olifants	23.1051	-33.4423	J31D	SFM	2	LF	H	C	C	Upstream	NP
G O	J23B-08279	gv31		Traka	22.5576	-33.1897	J32B	SFM	3	LF	H	C	B	Upstream	NP
G O	J32D-08383	gv32	D/s confluence Traka Kouka	Traka	22.9799	-33.2451	J32D	SFM	3	LF	H	C	B	FEPA	NP
G O	J23D-08474	gi3	u/s confluence Traka Maermanskraal	Traka	23.0708	-33.2715	J32D	SFM	3	LF	M	C	B	Upstream	NP
G O	J32E-08545	giv15	U/s confluence Traka Olifants	Traka	23.0952	-33.4392	J32E	SFM	3	LF	H	C	C	Phase2FEPA	NP
G O	J33A-08768	gvii16	gauge J3H016	Wilge	22.9747	-33.5429	J33A	SFM	3	UF	H	D	B	Upstream	NP
G O	J33B-08714	gv33	Place u/s Stompdrif reservoir	Olifants	22.6869	-33.5082	J33B	SFM	3	LF	H	D	D	FEPA	P
G O	J33E-08780	gvii17	gauge J3H042	Marnewicks	22.5817	-33.5751	J33E	SFM	2	T	H	D	C	FEPA	NP
G O	J33D-08538	gii6		Groot	22.5367	-33.33604	J33D	SFM	2	UF	VH	D	C	FishFSA	P
G O	J33D-08571	gv21		Meirings	22.5447	-33.4810	J33E	SFM	2	UF	VH	D	C	FishFSA	P
G O	J33E-08757	gv22		Olifants	22.4447	-33.5529	J33F	SFM	2	LF	H	D	D	FEPA	P
G O	J33F-08772	giv11	U/s confluence Olifants Kammanassie	Olifants	22.2434	-33.6147	J33F	SFM	2	LF	H	D	E		P
G O	J34B-08807	gv34		Kammanassie	23.1031	-33.6560	J34B	SFM	2	UF	VH	D	C	Upstream	P
G O	J34B-08817	gv35		Kammanassie	22.8772	-33.7011	J34C	SFM	2	LF	VH	D	D	FishFSA	P
G O	J34C-08869	gv36	U/s confluence Kammanassie Gansekraal	Kammanassie	22.6969	-33.7319	J34D	SFM	2	LF	H	D	C	FishFSA	P
G O	J34D-08868	gv37	Placed u/s of Kammanassie reservoir	Kammanassie	22.4685	-33.6719	J34D	SFM	2	LF	VH	D	C		P
G O	J34E-08910	gvii22	Kammanassie reservoir	Brak	22.4402	-33.7023	J34E	SFM	2	LF	H	D	D	Upstream	P
G O	J34F-08848	giv10	U/s confluence Leeu Koekemoer	Leeu	22.2404	-33.6241	J34F	SFM	2	LF	VH	D	E		P
G O	J35A-08544	gvii2	gauge J3H014	Grobbelaars	22.2474	-33.4260	J35A	SFM	2	UF	VH	D	C	FishCorrid	P
G O	J35A-08551	gvii3	gauge J3H015	Klein Leroux	22.2543	-33.4257	J35A	SFM	2	UF	VH	D	D	Upstream	P
G O	J35A-08653	giv9	U/s confluence Grobbelaars Olifants	Grobbelaars	22.2091	-33.5683	J35A	SFM	2	UF	H	D	E	Phase2FEPA	P
G O	J35B-08881	gvii20	gauge J3H017	Kandelaars	22.1311	-33.6766	J35B	SFM	2	LF	H	D	E	FishFSA	P
G O	J35C-08821	giv7	U/s confluence Olifants Moeras	Olifants	22.0830	-33.6382	J35D	SFM	2	LF	H	D	E	Upstream	P
G O	J35C-08882	giv8	U/s confluence Moeras Olifants	Moeras	22.0798	-33.6414	J35C	SFM	2	LF	H	D	E	FEPA	P
G O	J35D-08603	gvii4	gauge J3H020	Meul	21.9635	-33.4632	J35D	SFM	2	T	VH	D	B	Upstream	NP

IUA	SQ CODE	CODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
G O	J35D-08578	gvii5	gauge J3H018	Wynands	22.0013	-33.4728	J35D	SFM	2	UF	VH	D	B	Upstream	NP
G O	J35E-08764	gv19	D/s confluence Olifants Wynands	Olifants	22.0332	-33.6143	J35E	SFM	2	LF	H	D	E		P
G O	J35F-08849	gv20	D/s confluence Olifants Vlei	Olifants	21.9024	-33.6339	J35F	SFM	2	LF	H	D	E	FishFSA	NP
G O	J35F-08739	giv17	U/s confluence Olifants Gouritz	Olifants	21.7226	-33.6805	J35F	SFM	2	LF	H	D	D		P
G O	J40A-08924	gx1	U/s confluence Slang Gouritz	Slang	21.7403	-33.7950	J40A	SFM	2	UF	H	C	C	FishCorrid	NP
G O	J40A-09020	giv16	U/confluence Gouritz Kamma	Gouritz	21.7005	-33.8525	J40A	SFM	2	LF	H	C	C	Phase2FEPA	P
G O	J40B-09106	gi4	quat outlet J40B	Gouritz	21.6539	-33.9786	J40B	SCB	2	LF	VH	C	C	Phase2FEPA	P
L G	J40C-09156	gvii6	gauge J4H003	Weyers	21.5881	-34.0339	J40C	SCB	2	UF	VH	C	C	FishFSA	P
L G	J40D-09236	gv28	D/s confluence Gouritz Langtou	Gouritz	21.7510	-34.0791	J40D	SCB	2	L	H	C	D	FishFSA	P
L G	J40E-09284	gv9		Gouritz	21.7388	-34.1564	J40E	SCB	2	L	H	C	C		P
Dui	H80A-09154	gvii23	IBT	Duiwenhoks	20.9729	-33.9872	H80A	SCB	1	UF	VH	C	C	FishCorrid	P
Dui	H80C-09208	giii5		Duiwenhoks	20.9314	-34.0163	H80B	SCB	1	LF	VH	C	E	Upstream	P
Dui	H80D-09286	gv11		Duiwenhoks	20.9834	-34.1633	H80D	SCB	1	LF	VH	C	D	Upstream	P
Dui	H80E-09314	giii8		Duiwenhoks	20.9902	-34.2475	H80D	SCB	1	LF	VH	C	B	FEPA	P
Dui	H90B-09155	gvii24	IBT	Korinte	21.1580	-33.9882	H90B	SCB	1	T	H	C	D	Upstream	P
Dui	H90B-09155	giii6		Korinte	21.2330	-34.0346	H90C	SCB	1	UF	H	C	D	Upstream	P
Dui	H90C-09229	giii7	d/s confluence Goukou Kruis	Goukou	21.3386	-34.0732	H90C	SCB	1	UF	VH	C	D	FEPA	P
Dui	H90D-09287	gv10	D/s confluence Goukou Vet	Goukou	21.2815	-34.1173	H90D	SCB	1	LF	VH	C	D		P
Hes	H90E-09343	gv41		Goukou	21.3395	-34.3107	H90E	SCB	1	LF	H	C	C	FEPA	P
G-B	K10D-09159	gv40	D/s confluence Kouma Halekraal	Palmiet	21.9757	-33.9907	K10D	SCB	1	LF	H	C	D	FishFSA	NP
G-B	K10D-09121	gx2	U/s confluence Ruiterbos Palmiet, for Witels Reserve	Ruiterbos	22.0376	-34.0106	K10D	SCB	1	UF	VH	C	D	FishCorrid	NP
G-B	K10D-09163	giv25	U/s confluence Brandwag Klein Brak	Brandwag	22.1163	-34.0632	K10D	SCB	1	LF	H	C	D	Phase2FEPA	P
G-B	K10F-09139	gv39	D/s confluence Moordkuil Beneke	Moordkuil	22.1276	-33.9928	K10F	SCB	1	UF	H	C	D		P
G-B	K20A-09083	gvii7	gauge K2H002	Groot-Brak	22.2227	-34.0292	K20A	SCB	1	UF	VH	C	D	FishCorrid	P
G-B	K20A-09083	gviii2		Groot-Brak	22.1932	-33.9781	K20A	SCB	1	UF	VH	C	D	Upstream	P
G-B	U	gviii3		Varing	22.2320	-33.9973	K20A	SCB	1	U	U	C	CD	Upstream	P
Coa	K30A-09087	gviii4		Maalgate	22.3320	-33.9883	K30A	SCB	1	UF	VH	C	B		P
Coa	K30A-09087	gvii8	gauge K3H003	Malgate	22.3512	-34.0077	K30A	SCB	1	UF	VH	C	B	FishFSA	P
Coa	U	gviii5		Moeras	22.3443	-33.9837	K30A	SCB	1	U	U	C	D		P
Coa	K30B-09082	gvii9	gauge K3H004	Malgas	22.4210	-33.9529	K30B	SECB	1	UF	VH	C	B	FishFSA	P
Coa	K30B-09115	gvii10	gauge K3H007	Rooi	22.4404	-33.9732	K30B	SECB	1	UF	H	C	D	Upstream	NP
Coa	K30B-09151	gviii6		Gwaing	22.418	-33.9889	K30B	SCB	1	UF	H	C	C		P
Coa	K30C-09093	gviii7		Swart	22.5217	-33.9675	K30C	SECB	1	UF	H	B	D		P
Coa	K30C-09065	gvii11	gauge K3H001	Kaaimans	22.5472	-33.9714	K30C	SECB	1	UF	H	B	B	FEPA	P
Coa	U	gviii8		Silver	22.5561	-33.9767	K30C	SECB	1	T	VH	B	B		P
Coa	K30D-09042	gvii12	gauge K3H005	Touws	22.6128	-33.9459	K30D	SECB	1	UF	VH	B	B	Upstream	P
Coa	K30D-09108	gx8	DWS reserve	Klein Keurbooms	22.6543	-33.9757	K30D	SECB	1	MH	VH	B	D	Upstream	P
Coa	K40A-09027	giii10		Diep	22.7089	-33.9338	K40A	SECB	1	UF	VH	B	D	Upstream	P
Coa	K40B-09022	giii13		Hoekraal	22.8007	-33.9784	K40B	SECB	1	LF	VH	B	B	Phase2FEPA	P
Coa	K40C-09036	gvii13	gauge K4G002	Karatara	22.8383	-33.8830	K40C	SECB	1	UF	VH	B	B	FEPA	P
Coa	K40C-09140	giii11		Karatara	22.8271	-33.9977	K40C	SECB	1	UF	VH	B	B	Upstream	P
Coa	K40E-09016	gviii9		Goukou	22.9192	-33.9477	K40E	SECB	1	UF	VH	B	BC		P
Coa	K50A-09069	gvii14	gauge K5H002	Knysna	23.0308	-33.8935	K50A	SECB	1	UF	VH	B	B	Upstream	P
Coa	K50B-09111	gviii11	EWR 2 Outeniqua	Gouna	23.0346	-33.9862	K50B	SECB	1	UF	VH	B	B	Upstream	P
Coa	K50B-09117	giii12		Knysna	23.0016	-33.9872	K50A	SECB	1	UF	U	B	B	Upstream	P
Coa	K60G-09180	gviii10		Noetzie	23.1376	-34.0663	K60G	SECB	1	U	VH	B	B	Upstream	NP
Coa	K60G-09200	gx3	Piesang River EWR site	Piesang	23.3314	-34.0651	K60G	SECB	1	UF	VH	B	D	Upstream	P

IUA	SQ CODE	CODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
Coa	K60F-09092	giv4	U/s confluence Bitou Keurbooms	Bitou	23.3847	-34.0069	K60F	SECB	1	LF	VH	B	C	Upstream	P
Coa	K60A-08947	gv23		Keurbooms	23.1418	-33.8021	K60B	SECB	1	UF	VH	B	D	FEPA	P
Coa	K60C-08992	gv38		Keurbooms	23.2506	-33.8462	K60C	SECB	1	UF	VH	B	B		P
Coa	K60C-08992	giv6	U/s confluence Keurbooms Palmiet	Keurbooms	23.3618	-33.9271	K60C	SECB	1	UF	VH	B	B	Upstream	P
Coa	K60D-08996	giv5	U/s confluence Palmiet Keurbooms	Palmiet	23.3720	-33.9253	K60D	SECB	1	UF	VH	B	A	Upstream	P
Coa	K60E-09097	gx9	D/s confluence Keurbooms Duiwelsgat	Keurbooms	23.4018	-33.9573	K60E	SECB	1	LF	VH	B	B	Upstream	P
Coa	K70A-09110	gx4	U/s confluence	Buffels	23.4636	-33.9858	K70A	SECB	1	U	VH	B	B		NP
Coa	K70A-09086	gx5	U/s confluence	Sout	23.5189	-33.9731	K70A	SECB	1	U	VH	B	B	Upstream	NP
Coa	K70B-09055	gvii15	gauge K7H001	Bloukrans	23.64061	-33.9546	K70B	SECB	1	UF	VH	B	B	Upstream	P

IUA = Integrated Units of Analysis: Tou = Touws, G B = Groot Buffels, O B = Olifants Catchment, L G = Lower Gouritz, Dui = Duiwenhoks, Hes = Hessequa, G-B = Groot Brak, Coa = Coastal. SQ = sub-quaternary, as used in DWS 2014 PES/EIS dataset. LONG = longitude, LATI = latitude, QUAT = quaternary. ER = Ecoregion: WFM = Western Cape Fold Mountains, SMF = Southern CFM, GK = Groot Karoo, SCB = Southern Coastal Belt, SECB = Southeastern CB. GZ = geozone: UF = upper foothill, T = transitional, LF = lower foothill, L = lowland. EISC = Ecological Importance and Sensitivity: VH = verh high, H = high, M = moderate. EC = Ecological Condition. FEPA = Freshwater Ecosystem Priority Area: FSA = Fish Support Area, Corrid = corridor. Flow: P = perennial, NP = non-perennial. U = unclassified.

Table 3-2. Details of the estuary nodes of the Gouritz (names in bold are primary estuaries)

Estuary	Area (ha) incl. floodplain	Channel area (ha)	Mouth Node		Top Node	
			Longitude	Latitude	Longitude	Latitude
Gouritz	1 049.4[1]	319.0	21°53'09.25"	34°20'43.23"	21°44'37.18"	34°09'27.45"
Duiwenhoks	419.3[3]	108.3	21°00'04.26"	34°21'54.11"	20°59'30.94"	34°15'05.98"
Goukou	372.3[3]	122.4	21°25'24.70"	34°22'42.07"	21°18'29.59"	34°17'31.97"
Blinde	4.1[3]	2.1	22°00'46.61"	34°12'39.06"	22°00'32.00"	34°12'20.37"
Tweekuilen	9.8[2]	1.6	22°06'34.82"	34°09'05.77"	22°06'08.03"	34°09'03.32"
Gericke	3.6[2]	0.9	22°06'40.01"	34°08'38.20"	22°06'19.50"	34°08'27.76"
Hartenbos	236.9[3]	30.5	22°07'32.82"	34°06'54.40"	22°05'02.53"	34°06'42.98"
Klein Brak	976.9[3]	89.4	22°08'54.91"	34°05'34.55"	22°04'12.26"	34°04'26.25"
Groot Brak	205.1[3]	65.6	22°14'21.45"	34°03'26.11"	22°13'15.26"	34°01'32.99"
Rooi	-	<0.1	22°17'03.51"	34°03'03.31"	N/A	N/A
Maalgate	22.2[3]	17.0	22°21'15.98"	34°03'15.80"	22°21'07.69"	34°02'30.07"
Gwaing	10.6[3]	4.2	22°26'02.90"	34°03'23.29"	22°25'43.65"	34°02'48.46"
Skaapkop	1.1[2]	0.2	22°29'56.23"	34°02'11.86"	22°29'52.38"	34°02'8.88"
Meul	1.8[2]	0.3	22°32'34.46"	34°00'47.23"	22°32'25.68"	34°00'43.78"
Kaaimans	20.6[3]	9.0	22°33'25.40"	33°59'52.13"	22°33'33.41"	33°59'13.24"
Wilderness	1 091.7[3]	501.8	22°34'52.06"	33°59'44.73"	22°36'20.05"	33°58'26.54"
Swartvlei	2 037.9[1]	114.5	22°47'46.52"	34°01'53.46"	22°48'02.00"	33°58'10.44"
Goukamma	213.1[3]	45.3	22°56'56.89"	34°04'37.78"	22°55'54.68"	34°00'11.66"
Knysna	2 284.1[1]	1691.7	23°03'41.23"	34°04'57.74"	23°00'11.69"	33°59'53.81"
Noetsie	14.8[3]	8.0	23°07'44.95"	34°04'49.09"	23°08'21.36"	34°04'23.92"
Grooteiland	0.9[2]	0.2	23°12'34.55"	34°05'09.55"	23°12'38.77"	34°05'8.78"
Kranshoek	-	<0.1	23°13'27.76"	34°05'11.68"	N/A	N/A
Crooks	0.6[2]	0.0	23°14'44.74"	34°05'28.92"	23°14'45.52"	34°05'24.01"
Piesang	59.5[3]	4.9	23°22'43.54"	34°03'37.67"	23°21'21.29"	34°03'44.92"
Keurbooms	1 523.4[1]	398.2	23°22'41.47"	34°02'59.46"	23°19'57.04"	33°59'48.75"
Matjies	2.5[3]	0.5	23°28'12.66"	34°00'07.07"	23°28'10.78"	33°59'49.62"
Brak	-	<0.1	23°31'49.54"	33°59'49.05"	23°31'42.38"	33°59'49.53"
Sout (Oos)	13.8[3]	1.7	23°32'11.55"	33°59'22.21"	23°31'47.92"	33°59'07.00"
Groot (Wes)	64.4[3]	30.2	23°34' 09.05"	33°58'54.41"	23°33'24.02"	33°57'50.19"
Helpmekaars	-	<0.1	23°35'57.52"	33°58'48.34"	N/A	N/A
Klip	0.4[2]	<0.1	23°37'01.35"	33°58"42.35"	23°37'01.44"	33°58'41.56"
Bloukrans	4.2[1]	2.3	23°38'50.89"	33°58'46.72"	23°38'44.82"	33°58'33.14"

[1]Based on combination of NBA national estuary layer (delineated using the 5 m topographical contour obtained from Chief Directorate Surveys and Mapping), 5 m contour from SRTM data (http://eros.usgs.gov/) and satellite imagery

[2]Based on 5 m contour from SRTM data (http://eros.usgs.gov/) and satellite imagery.

[3]Based on NBA national estuary layer

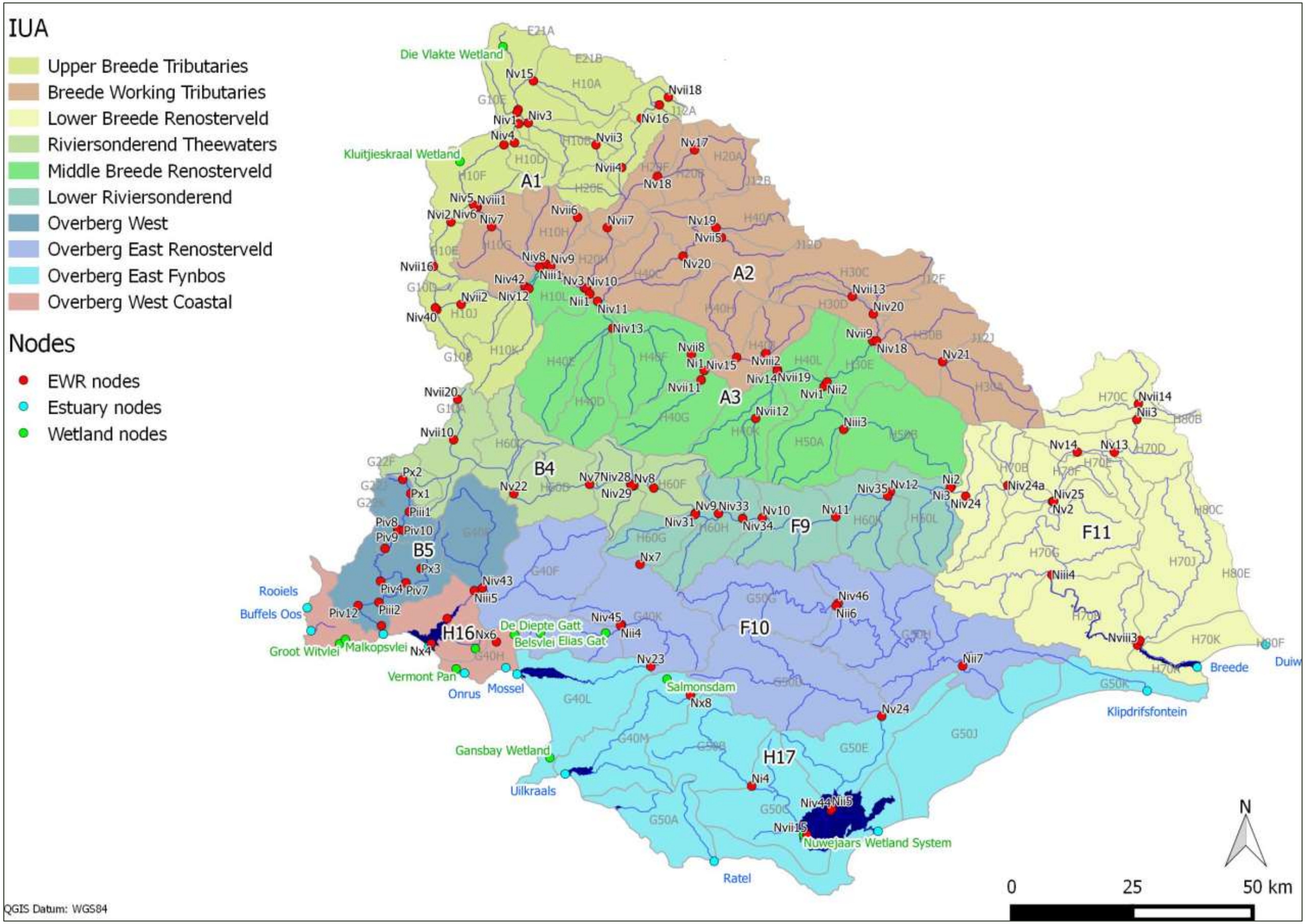


Figure 3-2. **Biophysical and allocation nodes in the Breede**

Table 3-3 Biophysical and allocation nodes in the Breede

IUA	SQ code	NODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
UBT	H10A-08511	Nv15		Skaap	19.3353	-33.2999	H10C	WFM	1	LF	H	D	D	Upstream	NP
UBT	H10C-08644	Niv2	U/s of confluence with Koekedou	Dwars	19.3006	-33.3544	H10C	WFM	1	LF	H	D	C	Upstream	P
UBT	H10C-08560	Niv1	U/s of confluence with Dwars	Koekedou	19.2983	-33.35961	H10C	WFM	1	UF	VH	D	D	FEPA	P
UBT	H10B-08746	Nvii3	U/s of confluence with Titus, at gauge H1H016	Rooikloof	19.4777	-33.4214	H10B	WFM	1	T	VH	D	B	FEPA	P
UBT	H10B-08700	Niv3	U/s of confluence with Breede	Titus	19.3236	-33.3798	H10C	WFM	1	LF	VH	C	C	FishCorrid	P
UBT	H10D-08702	Nvi4	2 km d/s of confluence with Dwars/ Titus	Breede	19.3022	-33.3812	H10C	WFM	1	UF	H	C	C		P
UBT	H10D-08755	Niv4	U/s of confluence with Breede	Witels	19.2924	-33.4174	H10D	WFM	1	T	VH	C	A	FEPA	P
UBT	H10F-08730	Nvi3	U/s of junction of roads R46/ R43	Breede	19.2684	-33.4214	H10D	WFM	1	UF	H	C	C		P
UBT	H10E-08836	Nvii16	u/s Gawie se water IBT	Witte	19.1081	-33.4214	H10E	WFM	1	UF	VH	A	A	FEPA	P
UBT	H10E-08836	Nvi2	At Tweede Tol on Bainskloof Pass (R303)	Witte	19.1479	-33.5678	H10E	WFM	1	UF	VH	A	A	FEPA	P
UBT	H10E-08836	Niv5	U/s of confluence with Breede	Witte	19.1994	-33.5357	H10F	WFM	1	LF	VH	D	A		P
UBT	H10F-08804	Niv6	U/s of confluence with Breede	Wabooms	19.2062	-33.5382	H10F	WFM	1	UF	H	D	D	FEPA	P
UBT	H10G-08837	Nviii1	D/s confluence Wabooms, EWR 1	Breede	19.2073	-33.5398	H10F	WFM	1	LF	H	D	C		P
UBT	H10J-09038	Niv40	U/s of confluence with Molenaars	Elands	19.1157	-33.7338	H10J	WFM	1	T	VH	C	B	FEPA	P
UBT	H10J-09000	Niv41	U/s of confluence with Molenaars	Krom	19.1123	-33.7301	H10J	WFM	1	T	VH	C	B	FEPA	P
UBT	H10J-08990	Nvii2	At gauging weir H1H018, EWR 2	Molenaars	19.1709	-33.7239	H10J	WFM	1	UF	H	C	C	FEPA	P
UBT	H20C-08642	Nvii17	u/s offtake to E22C, inverdoorn canal IBT	Spek	19.6220	-33.3454	H20C	WFM	1	MS	VH	D	B	FEPA	P
UBT	H20C-08593	Nvii18	u/s offtake to E22C, inverdoorn canal IBT	Valsgat	19.6423	-33.3310	H20C	WFM	1	T	H	D	D	Upstream	P
UBT	H20D-08627	Nv16	also for IBT node d/s as inflow into Roode Elsberg dam	Spek	19.5805	-33.3710	H20D	WFM	1	T	VH	D	B	FEPA	P
UBT	H20C-08627	Nvii4	At gauging weir H2H005, 7 km West of Hex River Valley	Sanddrif	19.5361	-33.4645	H20D	WFM	1	UF	VH	D	B	FEPA	P
BWT	H10G-08889	Niv7	U/s of confluence with Slanghoek	Slanghoek	19.2402	-33.5766	H10G	WFM	1	UF	H	D	D	Upstream	P
BWT	H10G-08844	Niii1	U/s of confluence with Molenaars (Smalblaar)	Breede	19.3491	-33.6536	H10G	WFM	1	LF	H	C	D		P
BWT	H10L-08968	Niv42	Just South of Rawsonville	Smalblaar	19.3159	-33.6899	H10J	WFM	1	UF	H	C	E	Upstream	P
BWT	H10H-08826	Niv8	U/s of confluence with Breede	Jan du Toit	19.3634	-33.6471	H10H	WFM	1	LF	VH	C	D	FEPA	P
BWT	H10H-08850	Nvii6	At gauging weir H1H020, 7.5 km North of Worcester	Hartbees	19.4359	-33.5589	H10H	WFM	1	MH	VH	C	D	Upstream	P
BWT	H10H-08850	Niv9	U/s of confluence with Breede	Hartbees	19.3747	-33.6519	H10H	WFM	1	T	VH	C	D	Upstream	P
BWT	H10K-08972'	Niv12	Just South of Rawsonville	Holsloot	19.3251	-33.6940	H10K	WFM	1	LF	H	C	C	Phase2FEPA	P
BWT	J10H-08895	Nv3	U/s of confluence with Hex (at Brandvlei reservoir)	Breede	19.4510	-33.6928	H10L	WFM	1	LF	H	C	C	FishFSA	P
BWT	H20A-08685	Nv17		Hex	19.7017	-33.4308	H20B	WFM	2	UF	VH	D	D	Phase2FEPA	NP
BWT	H20B-08691	Nv18		Hex	19.6175	-33.4811	H20F	WFM	2	UF	H	D	D	Phase2FEPA	P
BWT	H20H-08839	Nvii7	Gauging weir H2H006, offtake to OverHex u/s	Hex	19.5033	-33.5784	H20G	WFM	1	UF	H	D	D	FishFSA	P
BWT	H20H-08839	Niv10	U/s of confluence with Breede	Hex	19.4565	-33.6941	H20H	WFM	1	LF	H	D	D	FishFSA	P
BWT	H40C-08935	Nii1	D/s of Hex/Breede confluence	Breede	19.4638	-33.7037	H40C	WFM	2	LF	M	C	C	FishFSA	P
BWT	H40A-08809	Nv19		Die Brak	19.7507	-33.5787	H40B	SFM	2	MS	VH	C	D	FishFSA	NP
BWT	H40B-08890	Nvii5	At gauging weir H4H008, 2.3 km North of Worcester	Koo	19.7629	-33.5973	H40B	SFM	2	UF	H	C	D	Upstream	P
BWT	H40B-08880	Nv20		Nuy	19.6756	-33.6325	H40C	WFM	2	UF	VH	C	D	Phase2FEPA	P
BWT	H40C-08999	Niv11	U/s of confluence with Breede	Nuy	19.4813	-33.7180	H40C	WFM	2	LF	H	C	E		P
BWT	H30D-08966	Nvii13	gauge	Keisie	20.0605	-33.7087	H30D	SFM	2	UF	VH	C	D		P
BWT	H30C-08991	Niv20	U/s of confluence with Keisie	Pietersfontein	20.1083	-33.7419	H30C	SFM	2	UF	M	C	D		P
BWT	H30D-09015	Nvii9	U/s of confluence with Kogmanskloof	Keisie	20.1068	-33.7928	H30D	SFM	2	LF	H	C	D		P
BWT	H30B-09048	Nv21		Groot	20.2661	-33.8322	H30B	SFM	2	LF	H	C	D		P
BWT	H30B-08978	Niv18	U/s of confluence with Kogmanskloof	Kingna	20.1160	-33.7928	H30B	SFM	2	LF	H	C	D		P
MBR	H40D-09051	Niv13	U/s confluence Breede, d/s of Doring	Doring	19.5158	-33.7690	H40D	WFM	1	LF	H	C	E		P

IUA	SQ code	NODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
MBR	H40F-09026	Nvii8	Gauging weir H4H017, EWR 3, pumping scheme agterkliphoogte	Breede	19.6947	-33.8187	H40F	SFM	1	LF	H	D	B	Phase2FEPA	P
MBR	H40F-09026	Ni1	U/s of confluence with Poesjenels	Breede	19.7252	-33.8490	H40F	SFM	2	LF	H	D	B	Phase2FEPA	P
MBR	H40G-09126	Nvii11	gauge	Poesnels	19.7240	-33.8666	H40G	SFM	2	LF	H	D	D		P
MBR	H40H-09039	Niv15	U/s of confluence with Breede	Vink	19.7975	-33.8241	H40H	SFM	2	UF	VH	D	D		P
MBR	H40J-09007	Nviii2		Willem Nels	19.8640	-33.8163	H40J	SFM	1	UF	H	D	D		P
MBR	H40J-09072	Nvii19	at outlet H40J, for cogmanskloof et al offtakes IBT	Breede	19.8905	-33.8472	H40J	SFM	1	LF	H	D	B		P
MBR	J40K-09150	Nvii12	gauge	Keisers	19.8407	-33.9395	H40K	SFM	2	LF	VH	D	D	FEPA	P
MBR	H40K-09118	Niv14	U/s of confluence with Breede	Keisers	19.8899	-33.8503	H40K	SFM	2	LF	VH	D	D		P
MBR	H40L-09010	Nvi1	U/s of confluence with Kogmanskloof	Breede	19.9965	-33.8787	H40L	SFM	1	LF	H	C	D		P
MBR	H30E-09032	Nii2	At gauging weir H3H011, u/s of confluence with Breede	Kogmanskloof	20.0032	-33.8704	H30E	SFM	1	LF	VH	D	D		P
MBR	H50A-09168	Niii3	U/s of confluence with Boesmans	Breede	20.0426	-33.9599	H50A	SFM	1	LF	VH	C	D	FEPA	P
MBR	H50B-09129	Ni2	U/s of confluence with Riviersonderend	Breede	20.2866	-'34.0686	H50B	SCB	1	LF	H	C	D		P
MBR	H70A-09186	Niv24a	U/s of confluence with Riviersonderend	Klip	20.4151	-34.0661	H70B	SCB	1	UF	VH	C	E	Upstream	P
MBR	H70B-09251	Nv2	U/s of confluence with Buffelsjag	Breede	20.5172	-34.0656	H70B	SCB	1	LF	H	C	C		P
MBR	H70C-09131	Nvii14	gauge	Huis	20.7114	-33.9118	H70C	SCB	2	UF	VH	C	C	Phase2FEPA	NP
MBR	H70D-09157	Nii3		Tradouw	20.7077	-33.9413	H70D	SCB	2	UF	VH	C	B	Phase2FEPA	P
MBR	H70D-09183	Nv13	At Suurbraak	Buffeljags	20.6567	-34.0027	H70D	SCB	1	LF	H	C	E	Phase2FEPA	P
MBR	H70E-09184	Nv14	U/s of Buffeljags Dam	Buffeljags	20.57258	-34.0027	H70E	SCB	1	LF	H	C	D	Phase2FEPA	P
MBR	H70F-09226	Niv25	U/s of confluence with Riviersonderend	Buffeljags	20.5188	-34.0960	H70F	SCB	1	LF	H	C	E	Upstream	P
RTw	H60B-09162	Nvii20	mont rochelle offtake to Franschhoek, at pump station IBT	Du Toits	19.1629	-33.9032	H60B	SFM	1	MS	VH		B	FEPA	P
RTw	H60B-09162	Nvii10	U/s of Theewaterskloof Dam	Du Toits	19.1539	-33.9795	H60B	SFM	1	UF	VH	C	B	FEPA	P
RTw	H60D-09271	Nv22		Riviersonderend	19.2906	-34.0811	H60D	SCB	1	LF	H	D	D		P
RTw	H60D-09239	Nv7	2.5 km u/s of confluence with Meul	Riviersonderend	19.4633	-34.0636	H60D	SCB	1	LF	VH	C	C		P
RTw	H60E-09127	Niv28	U/s confluence Riviersonderend, d/s of EWR 6	Baviaans	19.5567	-34.0633	H60E	SCB	1	UF	VH	C	B	FEPA	P
RTw	H60E-09302	Niv29	U/s of confluence with Riviersonderend	Sersants	19.5591	-34.0660	H60E	SCB	1	UF	H	C	D		NP
RTw	H60F-09267	Nv8	South of Genadendal, d/s of R404 bridge	Riviersonderend	19.5639	-34.0663	H60E	SCB	1	LF	H	C	D	FishFSA	P
RTw	H60F-09248	Niv30	U/s of confluence with Riviersonderend	Gobos	19.6091	-34.0705	H60F	SCB	1	UF	VH	C	C	FEPA	P
RTw	H60F-09277	Nv9	At confluence with Kwartel	Riviersonderend	19.7049	-34.1178	H60F	SCB	1	LF	H	C	D		P
LRi	H60G-09321	Niv31	U/s of confluence with Riviersonderend	Kwartel	19.703	-34.1202	H60G	SCB	1	LF	H	C	D		NP
LRi	H60H-09275	Niv33	U/s of confluence with Riviersonderend	Soetmelksvlei	19.7563	-34.1185	H60H	SCB	1	UF	VH	C	D	FishFSA	P
LRi	H60H-09280	Niv34	U/s of confluence with Riviersonderend	Slang	19.8113	-34.1277	H60H	SCB	1	UF	VH	C	D		NP
LRi	H60H-09288	Nv10	D/s of confluence with Slang and Lindeshof town	Riviersonderend	19.8562	-34.1265	H60H	SCB	1	LF	VH	D	D		P
LRi	H60K-09263	Nv11	9 km u/s of Stormsvlei, alongside N2	Riviersonderend	20.0232	-34.1247	H60J	SCB	1	LF	VH	D	D		P
LRi	H60K-09297	Niv35	U/s of confluence with Riviersonderend	Kwassadie	20.1414	-34.0853	H60K	SCB	1	LF	VH	D	E		P
LRi	H60L-09252	Nv12	D/s of confluence with Kwassadie	Riviersonderend	20.1474	-34.0777	H60K	SCB	1	LF	H	D	D		P
LRi	H60L-09270	Ni3	U/s of confluence with Breede	Riviersonderend	20.2851	-34.0703	H60L	SCB	1	LF	H	D	D		P
LBR	H50B-09129	Niv24	U/s of confluence with Riviersonderend	Leeu	20.3186	-34.0859	H70A	SCB	1	UF	VH	C	E	FishFSA	P
LBR	H70G-09345	Niii4	D/s of EWR 4, at Napkei confluence	Breede	20.5146	-34.2337	H70G	SCB	1	L	H	C	B		P
LBR	H70H-09384	Nviii3		Breede	20.7092	-34.3658	H70H	SCB	1	L	U	C	B		P
LBR	H70J-09358	Niv26	U/s of confluence with Breede	Slang	20.7149	-34.3573	H70J	SCB	1	LF	H	C	E	Upstream	P
OWe	G40C-09305	Px2		Palmiet	19.0381	-34.3573	G40C	SFM	1	MS	H	D	D	Phase2FEPA	P
OWe	G40C-09305	Px1	Was in reservoir	Palmiet	19.0565	-34.0807	G40C	SFM	1	UF	H	D	D	Phase2FEPA	P
OWe	G40C-09305	Piii1	U/s Eikenhof Dam at EWR 1	Palmiet	19.05545	-34.1143	G40C	SFM	1	UF	H	D	D	Phase2FEPA	P
OWe	U	Piv10	U/s of confluence with Palmiet, 0.5km West of R231	Witklippieskloof	19.03684	-34.1463	G40C	SFM	1	U	H	D	D	Phase2FEPA	P
OWe	G40C-09305	Piv9	U/s of confluence with Klipdrif, 0.5km u/s of R231	Palmiet	19.02777	-34.1488	G40C	SFM	1	LF	H	D	D	Phase2FEPA	P

IUA	SQ code	NODE	COMMENT	RIVER	LONG	LATI	QUAT	ER	HI	GZ	EISC	1999EC	2014EC	FEPA	Flow
OWe	U	Piv8	U/s of confluence with Palmiet, 0.5km u/s of R231	Klipdrif	19.02679	-34.1487	G40C	SFM	1	U	H	D	D	Phase2FEPA	P
OWe	G40C-09305	Pvi1	U/s of Applethwaite reservoir	Palmiet	18.99791	-34.1842	G40C	SFM	1	LF	H	D	D	Phase2FEPA	P
OWe	U	Piv4	U/s of confluence with Palmiet	Klein-Palmiet	18.98786	-34.2458	G40D	SFM	1	U	H	C	D	Phase2FEPA	P
OWe	G40D-09333	Px3		Krom/Ribbok	19.0800	-34.2221	G40D	SFM	1	UF	VH	C	D	Upstream	P
OWe	G40D-09333	Piv7	U/s of confluence with Palmiet	Krom/Ribbok	19.04561	-34.2483	G40D	SFM	1	LF	VH	C	D	Upstream	P
OWe	G40D-09369	Piii2	At EWR 3	Palmiet	18.98457	-34.2857	G40D	SFM	1	LF	VH	C	C	FEPA	P
OWe	U	Piv12	D/s confluence of Dwars and Louws, =100% MAR	Dwars/Louws	18.93654	-34.2916	G40D	SFM	1	LF	VH	C	C	FEPA	P
OWe	G40D-09369	Piii3	Top of estuary. Just below or at IFR4	Palmiet	18.99073	-34.3305	G40D	SFM	1	LF	VH	C	C	FEPA	P
OWC	G40G-09370	Nx5	U/s of estuary	Bot	19.1392	-34.6722	G40G	SFM	1	L	VH	D	C		P
OWC	G40G-09370	Nii5		Kars	20.0141	-34.6722	G50C	SCB	2	LF	VH	C	E	FEPA	P
OWC	U	Nx4	Bot Estuary		19.1029	-34.3631	G40G	SFM	1	U	VH	D	U		P
OWC	G40H-09398	Nx6	was in reservoir	Onrus	19.2511	-34.3599	G40H	SFM	1	UF	H	C	E	FishFSA	P
OER	G40F-09365	Niv43		Swart	19.2192	-34.2589	G40F	SFM	1	LF	H	D	E		P
OER	U	Nx7	Steenbok upper	Steenbok	19.5639	-34.2336	G40K	SCB	2	U	VH	C	U		P
OER	G40K-09349	Niv45		Steenbok	19.5357	-34.3275	G40K	SCB	2	LF	VH	C	E		P
OER	G40J-09395	Nii4		Hartbees	19.5337	-34.3923	G40J	SCB	1	LF	VH	C	D		P
OER	G40L-09411	Nv23		Klein	19.6022	-34.4058	G40K	SCB	2	LF	H	C	C		P
OER	G50H-09340	Niv46			20.0287	-34.2874	G50H	SCB	2	LF	H	D	D	Upstream	P
OER	G50G-09352	Nii6		Sout	20.0238	-34.2921	G50H	SCB	2	LF	U	D	D	Upstream	P
OER	G50H-09406	Nii7		DeHoopVlei	20.3117	-34.4051	G50H	SCB	2	L	H	D	B	FEPA	P
OEF	G40M-09414	Nx8		Uilkraal	19.6926	-34.4601	G40M	SFM	1	T	VH	C	C	Phase2FEPA	P
OEF	G50B-09418	Ni4		Nuwejaar	19.8317	-34.6301	G50B	SCB	1	L	H	C	C	FishFSA	P
OEF	G50C-09432	Nvii15	u/s dam	Heuningness	19.9575	-34.7214	G50C	SCB	2	LF	U	C	D	FishFSA	P
OEF	G50C-09432	Niv44		Heuningnes	20.1020	-34.6575	G50C	SCB	2	LF	VH	C	D	FishFSA	P
OEF	G50E-09404	Nv24		Kars	20.1275	-34.4996	G50E	SCB	1	L	H	C	E	FEPA	P
OEF	G50E-09427	Niii5		Bot	19.2008	-34.2635	G40G	SFM	1	L	VH	D	C		P

IUA = Integrated Units of Analysis: UBT = Upper Breede Tributaries, BWT = Breede Working Tributaries, MBR= Middle Breede Renosterveld, RTw = Riviersonderend Theewaters, LRi = Lower Riviersonderend, LBR = Lower Breede Renosterveld, OWe = Overberg West, OWC = Overberg West Coastal, OER = Overberg East Renosterveld, EOF = Overberg East Fynbos. SQ = sub-quaternary, as used in DWS 2014 PES/EIS dataset LONG = longitude, LATI = latitude, QUAT = quaternary. ER = Ecoregion: WFM = Western Cape Fold Mountains, SMF = Southern CFM, SCB = Southern Coastal Belt. GZ = geozone: UF = upper foothill, T = transitional, LF = lower foothill, L = lowland. EISC = Ecological Importance and Sensitivity: VH = verh high, H = high, M = moderate. EC = Ecological Condition. FEPA = Freshwater Ecosystem Priority Area: FSA = Fish Support Area, Corrid = corridor. Flow: P = perennial, NP = non-perennial. U = unclassified.

Table 3-4. Details of the estuary nodes of the Breede (names in bold are primary estuaries)

Estuary	Area (ha) incl. floodplain	Channel area (ha)	Mouth Node		Top Node	
			Longitude	Latitude	Longitude	Latitude
Rooiels	16.0[3]	1.9	18°49'15.76"	34°17'44.79"	18°49'28.61"	34°18'08.71"
Buffels (Oos)	4.7[3]	1.3	18°49'46.33"	34°20'20.21"	18°50'23.05"	34°20'28.56"
Palmiet	28.5[3]	26.0	18°59'38.91"	34°20'43.58"	18°59'22.60"	34°19'47.80"
Bot/Kleinmond	2 039.0[1]	1229.2	19°50'49.68"	34°22'06.35"	19°10'05.76"	34°17'23.74"
Onrus	15.1[3]	3.5	19°10'43.29"	34°25'07.15"	19°11'03.83"	34°24'45.43"
Mossel	-	<0.1	19°16'21.41"	34°24'31.13"	N/A	N/A
Klein	1 802.3[3]	113.6	19°17'53.37"	34°25'14.35"	19°28'22.70"	34°26'10.28"
Uilkraals	702.3[1]	55.7	19°24'27.49"	34°36'27.18"	19°28'26.18"	34°36'16.48"
Haelkraal	59.0[2]	12	19°31'42.10"	34°40'34.93"	19°32'21.06"	34°40'14.80"
Rietfontein	3.0[2]	0.65	19°42'58.52"	34°45'48.84"	19°42'43.54"	34°45'38.99"
Ratel	8.6[3]	1.5	19°44'47.42"	34°46'15.67"	19°44'32.33"	34°45'48.01"
Drie Vleitjies	1.1[2]	0.2	19°46'23.85"	34°45'49.47"	19°46'23.90"	34°45'45.86"
Heuningnes	13 125.8[1]	1451.5	20°07'09.29"	34°42'53.24"	19°56'09.03"	34°42'33.04"
Klipdrifsfontein	2.2[3]	0.8	20°43'52.80"	34°27'06.86"	20°43'44.78"	34°26'56.43"
Papkuils	-	<0.1	20°45'08.61"	34°27'22.99"	N/A	N/A
Breede	2 079.4[3]	1147.6	20°50'43.20"	34°24'26.76"	20°32'43.95"	34°13'15.77"

[1]Based on combination of NBA national estuary layer (delineated using the 5 m topographical contour obtained from Chief Directorate Surveys and Mapping), 5 m contour from SRTM data (http://eros.usgs.gov/) and satellite imagery

[2]Based on 5 m contour from SRTM data (http://eros.usgs.gov/) and satellite imagery.

[3]Based on NBA national estuary layer

4 SOCIO-ECONOMICS AND ECOSYSTEM SERVICES STATUS QUO

Establishing the socio-economic component requires a suitable socio-economic evaluation framework for the Classification Process. This framework should be able to assess the implications of different catchment configuration scenarios at an IUA level on economic prosperity, social wellbeing and ecological condition. This component requires six sub-steps and two combined sub-steps (Figure 4-1).

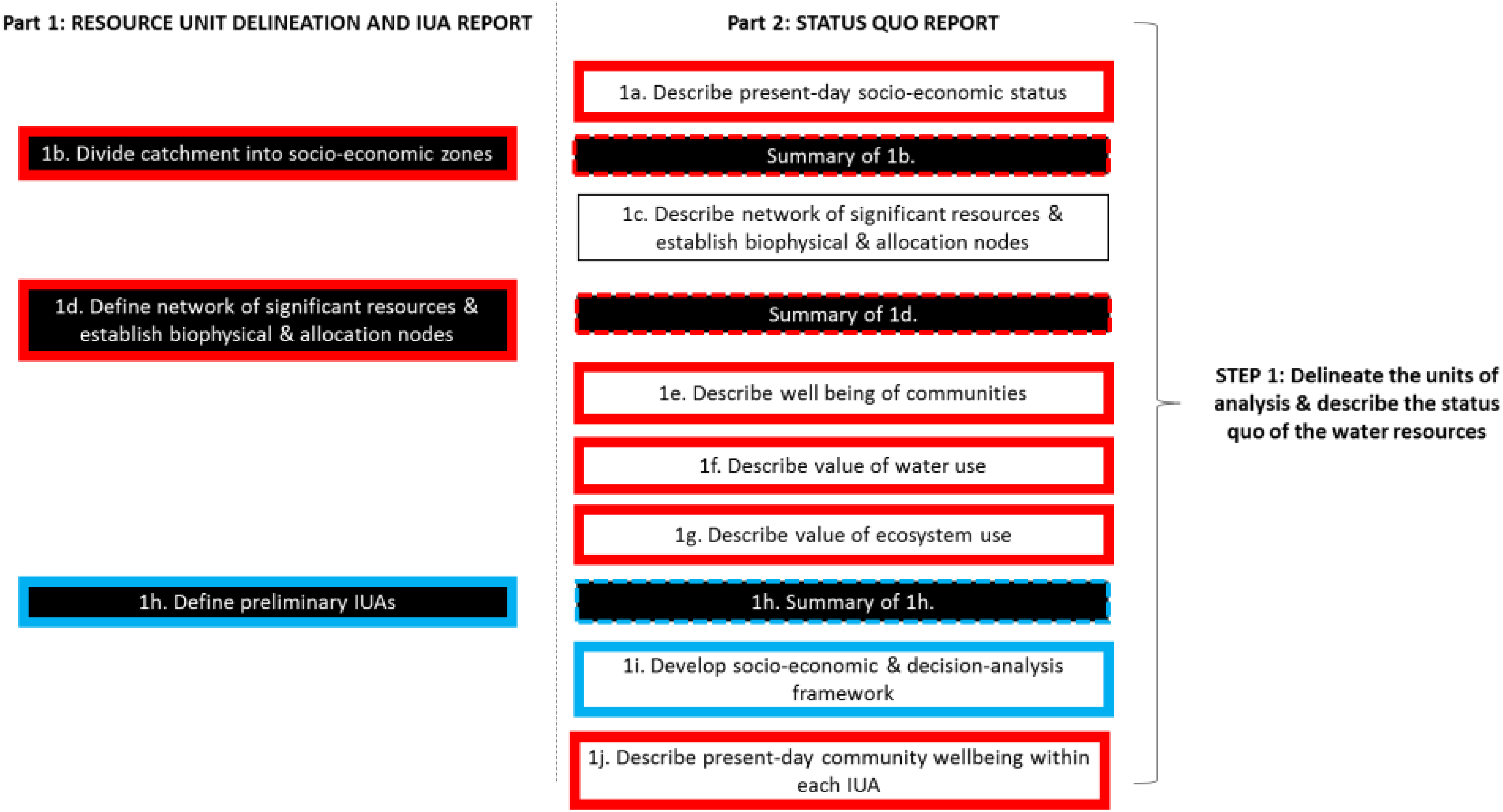


Figure 4-1. The ecological sub-steps for Step 1 of the Classification Procedure, with sub-steps highlighted in red and combined sub-steps highlighted in blue

The objective of this component is to define the relationships that will link change in the configuration of the Water Resource Class (WRC) scenario to a resulting economic value and social wellbeing across the WMA that will be used to inform the selection of the preferred WRC scenario.

4.1 Approach

To achieve this objective the following three sets of activities are required:

- Select the ecosystem values to be considered based on ecological and economic data, and discussion with the DWS.
- Describe the relationships that determine how economic value and social wellbeing are influenced by the ecosystem characteristics and the sectoral use of water.
- Define the scoring system for evaluating scenarios.

In detail, these activities will start with a preliminary spatially-disaggregated assessment of the values of the aquatic ecosystems and the values generated by the productive use of water, and how these values change. It is important to determine not only the relative values of different types of water use (including for instream flow), but to determine the relative sensitivity of these values to changes in water allocation. For example, if tourism values are high but are unrelated to any flow- or water quality-related variables, then this value would be relatively unimportant in the assessment of trade-offs. Thus a measure of sensitivity or elasticity will be included for all variables in the assessment.

It will involve a more comprehensive assessment of the value of both water use and freshwater dependent ecosystems in the study area in order to produce estimates of baseline values and develop estimates of (i) the way in which economic outputs and societal wellbeing change in response to changes in water available for use by households or productive sectors, (ii) the way in which economic outputs and societal wellbeing change in response to changes in ecosystem characteristics (with a focus on the effect of flow-related characteristics). Links will be made to the variables modelled by the ecological and water resource specialists.

The values of the aquatic ecosystems will include:

- Provisioning services such as fisheries, domestic use of instream water and other harvested resources.
- Regulating and supporting services such as water quality amelioration, flood attenuation and nursery function.
- Cultural values based on recreation, tourism and religious use.

The assessment of aquatic ecosystem values will require mapping of ecosystem services in order to assign relative values to specific resource units. Some services, such as tourism value and fisheries, are based on spatially definable characteristics such as water depth, bird species richness and fish biomass. These will be mapped using available spatial data on the relevant characteristics, and will be guided by available data on service values, and applying statistically-defensible benefit transfer techniques to extrapolate to the whole study area. Other services, such as water quality amelioration and flood attenuation can be assessed based on characteristics (e.g. as outlined in the WET-Ecosystem Services tool for wetlands), but ideally require catchment-scale modelling to determine relative value, as the value performed by one spatial unit is dependent on their spatial location within the landscape and the “work” being done elsewhere in the landscape. These services will be assessed using spatial modelling tools such as InVEST.

The values of ecosystem services will be a function of both supply and demand. Models will be generated to estimate how the supply of services changes with changing ecosystem characteristics, and to estimate the resulting change in value.

The values of the activities reliant on water use include:

- Afforestation and commercial agriculture

- Industrial/mining use, including effluent disposal
- Domestic use, including waste water disposal

For the latter, sectoral data and information on water use are readily available at the provincial level, but will be refined using municipal level information as far as possible. Estimates will be made of the responsiveness of these values to changes in water supply based on available information. Where necessary, further information will be obtained from representatives of different types of water users.

4.2 Description

4.2.1 Socio-economic zones

The purpose of delineating socio-economic zones (SEZs) is to make it easier to provide descriptions of the socio-economic implications of different classification scenarios that can be readily understood by stakeholders who can relate to the various areas that they depend upon. The rationale for the zonation process was that zones should be relatively homogenous in terms of the relationships of the economic activities in the zones with water. For example, some zones are heavily dependent on irrigation, with associated pressures on water resources, others may be dominated by dryland crops, others by use of natural areas for which ecosystem health is of greatest importance, and others by urban and industrial activities which have a high impact on water resources. In reality the study area contains a high diversity of activities and zones cannot be quite so neatly defined.

While the division of the study area into zones makes the socio-economic descriptions somewhat easier to digest, the study area should not be overly subdivided. In reality, economic activity is not confined to regions, but rather the activities in an area are linked to the economy of local towns, which in turn link to larger towns and cities, etc. Furthermore, when the balance of economic activity is changed by changing circumstances, be it the development of new industry or new tourism activities along the coast, people tend to shift towards those opportunities. Thus short term implications of changes that will be analysed spatially in the scenarios which lead to some areas apparently gaining at the expense of others will ultimately balance out in the long run. It is therefore not desirable to analyse changes at too fine a spatial scale, but rather to examine the economic implications for the region as a whole. Thus the approach was therefore to have a fewer large socio-economic zones rather than many small zones for the analysis.

Socio-economic zones were delineated after detailed inspection of a range of spatial information on geography, climate, drainage, vegetation and land use. The zones were demarcated primarily on the basis of agricultural land use. Layers that were the most important in this process included:

- Land Cover 2014;
- Agricultural Census (Western Cape DoA), which shows detailed spatial information on crops planted at the sub-farm level, and
- Homogenous Farming Areas.

Although Homogenous Farming Areas initially seemed to provide a good guide, there were significant discrepancies between these zones and the census and land cover data, so the latter were taken as the primary determinants of land use zones. Initial boundaries were then compared with river characteristics and catchment boundaries. After input from the rest of the team, some of the socio-economic boundaries were slightly realigned in order to facilitate the summarising of data between the different disciplines. The socio-economic zones for the Breede-Gouritz WMA are listed in Table 4-1 and shown in Figure 4-2 and Figure 4-3.

Table 4-1. A list of the nine socio-economic zones delineated for the Breede-Gouritz WMA. The map code relates to the position of each zone shown in Figure 4-2 **and** Figure 4-3

Map Code	Socio-economic zone
B1	Upper and Middle Breede
B2	Upper Riviersonderend and Palmiet
B3	Overberg Coast
B4	Wheat Belt
B5	Hessequa Coast
B6	Little Karoo West
B7	Great Karoo
B8	Little Karoo East
B9	Garden Route Coast

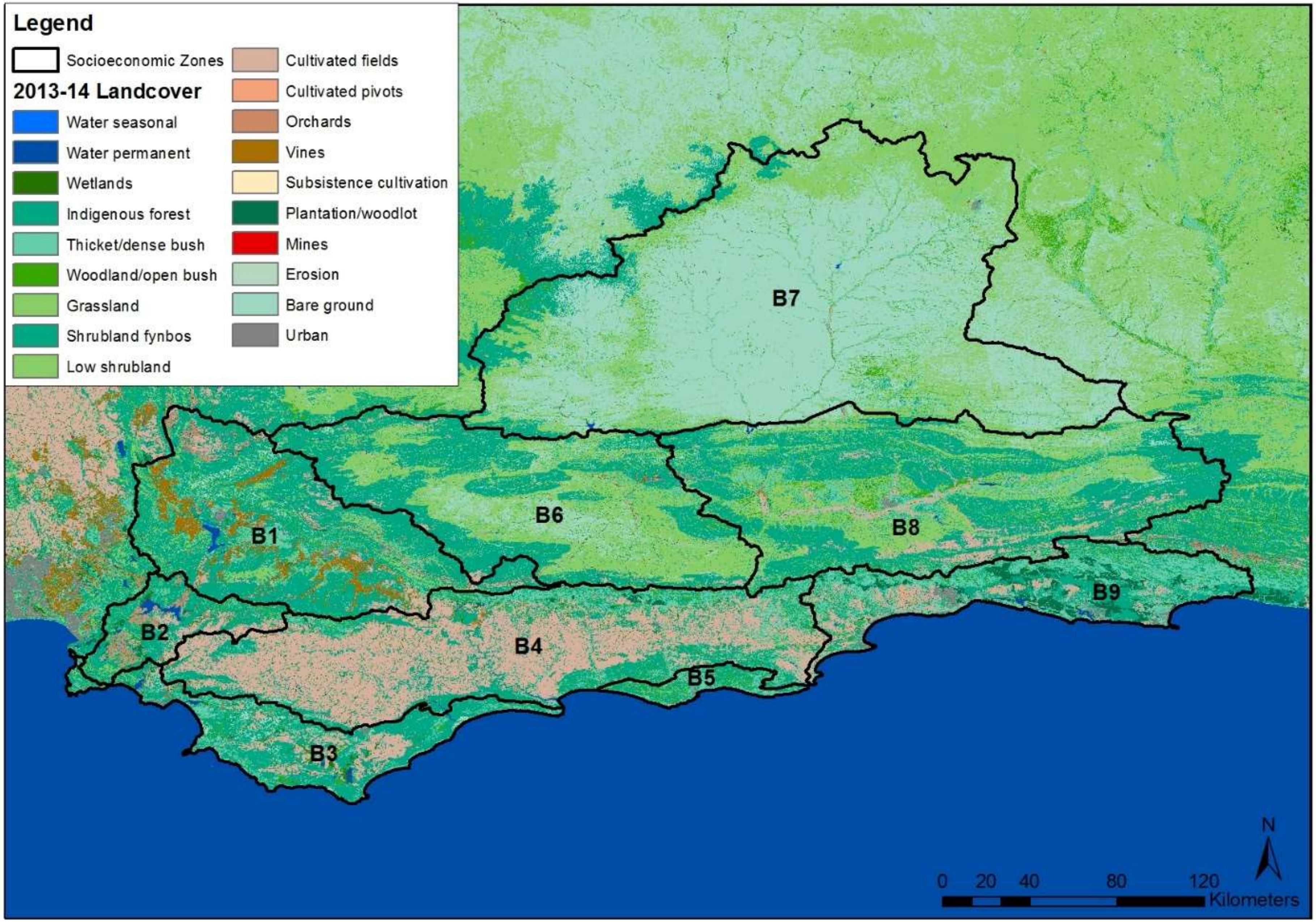


Figure 4-2. The nine socio-economic zones in relation to the 2013/14 land cover

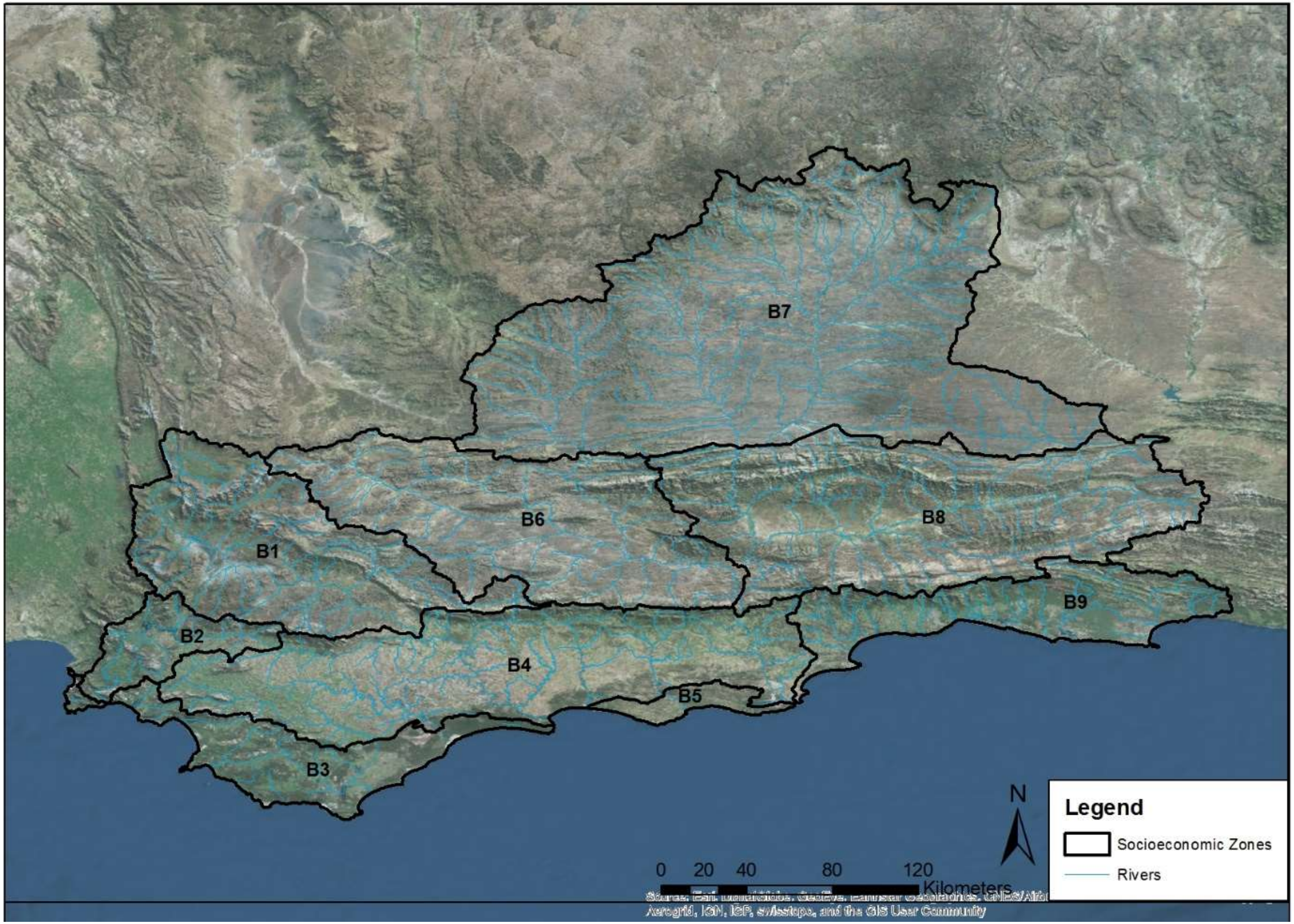


Figure 4-3. The nine socio-economic zones in relation topography

4.2.1.1 Integrated units of analysis (IUAs) for the Classification Study

Many of the socio-economic zones in the Breede-Gouritz WMA are aligned from west to east while catchments largely flow from north to south, and these areas tend to intersect one another. The intersected areas form the IUAs. Therefore each socio-economic zone corresponds to one or more of the IUAs. The IUAs form the basis of assessment for changes in water use and socio-economic impacts. Economic water using activities, such as agricultural irrigation, are described in a later section at the IUA level.

Table 4-2. A list of the nine socio-economic zones and the IUAs that fall within each zone

Socio-economic zone	IUA Name	IUA Code
Upper and Middle Breede	Upper Breede Tributaries	A1
	Breede Working Tributaries	A2
	Middle Breede Renosterveld	A3
Upper Riviersonderend and Palmiet	Riviersonderend Theewaters	B4
	Overberg West	B5
Great Karoo	Gamka-Buffels	C6
Little Karoo East	Gouritz-Olifants	D7
Little Karoo West	Touws	E8
Wheat Belt	Lower Riviersonderend	F9
	Overberg East Renosterveld	F10
	Lower Breede Renosterveld	F11
	Duiwenhoks	F12
	Lower Gouritz	F13
Garden Route Coast	Groot Brak	G14
	Coastal	G15
Overberg Coast	Overberg West Coastal	H16
	Overberg East Fynbos	H17
Hessequa Coast	Hessequa	I18

Economic activity and output will be assessed in later sections by IUA.

4.3 Status quo assessment

This section of the report provides a description of the status quo in terms of (1) economic activities, outputs and employment and (2) the characteristics and current socio-economic situation of people living within the Breede-Gouritz WMA. The status quo assessment will provide a baseline against which to measure the potential impacts associated with changes in water yields and environmental flows and how this will affect economic output and social well-being under a range of classification scenarios. As well as providing the overall context against which to evaluate change, the descriptions provided in this section highlight these linkages to water and focus on the aspects of economy and livelihoods that are likely to change under changed availability and allocation of water resources.

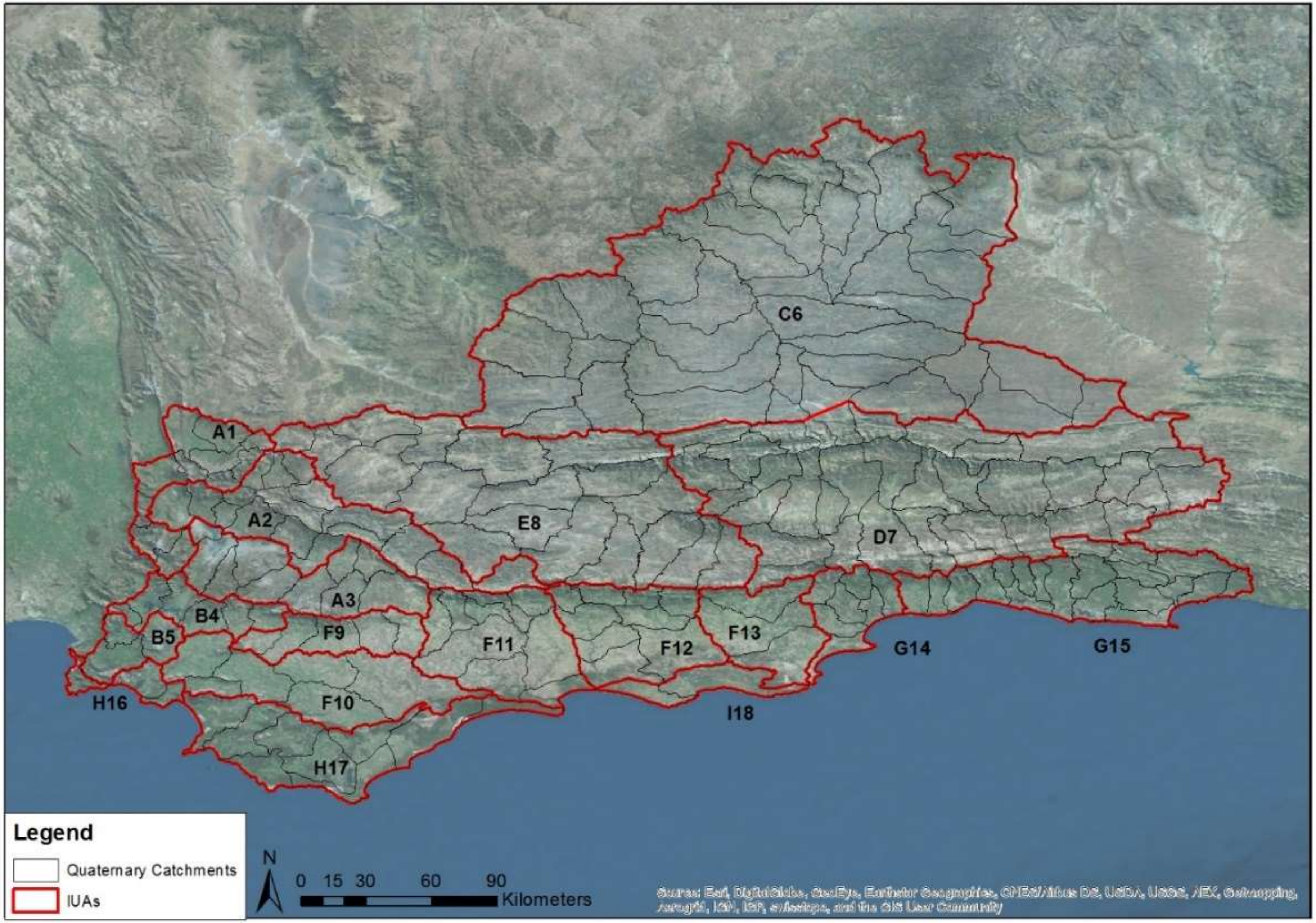


Figure 4-4. Integrated units of analysis for the Breede-Gouritz WMA shown in relation to the quaternary catchments

Economic outputs and social wellbeing are related and are each directly influenced by both water supply and environmental flows in different ways. Economic activities that depend on licenced use of water include irrigation agriculture, plantation forestry and industry. Economic activities whose outputs are linked to the quality of aquatic ecosystems include tourism and freshwater, estuarine and marine fisheries. In addition, the functioning of aquatic ecosystems also plays a role in overall economic productivity through ecosystem services that lead to cost savings, such as flood attenuation, sediment retention and water quality amelioration. These cost savings manifest in both the private and public sector.

Similarly, social wellbeing within the study area is determined by both water supply and instream flows, namely the abstraction and supply of water for domestic purposes, the supply of abstracted or instream water to economic activities which provide employment opportunities, and the supply of instream flows which lead to the provision of instream water, natural resources and opportunities for recreation and spiritual fulfilment.

Ecosystem services are therefore an integral factor influencing the economic and social status of the different parts of the catchment. For this reason they are not treated separately in this report, but are woven into the description of the status quo. We have also avoided as far as possible the potentially confusing use of ecosystem services jargon, although this is explained more fully in Box 4.1. The roles of water and aquatic ecosystem services in determining the economic prosperity and the social wellbeing of people living in the study area are summarised in Figure 4-5 .

Economic outputs are summarised in terms of direct and total gross value added (GVA), and total employment. Direct GVA is the sum of all income generated to business owners and as wages in the activities described. Total GVA includes incomes generated indirectly in all sectors as a result of these activities, such as through the purchase of inputs, and incomes generated as a result of spending by wage earners. Social wellbeing is constructed as a composite index of measures of household income and other benefits (Figure 4-5).

This chapter begins with thematic overviews of the above activities and variables with a description of how they vary across the study area and its socio-economic zones, and then summarises the information by socio-economic zone for later comparison in the scenario analyses. Within the descriptions of the socio-economic zones, relevant water-related variables are further disaggregated to the level of the IUAs.

Estimates of gross value added (GVA) and employment per sector per socio-economic zone were made for 2015. These were based on the spatial disaggregation of GVA and employment data by mesozone for 2009 from the CSIR Geospatial Analysis Platform (GAP 2011). These figures were adjusted using detailed district municipality GDPR and employment data from the Western Cape Government Municipal Economic Review and Outlook (2014) and then adjusted at the national level from 2013 to 2015 using national GDP nominal growth rate statistics for GVA and real growth rate statistics for employment (StatsSA 2016).

Information on population, income, livelihoods and living conditions was derived from StatsSA Census data for 1996, 2001 and 2011. Where census data had been disaggregated into mesozones by StepSA (2015), these were used to obtain summaries at the level of the socio-economic zone. For other census data, summaries were produced based on data at the slightly larger sub-place (SP) level.

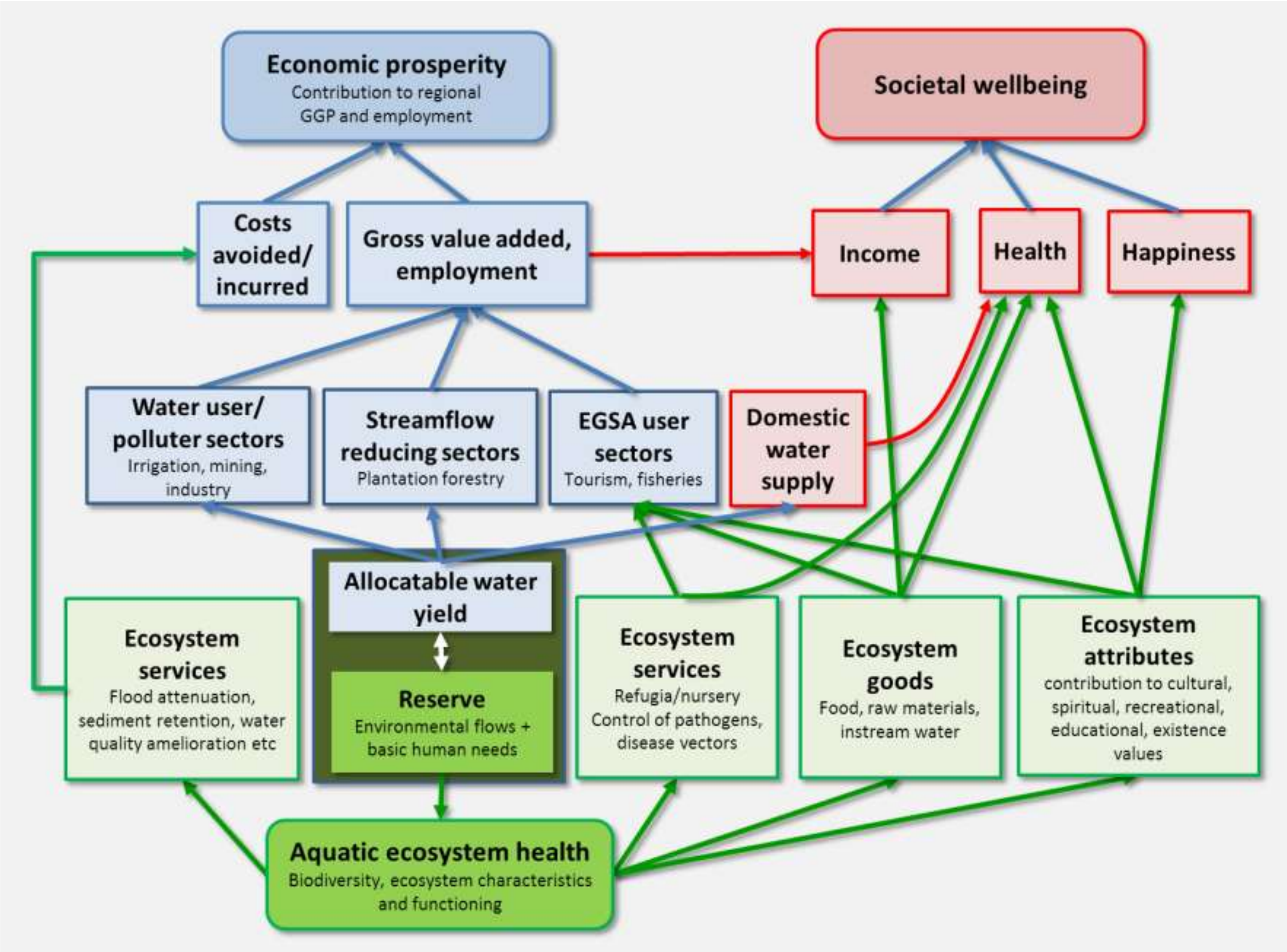


Figure 4-5. Linkages arising from the trade-off between water abstracted for use and water retained for the Reserve (source: Author, modified from Turpie et al. 2006)

Box 4.1. Ecosystem services, classification and valuation frameworks

Ecosystem services provided by aquatic ecosystems

- ***Provision of harvested resources***
  Several kinds of living (e.g. reeds, thatching grass, firewood, fish) and non-living resources (e.g. water, clay) are harvested from aquatic ecosystems for food, medicine and raw materials. Wetlands are also used as grazing areas, especially during the dry season and have a higher grazing potential than surrounding uplands.

- ***Flood attenuation***
  Vegetated landscapes, and wetlands in particular, regulate flows through flood attenuation, groundwater recharge and, through this, the maintenance of base flows. Rivers will also perform these roles to some extent, but the bulk of research has focussed on wetlands. Wetlands play an important role in attenuating floods, but providing temporary storage for high flows and slowing their movement through the catchment.

- ***Sediment retention***
  When flows enter wetlands, they are slowed down and part of the load settles out. This enriches the productivity of the wetland and also the agricultural potential of floodplains. In addition, where catchment sediment loads are elevated by erosion, the settling out of sediments in wetlands reduces the damage caused downstream. The ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity, and is thus closely related to a wetlands flow regulation capacity. This service is therefore linked to flood attenuation.

- ***Waste treatment***
  Aquatic ecosystems play a role in ameliorating water quality either through trapping, absorption and breakdown of organic and inorganic pollutants, or through dilution.

- ***Carbon sequestration***
  The sequestration of carbon by ecosystems acts as a natural offset to damage caused by increasing anthropogenically linked atmospheric carbon and resultant global climate change. Carbon is sequestered when it is taken up by plants in the growth process and stored in above and below-ground plant biomass. In addition, litter production and other processes lead to the accumulation of carbon in soil. Carbon sequestration by aquatic ecosystems is still poorly understood, and values were obtained from available literature sources. The highest rates of carbon sequestration occur within swamp and mangrove forests. Saline marsh areas have a much higher sequestration rate than freshwater marsh areas.

- ***Ecological regulation***
  Some ecosystems support organisms that help to keep pests under control (e.g. fish that eat disease vectors). Aquatic ecosystem degradation can improve conditions for certain pests (e.g. reduction in flows leading to stagnant water ideal for mosquitoes, bilharzias and black fly, or invasive plants such as water hyacinth.

- ***Refugia and nursery functions***
  This service is supplied when an ecosystem provides critical habitat for a population that is utilised elsewhere, such as the nursery function that estuaries provide for certain marine species. This also includes the aquaculture opportunities provided by aquatic ecosystems. Estuaries act as nursery areas for fish and prawns captured in inshore marine fisheries, and also export sediments and nutrients that are vital for offshore crustacean fisheries.

- ***Aesthetic, recreational, spiritual and cultural values***
  The aesthetic, recreational, spiritual and cultural values of ecosystems are derived from their attributes such as beauty and rarity. These attributes determine whether an area is suitable or attractive for recreational use, religious ceremonies or spiritual fulfilment. Some of the more intangible aspects of these values are extremely difficult to estimate, even when applying best-practice comprehensive survey methods. However, some of the more measurable manifestations of these values include the expenditure that people incur in order to view or visit aquatic ecosystems (tourism value), and the extra amounts, or premiums, that people pay for properties in order to have access to or views of aquatic systems (property value).

Classification of ecosystem services

The concept of ecosystem goods and services stems from the perception of ecosystems as natural capital which contributes to economic production. Ecosystems can be seen to provide a range of 'goods' and 'services' and have 'attributes' that generate value and contribute to human welfare (Barbier 1994, 2011). Goods, services and attributes may be defined as follows:

- **Goods** are harvested resources, such as fish.
- **Services** are processes that contribute to economic production or save costs, such as water purification.
- **Attributes** relate to the structure and organisation of biodiversity, such as beauty, rarity or diversity, and generate less tangible values such as spiritual, educational, cultural and recreational value.

Goods, services and attributes are often referred to collectively as 'ecosystem services', or 'ecosystem goods and services'. More recently, the Millennium Ecosystem Assessment (2003) defined ecosystem services as "the benefits people obtain from ecosystems" and categorized the services obtained from ecosystems as follows:

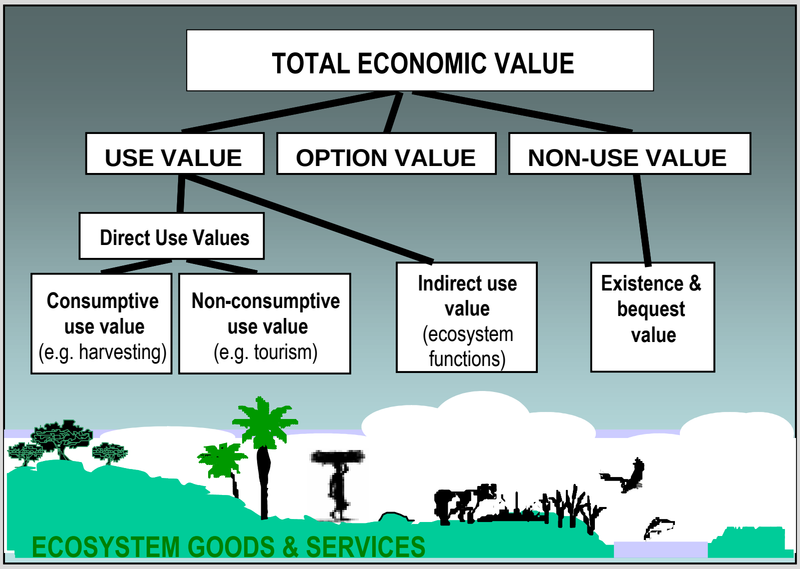
- **Provisioning services** such as food and water;
- **Regulating services** such as flood and disease control;
- **Cultural services** such as spiritual, recreational, and cultural benefits; and
- **Supporting services**, such as nutrient cycling, which maintain the conditions for life on Earth.

Values and valuation of ecosystem services

The values produced by ecosystem services are also categorised into different types. The Total Economic Value of an ecosystem comprises direct use, indirect, option and non-use values. Direct use values may be generated through the consumptive or non-consumptive use of resources. In the case of South African estuaries, most, if not all, of this use is recreational, and includes both consumptive (fishing and bait collecting) and non-consumptive (e.g. boating, bird watching) activities. Indirect use values are values generated by outputs from estuaries that form inputs into production by other sectors of the economy, or that contribute to net economic outputs elsewhere in the economy by saving on costs. These outputs are derived from ecosystem functioning such as water purification and nursery functions. Non-use values include the value of having the option to use the resources (e.g. genetic) of estuaries in the future (option value), and the value of knowing that their biodiversity is protected (existence value). Although far less tangible than the above values, non-use values are reflected in society's willingness to pay to conserve these resources, sometimes expressed in the form of donations. The relationships between the concepts of ecosystem services and values are shown below.

Broad relationships between the concepts of ecosystem services and values (source: Author)

Ecological descriptors	Ecosystem services		Total Economic Value
	Barbier 1994, 2011	Millennium Ecosystem Assessment 2005	
Natural resource stocks	Goods	Provisioning services	Consumptive use value
Ecological functioning	Services	Regulating & supporting services	Indirect use value
Ecosystem structure and organisation	Attributes	Cultural services	Non-consumptive use value
			Non-use value



The classification of ecosystem values that make up Total Economic Value (based on Turpie *et al.* 1999).

Much of the confusion and debate around categorising and assessing the value of ecosystem services revolves around the extent to which different services should be treated as intermediate versus final services, and the extent to which the ecosystem is responsible for the benefits described (Barbier *et al.* 2011). For example recreational benefits are derived from a combination of natural and man-made capital. These problems only really exist for static assessments of value such as those by Costanza *et al.* (1997, 2014). To some extent, this can be solved by focussing only on the final services in order to avoid double counting. However, since it is often the supporting or intermediate services that are affected by policy changes, it is far more relevant to assess changes in welfare that will result from a change in the state of natural capital. That way, the fact that values depend partly on man-made capital, such as hotels and boats, is not problematic to the analysis.

The way in which values of ecosystem services are expressed also varies. Different measures of value are relevant to different decision-makers. Individuals and firms make decisions on the basis of their own financial and/or utility gains. Governments make decisions on the basis of overall welfare gains (including contribution to income and employment as measured in the national accounts). At a more local level, municipalities may make decisions based on the generation of revenues, e.g. from property rates. It is important to understand value from both an individual/firm perspective and a government or social planner perspective, since the former constitute the market forces of change, and the latter are required to make decisions that are in the overall interest of society. In this study, we take a social planner perspective.

4.3.1 Overall economic context

4.3.1.1 Economic activities and sectoral outputs

Land use in the Breede-Gouritz WMA is dominated by commercial agriculture in the North West and South West inland areas of the WMA where fruit farming and vineyards are the most economically important crops. The most abundant and economically important fruit crops include grapes, apples and pears, stone fruits and citrus fruits. In the inland area of the Gouritz portion of the WMA economic activities include agriculture, forestry, trade and manufacturing. Most economic contributions in the Gouritz portion of the WMA come from the George and Oudtshoorn areas (BOCMA 2011). Wheat farming is important in the central inland areas of the WMA and dry-land agriculture and livestock farming are dominant in the Karoo and Swartberg areas. In the areas where agriculture is the dominant land use, associated sectors, such as manufacturing, tend to be strong and diverse (Golder Associates 2016). Along the length of the coastline of the WMA, financial services and tourism-related services are the most important economic activities. The Garden Route Coast, in particular, is a popular tourism destination with towns such as Knysna, George and Plettenberg Bay attracting both local and international tourists every year.

The Breede-Gouritz WMA area covers much of the Cape Winelands District Municipality (DM) and Central Karoo DM, and all of the Overberg and Eden DMs, as is depicted in Figure 4-6. A minor part of the Gouritz portion of the WMA falls within the Cacadu DM. The sectoral economic profiles of the four main District Municipalities that straddle the study area are presented in Table 4-3 (WCG 2014).

Table 4-3. Economic profiles of primary District Municipalities (% of total GDP) in the study area in 2013 (Source: WCG 2014)

Economic Sub-Sector	Eden	Central Karoo	Overberg	Cape Winelands
Agriculture, Forestry & Fishing	5.2	8.6	11.5	11.6
Mining	0.2	0.1	0.1	0.3
Manufacturing	15.2	8.4	11.8	19.0
Electricity, Gas & Water	2.3	1.6	1.9	1.4
Construction	9.5	6.3	8.7	4.0
Trade, retail, catering & accommodation	20.9	16.4	17.1	17.4
Transportation & Communication	6.6	11.5	6.8	7.0
Finance, Real Estate & Business Services	21.1	25.8	26.0	21.5
Community, social and personal services	5.1	6.1	4.1	5.8
Government Services	14.0	15.1	12.1	12.1

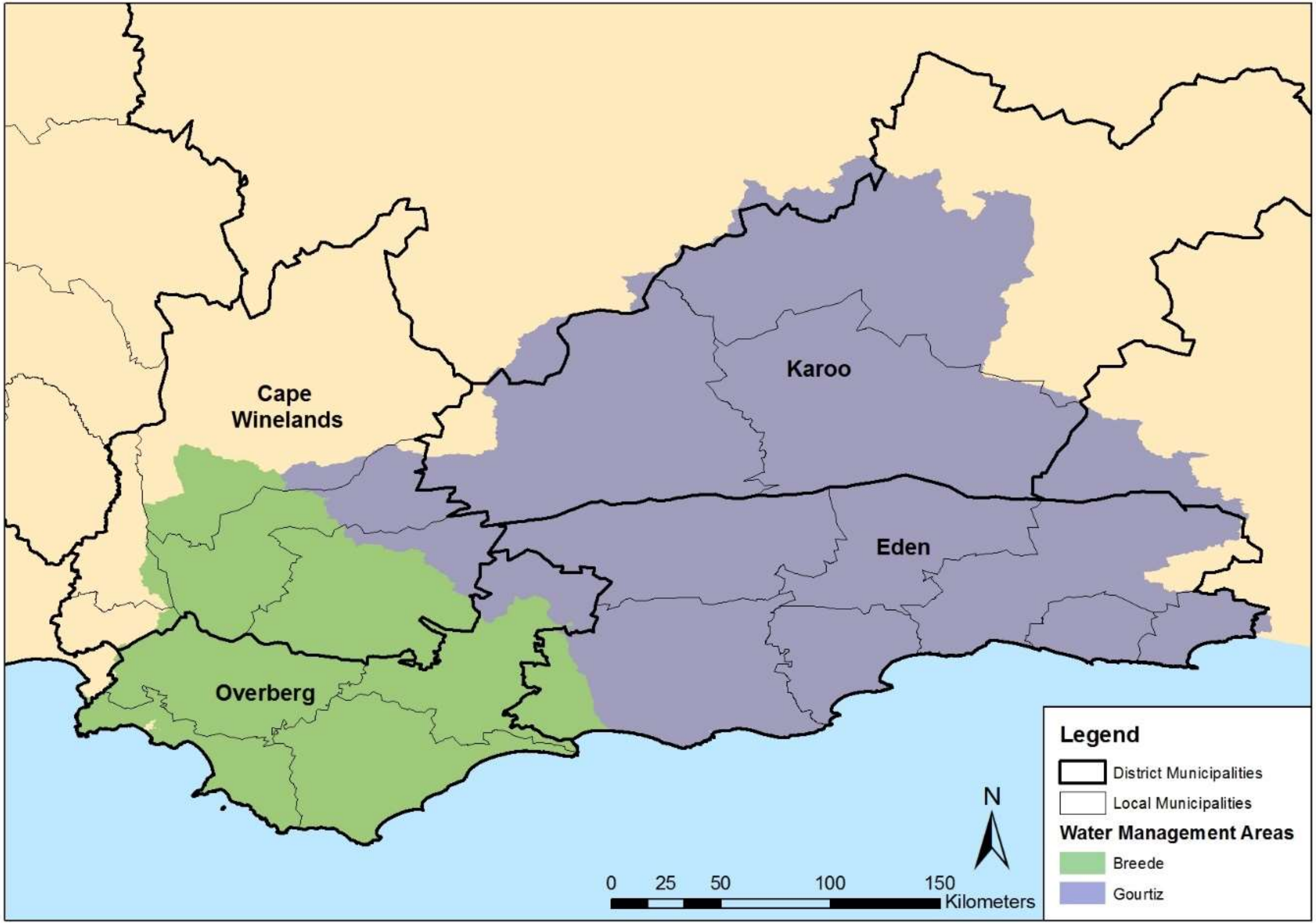


Figure 4-6. Map of the District and Local Municipalities within the Breede-Gouritz WMA boundary

Within the Breede part of the WMA, most of the economic production is from the areas where irrigation is practised and where processing and packaging plants are located (DWAF 2003a - ISP). The agricultural sector is relatively diversified, encompassing an important fruit and wine industry as well as substantial wheat production. Trading activities are concentrated on wholesale wine, fruit and wheat, local retail services and on tourism. The manufacturing sector is also strongly linked to the area's agricultural activities, with the majority of manufacturing activities being in the food and beverage sub-sectors. Financial services are closely linked to the region's other economic activities, with the sector also benefiting from a relatively strong property market. The competitive agricultural sector in this region can be attributed to its Mediterranean climate which is different to most other parts of the country, as well as the large domestic and international demand for products from this region. Agriculture presents opportunities for growth, along with tourism and the development of coastal properties, which are likely to be stimulated by the proximity of Cape Town.

In the Gouritz part of the WMA, most of economic production is centred around the main urban centres as well as intensive irrigation enterprises where high value outputs are produced. The trade sector is important and is supported by a strong transport industry, service-orientated activities, and a growing tourism market. The agricultural sector is relatively competitive and is based on a variety of products including grains, fruit, vegetables, livestock, timber and fishing. The area produces a large share of the hops required by the country's brewing industry. Ostrich production is not as important as it was due to international competition, but still plays an important role. Forestry is one of the most important components of the agricultural sector, and supports major processing and manufacturing activities. Wooden furniture made from indigenous timber is one of the most important exports from the WMA. The financial sector is focussed on the agricultural and trade sectors as well as the strong property market along the coastal area. Manufacturing activities are predominantly in Mossel Bay and George and also Oudtshoorn. The most important industrial activity in the region is the Mossgas natural gas extraction and refinery project near Mossel Bay, which plays a large role in the manufacturing industry. Growth is expected in the tourism and coastal property markets, and could also occur in the petro-chemical industries (DWAF 2003b - ISP).

The most important areas of economic activity in the Breede-Gouritz WMA as a whole have been identified as follows (Golder Associates 2016):

- Intensive coastal urban economies in the western (Overberg Coast) and eastern (Garden Route Coast) sections of the WMA;
- Intensive irrigation agricultural and small town economy along the Breede River, including the towns of Swellendam and Robertson;
- Intensive irrigation agricultural and small town economy in the Upper Riviersonderend and Palmiet areas;
- Widespread dry-land cultivation economy in the Wheat Belt and Little Karoo East socio-economic zones;
- Extensive farming and small town economy in the Great and Little Karoo West socio-economic zones, including the towns of Prince Albert, Beaufort West and Laingsburg; and
- Important tourism economy that covers large areas of the WMA and is associated in particular with coastal urban areas as well as protected areas.

The total GVA for the Breede-Gouritz WMA was estimated to be R62.9 billion in 2015 (based on GAP 2011, WCG 2014, StatsSA 2016) (Figure 4-7, Table 4-4). The highest GVA values are found in and around towns and villages, particularly along the Garden Route Coast, Upper and Middle Breede and the Overberg Coast (Figure 4-8). GVA is lowest in the Little Karoo West and Great Karoo zones.

Overall, financial services contributed the most to GVA at R13.9 billion followed by the trade, catering and accommodation sector (R13.4 billion), the community, social and government services sector (R12.7 billion), the manufacturing sector (R10.6 billion) and the agriculture, forestry and fisheries sector (R6.2 billion) (Table 4-4). Since 2009, the percentage share of GVA has decreased by 4% in the agriculture, forestry and fisheries sector and by 2% for the manufacturing sector and for the transport, storage and communication sectors (Table 4-4). GVA has increased for the wholesale trade, catering and accommodation sector and the community, social and government services sector. The financial services sector has remained stable since 2009.

The Garden Route Coast and the Upper and Middle Breede had the highest percentage contribution to total GVA of 42.4% (R26.6 billion) and 19% (R12 billion), respectively (Figure 4-7, Figure 4-8). The Hessequa Coast, Little Karoo West and Great Karoo contributed the least to overall GVA in the WMA (Figure 4-8).

GVA in the agriculture, forestry and fisheries sector and associated manufacturing sector was highest in the Upper and Middle Breede, Little Karoo West and Upper Riviersonderend and Palmiet zones (Figure 4-9). The financial services sector and wholesale trade, catering and accommodation sector are important contributors to GVA in all socio-economic zones (Figure 4-9).

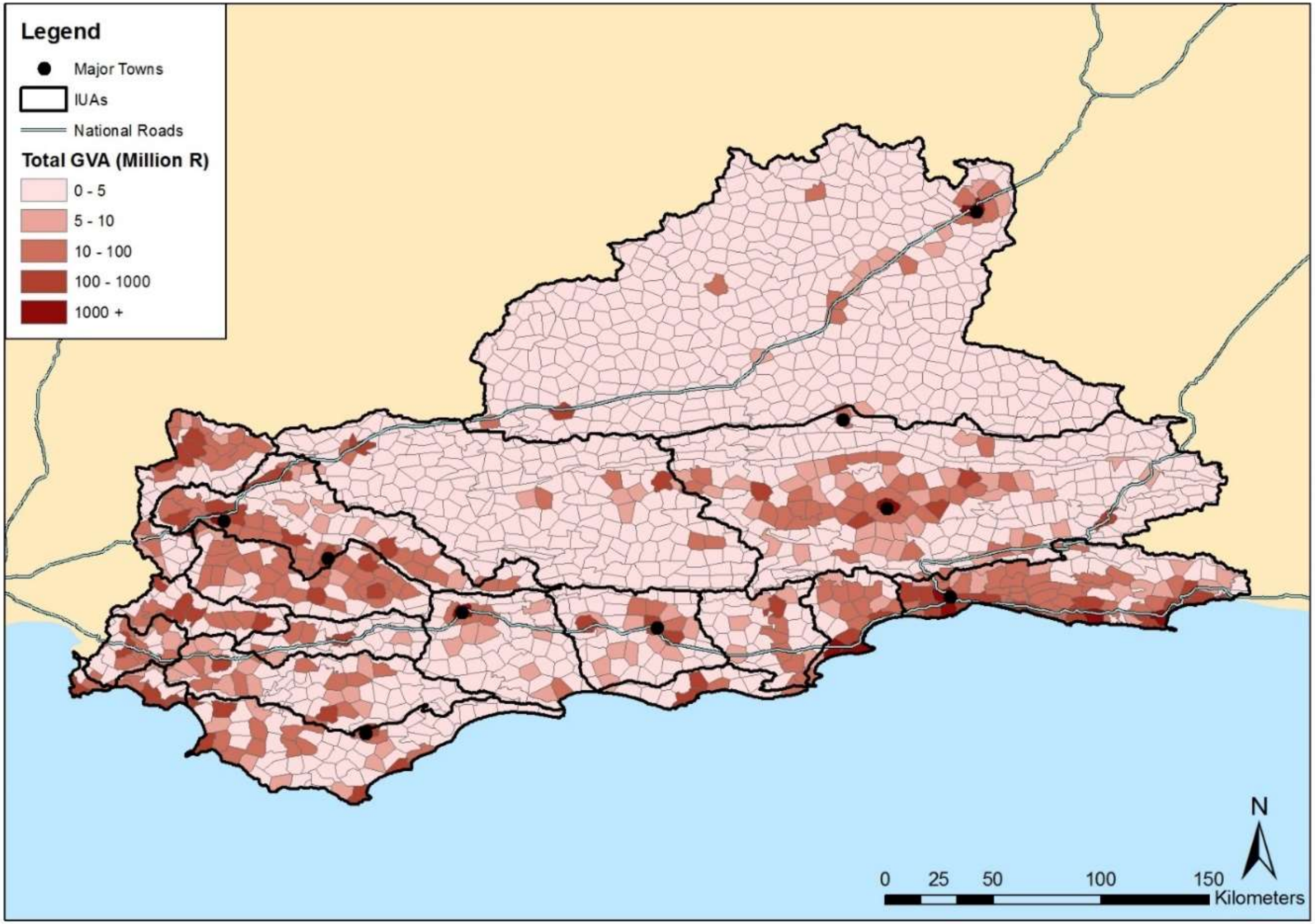


Figure 4-7. Total GVA (R millions) in 2015 for each mesozone within each IUA (Source: GAP 2011, WCG 2014, and StatsSA 2016)

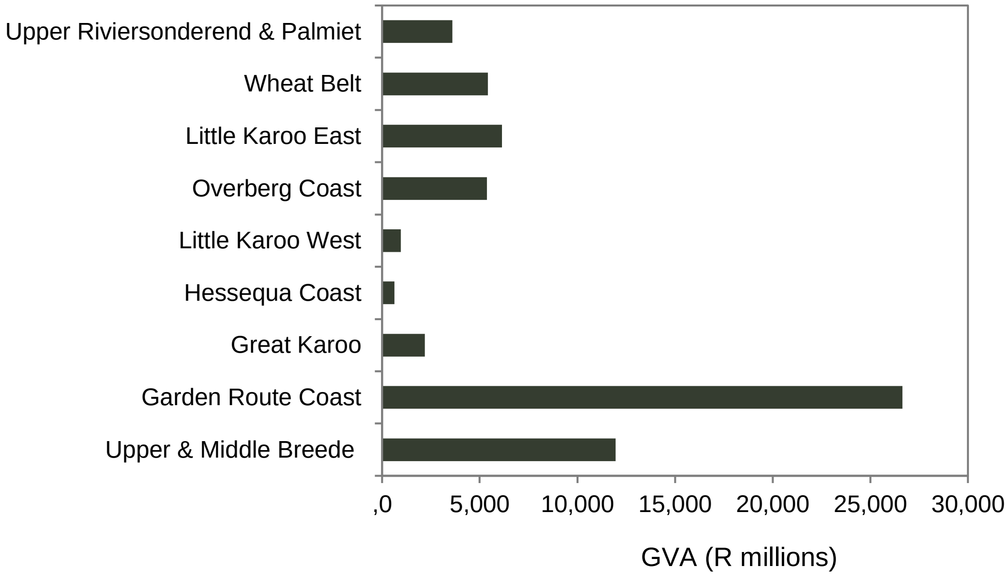


Figure 4-8. GVA (R millions) for each socio-economic zone in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

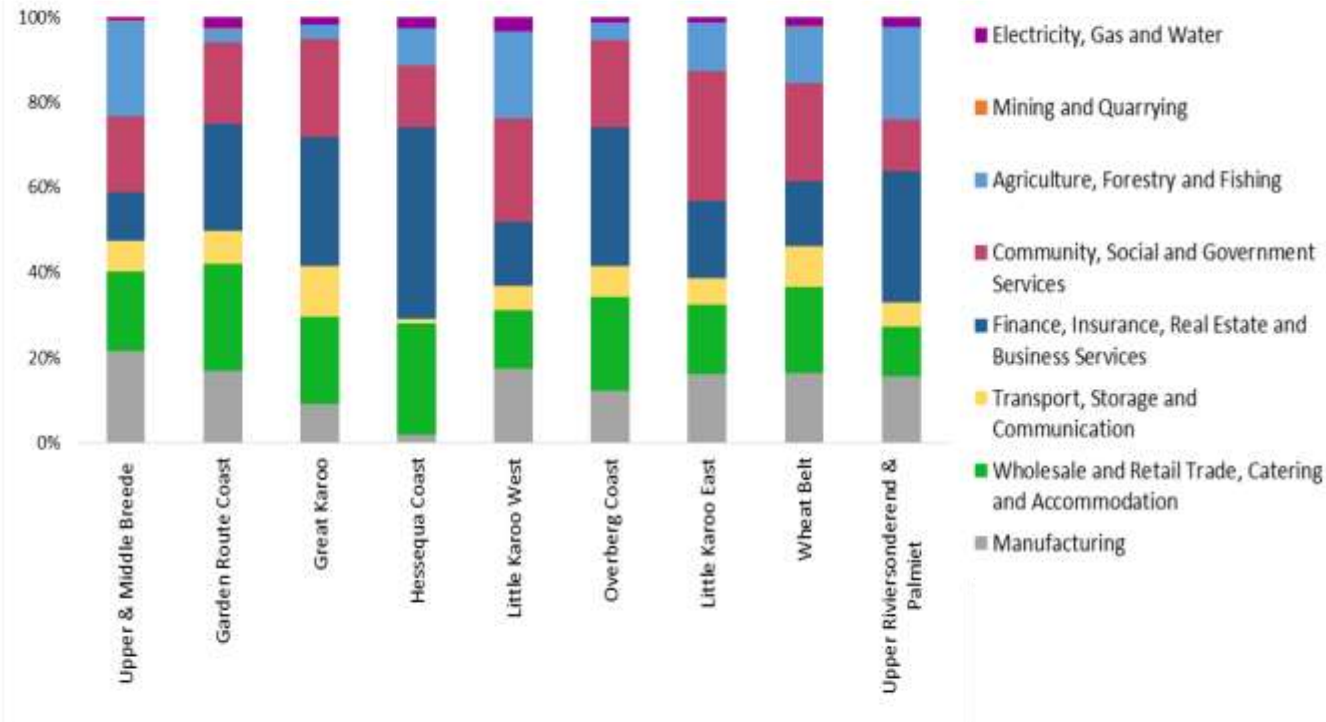


Figure 4-9. Percentage contribution of different sectors to total GVA in each socio-economic zone in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

Table 4-4. Total GVA (nominal 2015 prices) and percentage per sector contribution to GVA for each socio-economic zone in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

Socio-economic zone	Agriculture, Forestry and Fishing		Mining and Quarrying		Manufacturing		Electricity, Gas and Water		Wholesale and Retail Trade, Catering and Accommodation		Transport, Storage and Communication		Finance, Insurance, Real Estate and Business Services		Community, Social and Government Services	
Total (R millions)	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**
Upper & Middle Breede	2 803	2 672	56	29	3 123	2 565	98	85	1 609	2 247	1 109	859	1 619	1 357	1 831	2 142
Garden Route Coast	678	829	86	68	2 754	4 530	354	709	3 303	6 698	1 327	2 024	4 173	6 732	2 747	5 064
Great Karoo	72	74	-	-	133	201	21	41	243	449	162	259	400	667	289	502
Hessequa Coast	46	54	1	0	7	11	9	17	83	165	4	6	179	281	51	91
Little Karoo West	151	194	-	-	104	166	20	33	77	133	51	53	91	144	153	234
Overberg Coast	215	218	12	8	564	652	40	63	664	1 178	293	400	1 104	1 744	701	1 099
Little Karoo East	547	687	10	8	601	983	39	78	502	1 009	240	380	698	1 119	1 006	1 879
Wheat Belt	671	718	12	12	641	881	64	113	546	1 101	353	513	483	824	668	1 252
Upper Riviersonderend & Palmiet	820	789	2	2	462	559	48	81	206	421	147	209	731	1 106	246	437
Total	**6 002**	**6 235**	**178**	**127**	**8 389**	**10 549**	**693**	**1 220**	**7 233**	**13 400**	**3 685**	**4 705**	**9 477**	**13 974**	**7 691**	**12 699**
Percentage	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**
Upper & Middle Breede	23%	22%	0.5%	0.2%	25%	21%	1%	1%	13%	19%	9%	7%	13%	11%	15%	18%
Garden Route Coast	4%	3%	0.6%	0.3%	18%	17%	2%	3%	21%	25%	9%	8%	27%	25%	18%	19%
Great Karoo	5%	3%	0.0%	0.0%	10%	9%	2%	2%	18%	20%	12%	12%	30%	30%	22%	23%
Hessequa Coast	12%	9%	0.1%	0.0%	2%	2%	2%	3%	22%	26%	1%	1%	47%	45%	13%	15%
Little Karoo West	23%	20%	0.0%	0.0%	16%	17%	3%	3%	12%	14%	8%	6%	14%	15%	24%	24%

Socio-economic zone	Agriculture, Forestry and Fishing		Mining and Quarrying		Manufacturing		Electricity, Gas and Water		Wholesale and Retail Trade, Catering and Accommodation		Transport, Storage and Communication		Finance, Insurance, Real Estate and Business Services		Community, Social and Government Services	
Overberg Coast	6%	4%	0.3%	0.2%	16%	12%	1%	1%	18%	22%	8%	7%	31%	33%	20%	20%
Little Karoo East	15%	11%	0.3%	0.1%	17%	16%	1%	1%	14%	16%	7%	6%	19%	18%	28%	31%
Wheat Belt	20%	13%	0.3%	0.2%	19%	16%	2%	2%	16%	20%	10%	9%	14%	15%	19%	23%
Upper Riviersonderend & Palmiet	31%	22%	0.1%	0.1%	17%	16%	2%	2%	8%	12%	6%	6%	27%	31%	9%	12%
Total	**14%**	**10%**	**0.4%**	**0.2%**	**19%**	**17%**	**2%**	**2%**	**17%**	**21%**	**9%**	**7%**	**22%**	**22%**	**18%**	**20%**

It was estimated that the agriculture, forestry and fisheries sector contributed R6.2 billion to total GVA in the Breede-Gouritz WMA in 2015 (Figure 4-10). Outputs are highest in the Upper and Middle Breede, the Upper Riviersonderend and Palmiet, and the Garden Route Coast than in much of the Wheat Belt and Little Karoo East, and are lowest in the Great Karoo and Little Karoo West (Figure 4-10). Fisheries is important along sections of the Overstrand coast and along the Garden Route Coast, in particular in Mossel Bay.

4.3.1.2 Employment by sector

The community, social and government services sector employs the highest number of people in the WMA, followed by the wholesale trade, catering and accommodation sector and the agriculture, forestry and fisheries sector (Table 4-5). However, since 2009, the percentage of people employed in the agriculture, forestry and fishing sector has decreased by 0.5% and in the manufacturing sector by 2.5% (Figure 4-11). Percentage employment in the wholesale trade, catering and accommodation sector has seen the highest increase in percentage employment of 3.6%. The financial services sector and transport, storage and communication sectors also saw an increase in percentage employment from 2009 to 2015 (Figure 4-11).

Percentage employment per sector for each socio-economic zone is shown in Figure 4-12. Percentage employment in the agriculture, forestry and fisheries sector is highest in the Upper and Middle Breede, the Little Karoo West and Upper Riviersonderend and Palmiet zones (Figure 4-12). Employment in the wholesale trade, catering and accommodation section is highest in the coastal regions as well as the Great Karoo. The community, social and government services sector employs a significant number of people across all socio-economic zones.

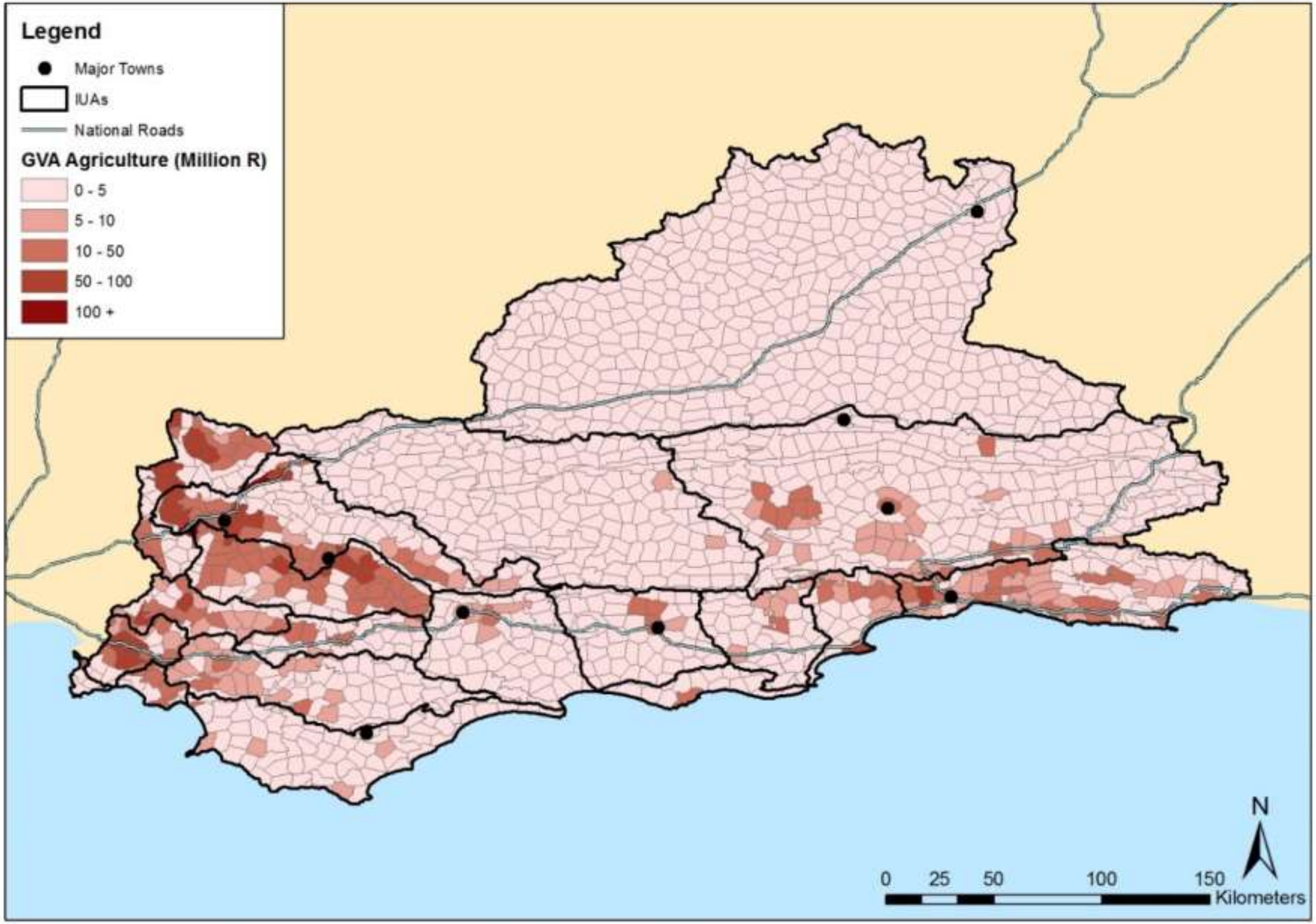


Figure 4-10. Agriculture GVA (R millions) in 2015 per mesozone (Source: GAP 2011, WCG 2014, and StatsSA 2016)

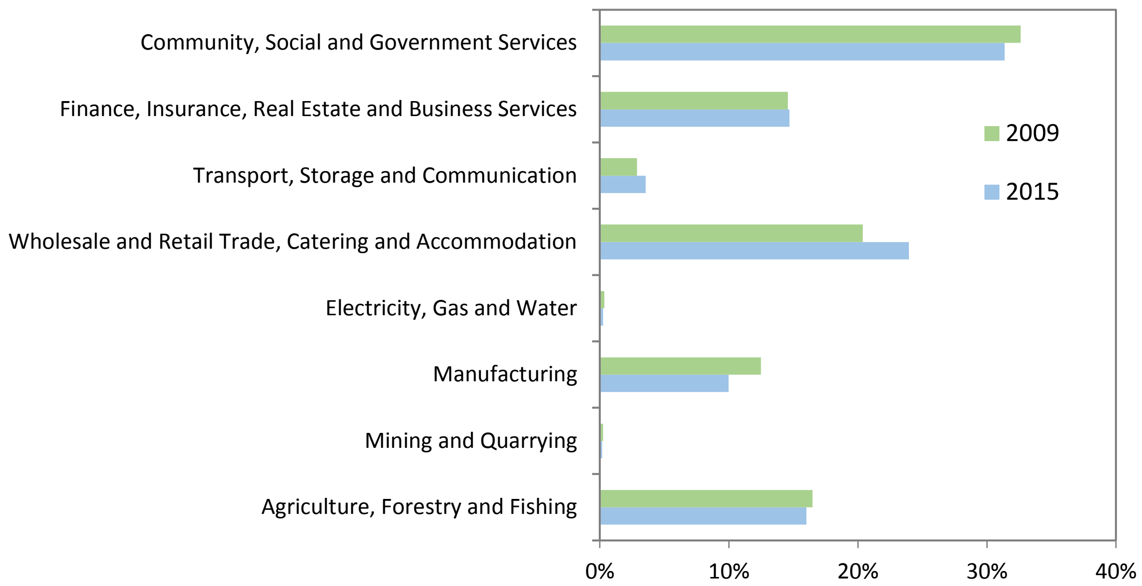


Figure 4-11. Percentage employment in each sector in the WMA in 2009 and in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

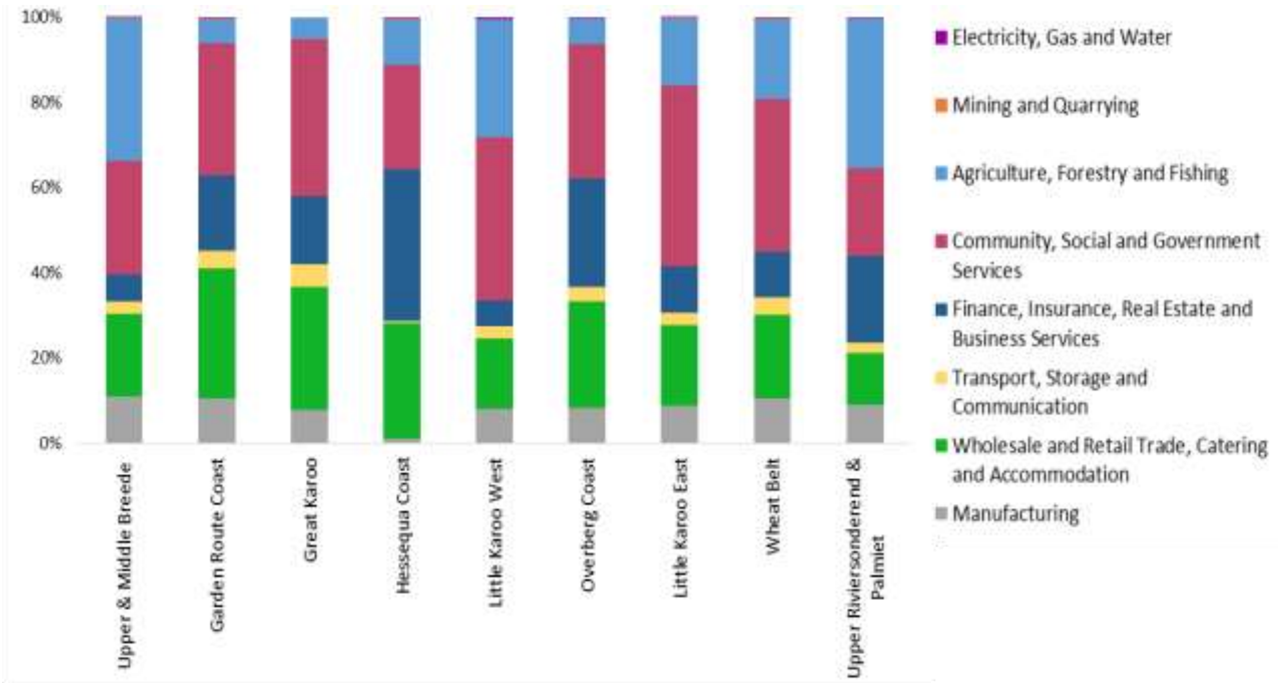


Figure 4-12. Percentage employment in each sector for each socio-economic zone in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

Table 4-5. Total number of individuals and percentage contribution to employment within each sector of the economy and for each socio-economic zone in 2015 (Source: GAP 2011, WCG 2014, and StatsSA 2016)

Socio-economic zone	Agriculture, Forestry and Fishing		Mining and Quarrying		Manufacturing		Electricity, Gas and Water		Wholesale and Retail Trade, Catering and Accommodation		Transport, Storage and Communication		Finance, Insurance, Real Estate and Business Services		Community, Social and Government Services	
Total individuals	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**
Upper & Middle Breede	19 180	21 570	246	140	10 075	7 161	138	62	11 441	12 416	2 160	1 886	5 763	4 030	19 907	17 135
Garden Route Coast	5 333	6 366	276	241	11 715	12 356	422	457	23 916	35 853	2 821	4 830	16 188	20 835	29 250	36 492
Great Karoo	523	524	-	-	652	800	31	-	1 998	2 900	293	535	1 192	1 596	3 155	3 708
Hessequa Coast	288	337	3	1	32	34	14	13	580	854	9	14	890	1 118	628	765
Little Karoo West	1 023	1 356	-	-	385	400	26	22	621	807	107	131	233	299	1 707	1 870
Overberg Coast	1 300	1 578	39	46	2 130	2 137	63	50	4 801	6 483	534	869	5 226	6 600	7 361	8 141
Little Karoo East	4 430	5 133	34	30	2 709	2 866	51	55	4 130	6 152	548	971	2758	3 533	10 927	13 778
Wheat Belt	4 567	5 416	52	65	2 859	3 067	93	85	3 688	5 655	697	1 184	2 254	3 071	8 138	10 365
Upper Riviersonderend & Palmiet	5 949	6 859	9	14	1 707	1 795	61	52	1 512	2 361	275	466	3 172	3 983	3 235	4 024
Total	42 592	49 138	659	538	32 263	30 614	898	798	52 686	73 482	7 443	10 885	37 676	45 064	84 308	96 278
Percentage	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**	**2009**	**2015**
Upper & Middle Breede	27.8%	33.5%	0.4%	0.2%	14.6%	11.1%	0.2%	0.1%	16.6%	19.3%	3.1%	2.9%	8.4%	6.3%	28.9%	26.6%
Garden Route Coast	5.9%	5.4%	0.3%	0.2%	13.0%	10.5%	0.5%	0.4%	26.6%	30.5%	3.1%	4.1%	18.0%	17.7%	32.5%	31.1%
Great Karoo	6.7%	5.2%	0.0%	0.0%	8.3%	7.9%	0.4%	0.0%	25.5%	28.8%	3.7%	5.3%	15.2%	15.9%	40.2%	36.8%
Hessequa Coast	11.8%	10.7%	0.1%	0.0%	1.3%	1.1%	0.6%	0.4%	23.8%	27.2%	0.4%	0.5%	36.4%	35.6%	25.7%	24.4%
Little Karoo West	24.9%	27.8%	0.0%	0.0%	9.4%	8.2%	0.6%	0.5%	15.1%	16.5%	2.6%	2.7%	5.7%	6.1%	41.6%	38.3%

Socio-economic zone	Agriculture, Forestry and Fishing		Mining and Quarrying		Manufacturing		Electricity, Gas and Water		Wholesale and Retail Trade, Catering and Accommodation		Transport, Storage and Communication		Finance, Insurance, Real Estate and Business Services		Community, Social and Government Services	
Overberg Coast	6.1%	6.1%	0.2%	0.2%	9.9%	8.2%	0.3%	0.2%	22.4%	25.0%	2.5%	3.4%	24.4%	25.5%	34.3%	31.4%
Little Karoo East	17.3%	15.8%	0.1%	0.1%	10.6%	8.8%	0.2%	0.2%	16.1%	18.9%	2.1%	3.0%	10.8%	10.9%	42.7%	42.4%
Wheat Belt	20.4%	18.7%	0.2%	0.2%	12.8%	10.6%	0.4%	0.3%	16.5%	19.6%	3.1%	4.1%	10.1%	10.6%	36.4%	35.9%
Upper Riviersonderend & Palmiet	37.4%	35.1%	0.1%	0.1%	10.7%	9.2%	0.4%	0.3%	9.5%	12.1%	1.7%	2.4%	19.9%	20.4%	20.3%	20.6%

4.3.2 Economic activities depending on water use

4.3.2.1 Overview of water use in the WMA

The most recent summary of water requirements is provided by the Internal Strategic Perspective documents produced by DWAF (2003a,b; Table 4-6). The bulk of the water requirements in the WMA is for irrigation agriculture, followed by urban use and plantation forestry. There is very little demand for water for industrial purposes outside of urban areas, apart from in the Mossel Bay area. The following sections describe the agricultural and forestry sectors in more detail.

Table 4-6. Year 2000 Water Requirements (million m³/a) (Source: DWAF 2003a,b)

Breede Sub-areas	Irriga-tion	Urban Incl. BHN	Rural incl. BHN	Mining and bulk industrial outside urban use	Thermal power gener-ation	Afforest-ation (impact on yield)	Total local require-ments	Trans-fers out	Total
Upper Breede	435	26	4	0	0	0	465	35	500
Riviersonderend	49	1	2	0	0	1	53	174	227
Lower Breede	28	2	1	0	0	0	31	0	31
Overberg East	0	2	2	0	0	0	4	0	4
Overberg West	64	8	2	0	0	5	79	23	102
Gouritz sub areas									
Gamka	49	5	1	0	0	0	55	0	55
Groot	49	2	2	0	0	0	53	0	53
Olifants	62	10	2	0	0	0	74	0	74
Gouritz	51	3	3	0	0	1	58	1	59
Coastal	43	32	3	6	0	14	98	0	98

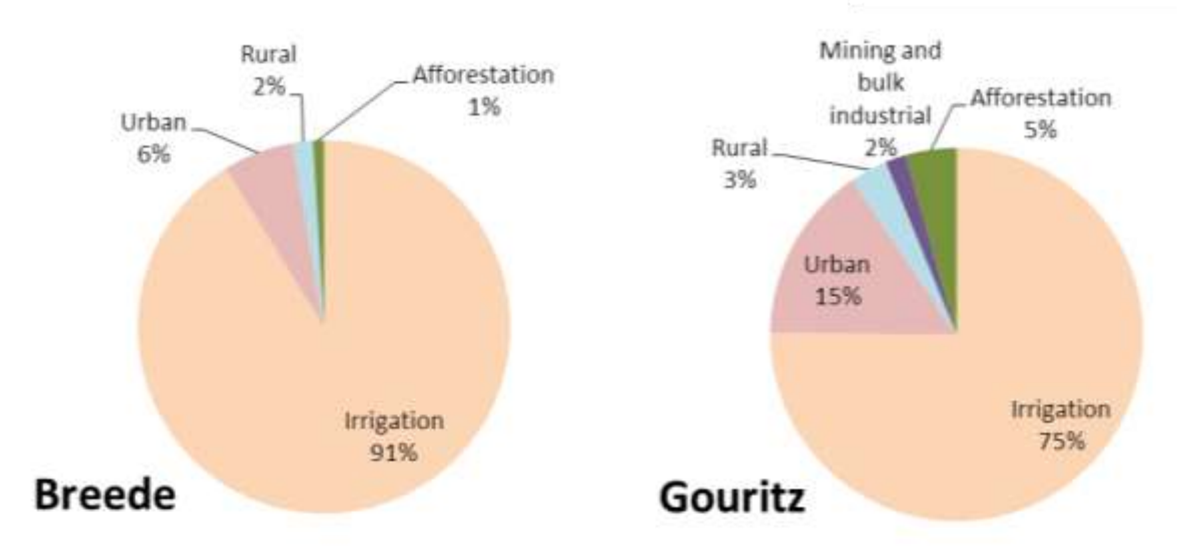


Figure 4-13.Proportion of the total water requirements by different sectors in 2000 (DWAF 2003a,b)

4.3.2.2 Agriculture

The extent of agricultural crop production in the WMA was assessed based on information collated from the Crop Census conducted by the Department of Agriculture in 2013. Details about the types and area of different irrigated and dryland crops were available and these were used to determine the overall agricultural outputs for the WMA. Detailed information relating to the extent of non-irrigated and irrigated agriculture in each IUA is given in Appendix E.

There are a total of almost 697 000 hectares of dryland crops and almost 120 000 hectares of irrigated crops within the Breede-Gouritz WMA (Table 4-7). Just more than 70% of the dryland crops are located in the five IUAs of the Wheat Belt and 55% of the irrigated crops are located within the Upper and Middle Breede (Table 4-7). Planted pasture represents 56%, grains 35% and oil seeds 8% of dryland crops in the WMA. Natural grazing and fallow land covered just under 70 000 ha within the WMA, with 50% of this being located in the Wheat Belt and 16% within the Upper and Middle Breede (Table 4-7).

Table 4-7. Estimated total hectares of irrigated agricultural area and dryland agricultural area, excluding fallow area, in each socio-economic zone

Socio-economic zone	Dryland Crops	Irrigated Crops
Upper & Middle Breede	32 402	65 740
Great Karoo	1 141	984
Garden Route Coast	38 801	6 341
Hessequa Coast	724	50
Little Karoo West	8 018	3 668
Overberg Coast	49 772	1 763
Upper Riviersonderend & Palmiet	22 465	15 821
Little Karoo East	52 875	14 831
Wheat Belt	490 765	10 222
Total	**696 963**	**119 422**

(Source: Western Cape DoA Crop Census 2013)

Of the irrigated crops, wine grapes cover the largest area in the WMA accounting for 35% of the total irrigated crop area, followed by pome fruit (apples and pears; 20%), planted pastures (20%), and stone fruit (13%; Table 4-8).

Irrigation agriculture plays a very important role not only in direct exports of fresh produce but in underpinning a number of agro-processing industries in the Western Cape, many of which are important export industries (Figure 4-15).

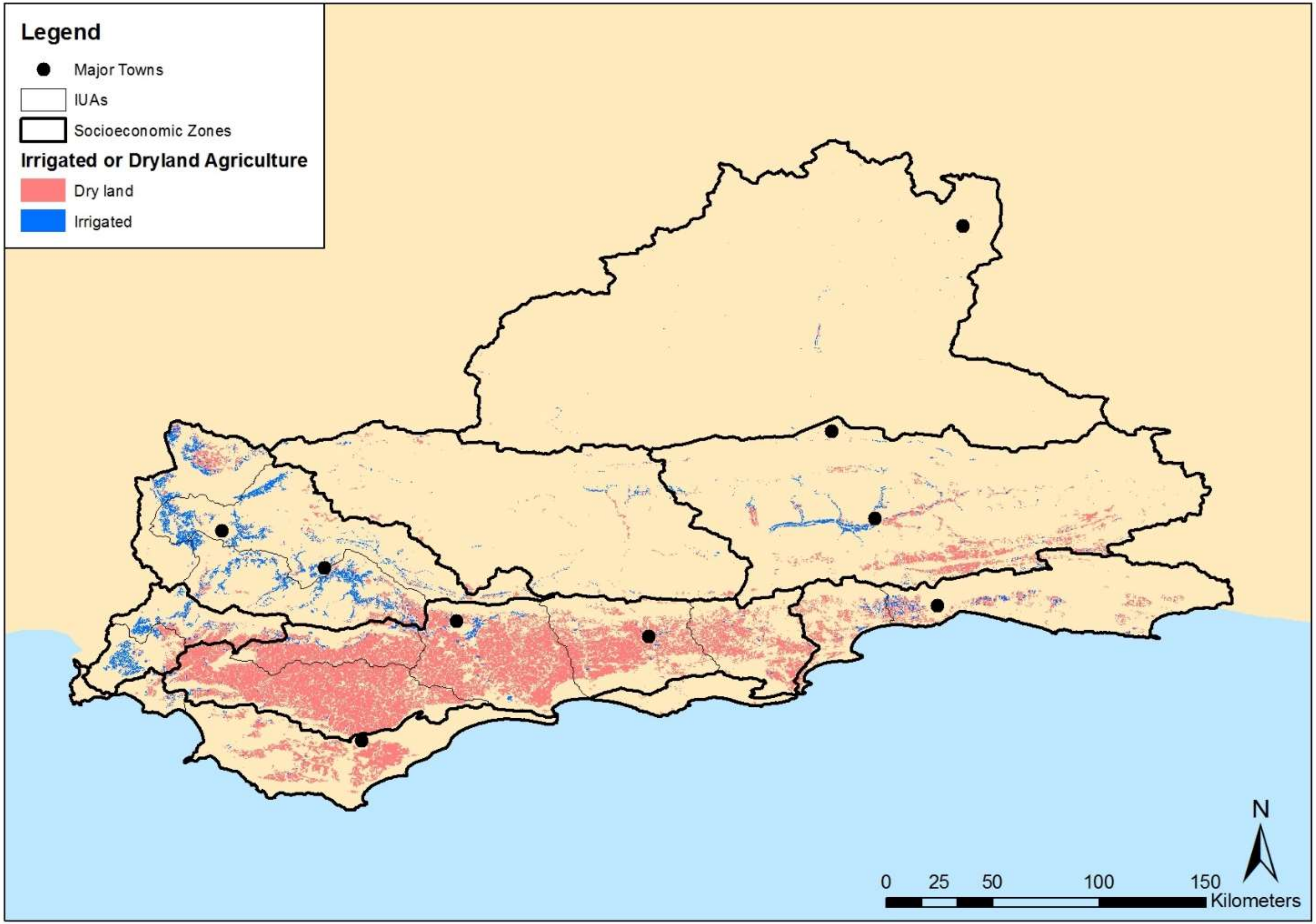


Figure 4-14.Extent of dryland crops and irrigated crops in the Breede-Gouritz WMA (Source: Western Cape DoA Crop Census 2013)

Table 4-8. Total area of irrigated and dryland crops in the Breede-Gouritz WMA, excluding fallow area (Data source: Western Cape DoA Crop Census 2013)

Irrigated Crop Type	Irrigated (ha)	Dryland (ha)
Grapes - Wine	41 570	2
Pome Fruit (apples and pears)	23 472	
Planted Pasture	23 282	387 827
Stone Fruit	15 170	
Grapes - Table	6 001	
Grains	4 190	240707
Citrus / sub-tropical Fruit	2 285	
Other fruit crops	1 593	
Vegetables	1 149	2 790
Nuts & oil seeds	681	55 597
Lupines		8 356
Flowers		1 191
Other crops		498
Total	**119 393**	**696 967**

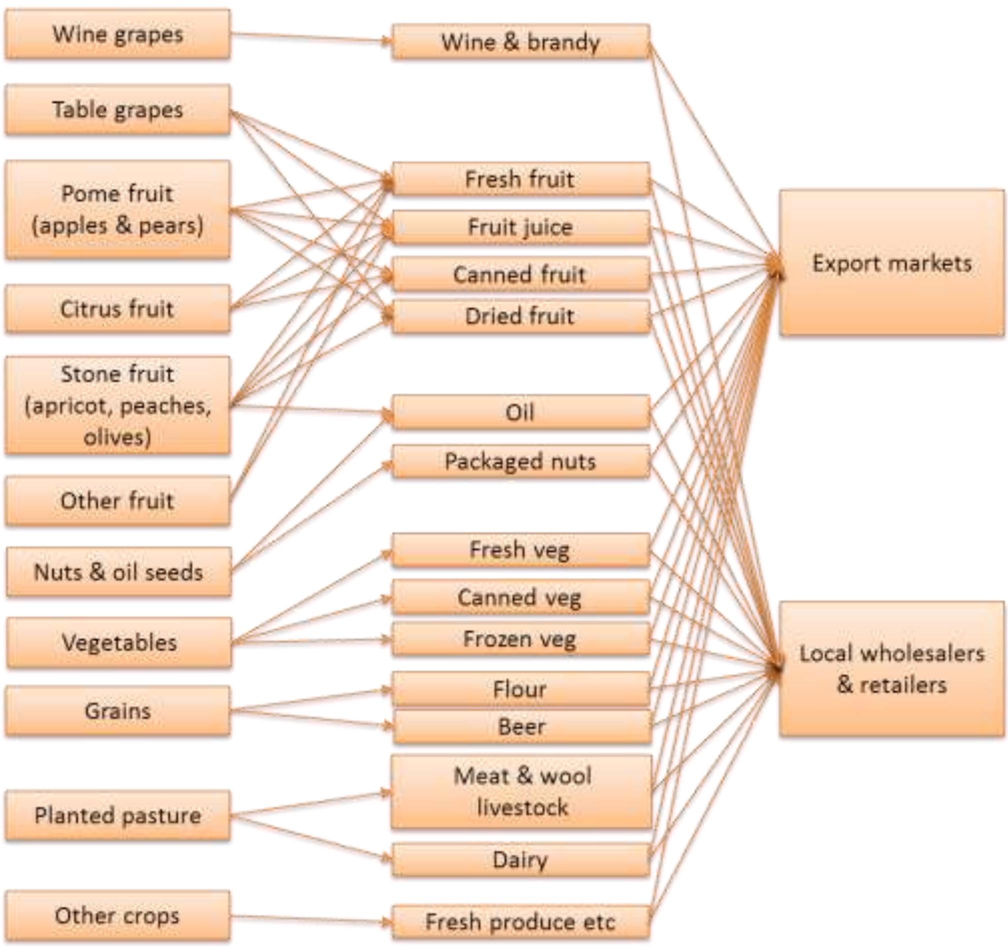


Figure 4-15.Summary of irrigated crops in the study area and their products

Economic outputs and employment associated with irrigated agriculture in the WMA were estimated using information collated from the industry specific reports from the relevant farming association websites (see Table 4-9), summary crop statistics for 2015 from the Department of Agriculture, Forestry and Fisheries website, the ‘Trends in the Agricultural Sector’ 2016 Report and the ‘Abstract of Agricultural Statistics’ 2016 Report. Total production for each irrigated crop type was calculated by multiplying the average production per hectare by the total area of crop within the WMA. This was then multiplied by the average price per tonne (2015 Rands) to determine average gross output per crop in 2015 Rands. Western Cape multipliers (Conningarth 2015, updated to 2014) were used to estimate direct, indirect and total value added as well as total employment for each irrigated agricultural activity. These multipliers are disaggregated by agricultural crop types.

The gross output for all irrigated crops was estimated to be R14.9 billion (Table 4-10). Pome fruit, stone fruit and grapes contributed the most to the overall output. Berries, tree fruits such as figs, pomegranates and guavas, and table grapes had the highest average price per tonne (Table 4-10). Direct value added amounted to R7.2 billion, indirect and induced value added was R4.6 billion and total value added was estimated to be R11.8 billion in 2015 (Table 4-10).

Table 4-9. A list of the associations and their websites for the main agricultural crops in the WMA

Irrigated Crop Type	Association and report references
Pome Fruit (apples and pears)	SA Apple and Pear Producers Association (SAAPPA) www.hortgro.co.za/ Hortgro (2016)
Stone Fruit	SA Stone Fruit Producers Association (SASPA) www.hortgro.co.za/ Hortgro (2016)
Grapes - Wine	SA Wine Industry Information & Systems (SAWIS) www.sawis.co.za/ SAWIS (2016)
Grapes - Table	SA Table Grape Industry www.satgi.co.za/ SATI (2016)
Nuts & oil seeds	Oil and Protein Seeds Development Trust (OPDT) www.opot.co.za/ DAFF (2016a, 2016b)
Citrus / Sub-tropical fruit	Citrus Growers Association (CGA) www.cga.co.za/ SA Subtropical Growers Association (Subtrop) www.subtrop.co.za/ DAFF (2016a, 2016b)
Berries	SA Berry Producers Association(SABPA) www.saberries.co.za/ DAFF (2016a, 2016b)
Grains	Grain SA www.grainsa.co.za/ DAFF (2016a, 2016b)

It is estimated that almost 100 000 people are employed in irrigated farming in the WMA (Table 4-10). Total employment includes direct, indirect and induced employment effects and includes all labourers employed within each activity, which are either skilled, semi-skilled or unskilled. Employment was highest in pome fruit farming, the most economically productive crop within the WMA, with almost 36 000 labourers employed. This was followed by stone fruit farming and wine grape farming.

Table 4-10. Total gross output, direct and total value added and total employment for the main irrigated crop types in the WMA (2015 rands, Western Cape 2014 multipliers)

Irrigated Crop Type	Average production per ha (tons/a)	Average price per tonne (R, 2015/16)	Gross output	Direct value added	Total value added	Total employment
Grapes - Wine	17	3 245	2 358	1 188	1 887	19 055
Grapes - Table	15	12 989	1 169	589	937	6 056
Pome Fruit	36	6 880	5 814	2 808	4 634	38 559
Stone Fruit	21	10 653	3 394	1 639	2 705	22 509
Citrus / sub-tropical Fruit	43	4 592	451	218	360	2 993
Tree Fruit Other	25	13 731	423	204	337	2 808
Berries	23	16 022	124	60	99	826
Grains	3	3 487	48	10	21	129
Planted Pasture	22.5	1 853	971	430	700	6 087
Vegetables	30	3 988	134	60	98	624
Nuts & oil seeds	1.14	6 628	5	2	4	32
Total			**14 892**	**7 208**	**11 784**	**99 678**

4.3.2.3 Forestry

About 7% of South Africa is under commercial forestry. In 2012/13 there were a total of 54 361 ha of plantation forests in the Western Cape, representing 4.3% of the national total (Forestry South Africa 2015). This is lower than the approximately 64 000 ha indicated by the 2013/14 land cover map. 96% of plantations are softwood, mainly pines and gums. This yielded a sawlog production of 4.5 million m^3 in 2012/13 (Forestry South Africa 2015). Based on land cover data, 83% of the Western Cape's plantation forestry area is within the Breede-Gouritz WMA (**Error! Reference source not found.**). Most of this is found within the Garden Route Coast (73%) and Upper Riviersonderend and Palmiet (7%) socio-economic zones (Figure 4-16).

Forestry production was estimated based on data collated from the Abstract of South African Forestry Facts for the year 2012/13. The value per m^3 for sawlogs was calculated using the gross value of outputs and the total volume of roundwood sales for the Western Cape. Roundwood production of 11m^3 per ha was determined using provincial roundwood production estimates. The gross output per ha per year was then calculated using these two estimates. The total gross output for the WMA was then determined by multiplying the output per ha by the total plantation area within the WMA. Values were then updated to 2015 Rands.

Estimated plantation production statistics are summarised in Table 4-11. In 2015 the total output for plantation forestry in the WMA was estimated to be R618 million, with the Garden Route Coast socio-economic zone contributing R452 million to this. Direct value added was estimated to be R274 million and total value added R446 million. It was estimated that 3 878 people were employed in the forestry sector in the WMA in 2015 with 2 837 of these jobs being in the Garden Route Coast socio-economic zone.

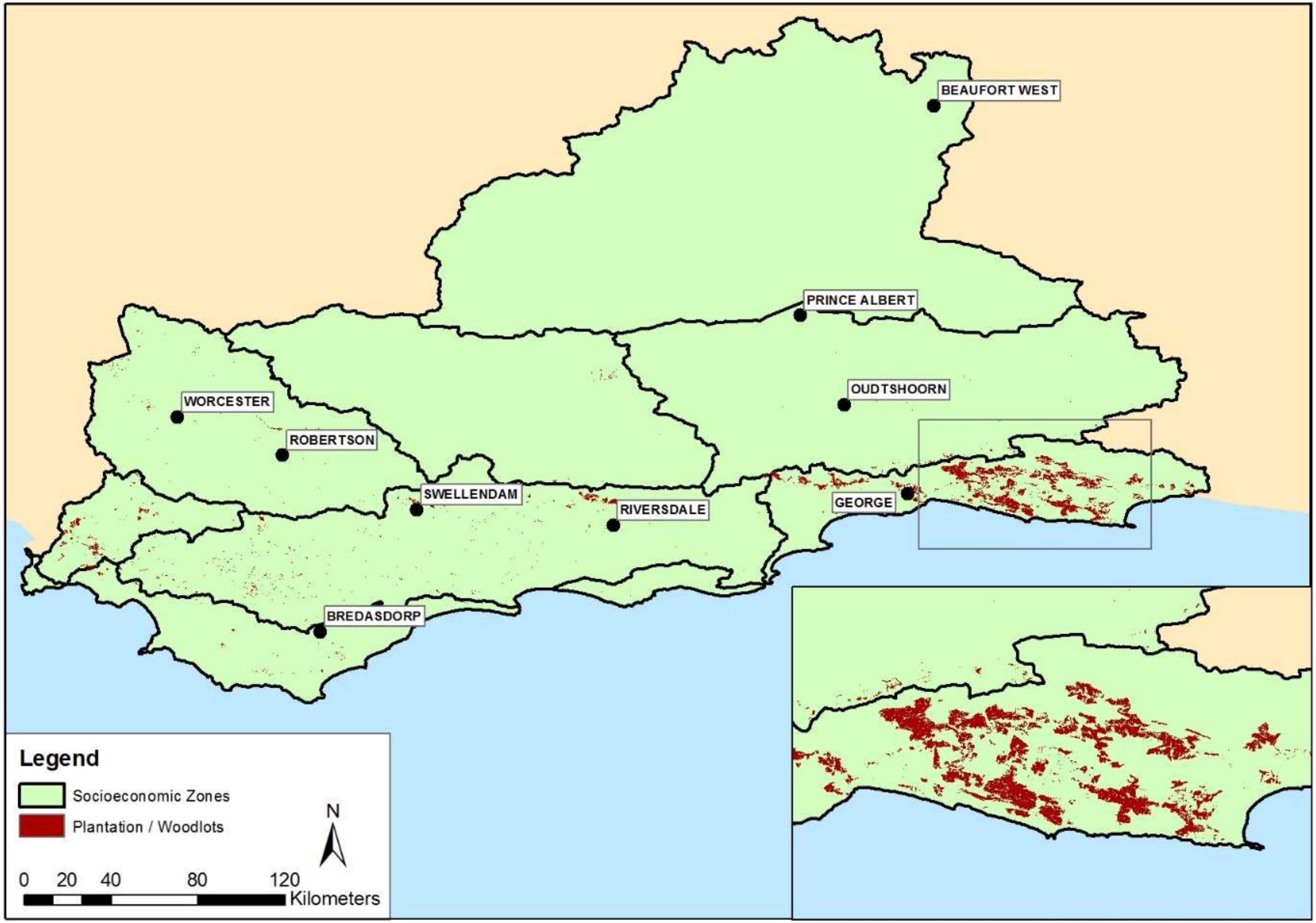


Figure 4-16.Extent of forestry plantations and woodlots within the Breede-Gouritz WMA (Source: DEA, National Land Cover 2013/14)

Table 4-11. Total gross output, direct and total value added and total employment in 2015 for plantation forestry in the WMA

Socio-economic zone	Gross output (R million)	Direct value added (R million)	Total value added (R million)	Total employment
Garden Route Coast	452	200	326	2 837
Upper Riviersonderend & Palmiet	43	19	31	270
All other socio-economic zones	123	54	89	771
Total WMA	**618**	**274**	**446**	**3 878**

4.3.3 Tourism

Tourism is an integral and significant part of the Western Cape economy. The study area includes some of South Africa's and the Western Cape's major attractions for overseas tourists. The WMA is also an important domestic tourism area, particularly for people living in major urban centres of Cape Town and Port Elizabeth. Tourism activities are centred on a wide range of attractions, many of which are or are linked to natural environments, in which aquatic ecosystems are often a significant feature. In addition, wine tasting is an important feature of tourism in the Western Cape, which is in turn an additional benefit of irrigation agriculture. Thus choices regarding water allocation and RQOs may impact on the value of tourism in the study area, with knock-on effects within and beyond this area.

The types of tourism and recreation that are potentially affected include:

- river-based adventure tourism, through impacts on water flows suitable for the activities;
- freshwater, estuary and shore angling, through impacts on fish stocks;
- general nature-based tourism, through impacts on landscapes, biodiversity, water levels for swimming etc. and suitability for human recreational contact; and
- wine-tourism, through impacts on the extent of viticulture.

Available information on some of these activities is described briefly below. However, information is patchy, and it is difficult to estimate the tourism value of any of these activities in the absence of reliable and comprehensive information on the numbers of participants and their expenditure. Therefore in the sections that follow, we have taken the approach of estimating the value of wine- and nature-based tourism in each of the socio-economic zones and IUAs from provincial and regional data, using mapping techniques.

4.3.3.1 Information on water-related tourism activities

River-based adventure tourism

There are a number of companies offering river-based adventure activities within the Breede-Gouritz WMA, mainly in the Breede River, the Garden Route, the Hottentot Hollands, Langeberg, Hawequa and Hex Mountains. The main companies offering these activities were contacted for information on pricing and approximate annual number of participants in these water-associated activities (Table 4-12). The annual turnover of the major companies offering activities in aquatic systems was approximately R4.38 million. These data came from approximately 80% of the companies operating in the area who were willing to participate in providing information. It is possible this estimate could be as much as **R5.5 million** including the companies for which data wasn't available. While some people do undertake these activities on their own, the information on commercial activities gives an indication of the economic contribution of these activities. Most of these activities are seasonal, relying mainly on higher demand during summer months, apart from white water rafting during winter.

Table 4-12. Companies offering recreational activities in rivers and estuaries within the Breede-Gouritz WMA along with data on approximate participation and turnover supplied by companies

Company	**Area**	**Activity**	**Approximate participation (ppl/yr)**
Gravity Adventure Group	Bainskloof	Kloofing	500
Gravity Adventure Group	Breede River	Paddling	200
Gravity Adventure Group	Palmiet	Paddling	400
Simonskloof Mountain Retreat	Nuy River Gorge (Upper Breede)	Kloofing	110
Route 62 Paddling	Breede River	Paddling	200
Eden Adventures	Touw/Kaaimans River	Paddling	
Frixon Adventures	Breede River	Paddling	200
Frixon Adventures	Hottentots Holland	Kloofing	75
Frixon Adventures	Limiet Mountains	Kloofing	555
AfriCanyon	Sout River (Garden Route)	Kloofing	2900
Tripout Knysna	Knysna Area	Kloofing	680
Tony Cook Adventures	Goukamma River	Paddling	234
Tony Cook Adventures	Knysna Lagoon	Paddling	220
TOTAL			**6274**

Most of these activities are sensitive to both the quantity and quality of water flowing through these systems. During low flow or drought periods a number of these operations become unsafe to operate such as kloofing experiences. Poor water quality would also be expected to negatively impact the participation in these activities.

Freshwater angling

Freshwater angling in the study area is dominated by trout and bass fishing. Trout were introduced into Cape streams over 100 years ago and have since survived as wild populations. Rainbow trout are most common, although brown trout occur in some streams. The scenic beauty and clear streams of the Western Cape make fly fishing for trout a popular sport.

Most of the trout fishing waters within the Western Cape are state-owned. However, access is controlled by the Cape Piscatorial Society (CPS) on behalf of Cape Nature. The CPS controls access to the streams through a beat system whereby only one permit per beat per day is awarded to an individual. Fees are charged by CPS which are then passed onto the province. The season for river fishing is from 1 Sep to 31 May.

Rivers controlled by the CPS within the Breede-Gouritz WMA include Jan du Toits River, Smalblaar River (6 beats), Elandspad River (6 beats), Molenaars River, Holsloot River (6 beats) and Witte River (6 beats). All of these rivers are within the upper Breede catchment. Angers are required to have a provincial angling license from Cape Nature (R70) as well as a daily angling permit from CPS (R55/day) and a forestry permit if applicable to the river. CPS also controls access to Lakenvlei Dam, which is limited to 16 people per day. Other locations where trout fishing occurs within the Breede-Gouritz WMA include Bovlakte near Barrydale, in Theewaterskloof dam, Voorhoede near Caledon and smaller marginal pockets near the Swartberg pass and Plettenberg Bay.

The vulnerable endemic Berg-Breede whitefish or witvis is also a recreational fishing species within the upper Breede system. While this species population has suffered due to habitat modifications and the introduction of alien species like bass and bluegills, it still inhabits some dams and streams within the WMA.

Fishing for this species is mainly restricted to dams as populations outside of these areas are very low. The main area where fishing occurs for this species is in the Brandvlei dam. Fishing in dams also requires a freshwater angling licence.

While various studies exist on the value of freshwater angling in other parts of the country, there are no estimates for the Western Cape. If all beats were occupied throughout the season (which is likely the case), this would amount to 11466 angler days per year. The expenditure associated with this activity is unknown, however.

Estuary angling and recreation

Many of the estuaries along the coast of the Breede-Gouritz WMA are popular for recreational angling as well as a host of other recreational activities. It is difficult to separate these values. Lamberth & Turpie (2003) estimated the value of estuary-based angling at the national scale to be in the order of R428.5 million (2001 rands), with the Cape South Coast (Cape Point to Port Elizabeth), making up 40% of this value (R450 million in 2015 Rands). Based on their estimates of relative catches in each estuary, this puts the angling value of estuaries in the Breede-Gouritz WMA at about **R387 million** per annum. More recently, Turpie & Goss (2014) estimated the value of recreational angling at the Breede estuary, a particularly revered fishing spot in the study area, to be at least R54 million per year. This is even higher than the R34 million estimated in the above method. Note that estuary angling activities are very much tied up with other estuary-based activities, all of which contribution to tourism value of estuaries, which is discussed in more detail below.

Inshore marine angling

Shore and boat-based angling along the Breede-Gouritz coast targets many species that use estuaries at some stage in their life cycle (see Box 4.2 on estuary nursery function as an ecosystem service). These species are sensitive to estuarine hydrodynamics and water quality, and their abundance is related to environmental flows. McGrath et al. (1997) found that the economic impact of recreational angling was far more significant than the value added by inshore commercial fisheries. Lamberth & Turpie (2003) estimated the estuary contribution to shore angling for the whole country, and showed that estuaries along the Cape South Coast contributed R17.4 million in 2015 rands to the value of marine recreational fisheries. Based on the relative size and functionality of the estuaries along this stretch of coast, this suggests that current contribution of the estuaries in the study area to marine recreational fisheries could be in the order of R15 million in 2015 rands, with five of these estuaries, the Knysna, Bot/Kleinmond, Swartvlei, Klein and Keurbooms together accounting for 75% of this value. Note, however, that more recent studies have found a decrease in recreational fishing effort in recent years (e.g. Dunlop & Mann 2012, 2013 for KwaZulu-Natal), and these estimates need to be updated with further research.

Nature-based tourism in general

Nature-based tourism encompasses a wide range of activities including taking scenic drives, hiking, visiting nature reserves (e.g. Kogelberg Biosphere Reserve), staying in attractive locations such as along rivers or at estuary mouths (e.g. Knysna), going to the beach, etc., including the adventure and angling activities described above. As with the above, the value of nature based tourism can be estimated using statistics of user numbers and expenditure. These are usually derived from data records (e.g. hotel statistics), surveys and/or observations. Few studies have been carried out on the value of nature-based tourism in the study area. Turpie et al. (2003) estimated the value of ecotourism for the Cape Floral Kingdom based on scant available data at the time. Most studies have focused on specific localities or regions. Turpie & de Wet (2009a,b) estimated the value of the Kogelberg and Garden Route Coasts. In addition, several studies have attempted to estimate the recreational and tourism value of estuaries. For example, Turpie et al. (2004) estimated the recreational use value of the Knysna estuary. They estimated that the Knysna estuary contributed about 60% of the tourism value of Knysna for both residents and visitors. Based on a survey of some 1 000 visitors, it was estimated that about R1 billion of visitors' expenditure on visiting Knysna could be attributed to the estuary (Turpie et al. 2004). The Goukamma estuary was estimated to account for about R350 000 in terms of annual visitor expenditure (Turpie *et al.* 2007). Based on these and other studies outside the WMA, Turpie & Clark (2007) estimated the tourism values of each of the estuaries in the Cape.

These estimates suggest that the tourism value of estuaries in the Breede-Gouritz WMA would be in the region of R3 billion per annum in 2015 rands (Table 4-13), which is almost ten times the value estimated above for angling alone.

Table 4-13. Ballpark estimates of tourism value of estuaries within the Breede-Gouritz WMA., updated from Turpie & Clark (2007) using CPI index

Socioeconomic Zone	Estuary	Tourism value (R/yr)	Socioeconomic Zone	Estuary	Tourism Value (R/yr)
Overberg	Rooiels	322 000	Garden Route	Klein Brak	8 050 000
Overberg	Buffels (Oos)	322 000	Garden Route	Groot Brak	16 100 000
Overberg	Palmiet	1 207 500	Garden Route	Maalgate	32 200
Overberg	Bot/Kleinmond	8 050 000	Garden Route	Gwaing	32 200
Overberg	Onrus	483 000	Garden Route	Kaaimans	80 500
Overberg	Klein	322 000 000	Garden Route	Wilderness	161 000 000
Overberg	Uilskraals	161 000	Garden Route	Swartvlei	120 750 000
Overberg	Ratel	32 200	Garden Route	Goukamma	563 500
Overberg	Heuningnes	805 000	Garden Route	Knysna	1 610 000 000
Overberg	Klipdrifsfontein	80 500	Garden Route	Noetsie	1 610
Wheat Belt	Breede	40 250 000	Garden Route	Piesang	1 207 500
Wheat Belt	Duiwenhoks	1 207 500	Garden Route	Keurbooms	644 000 000
Hessequa	Goukou	80 500 000	Garden Route	Matjies	48 300
Wheat Belt	Gouritz	805 000	Garden Route	Sout (Oos)	32 200
Garden Route	Blinde	161 000	Garden Route	Groot (Wes)	3 220 000
Garden Route	Hartenbos	1 610 000	Garden Route	Bloukrans	423 108
			TOTAL		**3 023 537 818**

4.3.3.2 Estimate of tourism values using a spatial approach

Overall value of tourism in the Western Cape

Tourism in the Western Cape makes a significant contribution to both the regional and national economy. Much of this tourism value is linked to natural attractions, as well as to the wine industry. Indeed, in 2015, visiting the winelands ranked fifth for tourists visiting South Africa, after Cape Town city, V&A waterfront, Table Mountain Cableway and Cape Point. The Garden Route ranks 7th.

Total foreign direct spend (TFDS) in the Western Cape was estimated to be R14.9 billion in 2015; some 21.8% of the national TFDS (Wesgro 2016). 51.5% of the 1.324 million foreign visitors in 2015 were on holiday, and 20.8 were on business trips (SA Tourism 2016). The proportion visiting on holiday is much higher for the Western Cape than in the rest of the country. The remainder were mostly visiting friends and relatives (VFR). International visitors spent 16.25 million bed nights in the province. Domestic visitor expenditure in the Western Cape during the same period was estimated to be R2124 million (Tourism SA 2016). This was spent on 2.2 million day trips and 2.8 million overnight trips. Thus total tourism expenditure during 2015 was in the order of R17 billion.

The majority of overseas visitors were visiting friends and relatives, whereas the majority of domestic visitors were on holiday. Holiday tourism accounts for the highest proportion of expenditure (Table 4-14).

Table 4-14. Percentage contribution of different types of visitors to total number of visits and total expenditure for overseas and domestic tourists to the Western Cape during 2015. Source: Tourism SA (2016), Wesgro (2016) and own calculations

Origin	Main purpose of visit	% visits[1]	% spend[1]	Total spend (R millions)	% visiting tourist offices[2]	Estimated spend relating to attractions (R millions)
Overseas	Holiday	30.0	52.5	9 352.1	95.0	9 352.1
	Business	13.0	17.3	3 599.8	1.7	157.1
	VFR*	54.0	29.3	946.8	0.5	14.5
	Other	3.0	0.8	1 015.8	2.8	154.6
	Subtotal			**14 914.6**		**9 678.4**
Domestic	Holiday	51.5	62.8	1 115.6	87	1 115.6
	Business	20.8	24.2	368.2	9	89.9
	VFR*	17.7	6.4	622.2	4	16.2
	Other	10	6.8	18.0	0	0
	Subtotal			**2 124.0**		**1 221.8**
Overall	**Total**			**17 038.6**		**10 900.2**

*1. Tourism SA (2016). 2. Wesgro (2016, multiple regional reports) * VFR: Visiting Friends and Relatives*

The contribution of the Western Cape's attractions

In this study, the main interest is in the value of tourism relating to attractions that may be affected by water allocation. As a first step, this requires estimating how much of tourism expenditure can be attributed to attractions generally, such as going to enjoy beaches, nature, wine routes etc., as opposed to spending that is not related to attractions, such as going to conferences, medical treatments, etc. Expenditure on attractions cannot simply be estimated as the expenditure by holiday tourists, as it is often also the case that tourists visiting for another primary reason such as business, also take some time to enjoy local attractions. This is evident from the tourism statistics are also gathered by tourism offices within each of the Western Cape's tourism regions (Table 4-14; Figure 4-17). According to these data, almost all visitors to tourism offices in the different regions are holiday visitors, but the mix also includes visitors of other types. These statistics were used to derive the estimated expenditure by overseas and domestic visitors that could be attributed to visiting tourism attractions in the Western Cape. Overall it was estimated that 65% of overseas visitor expenditure and 58% of domestic visitor expenditure in 2015 was on attractions, with a total of R10.9 billion, accounting for 64% of total tourism expenditure. Most of this (R9.7 billion) was by overseas tourists.

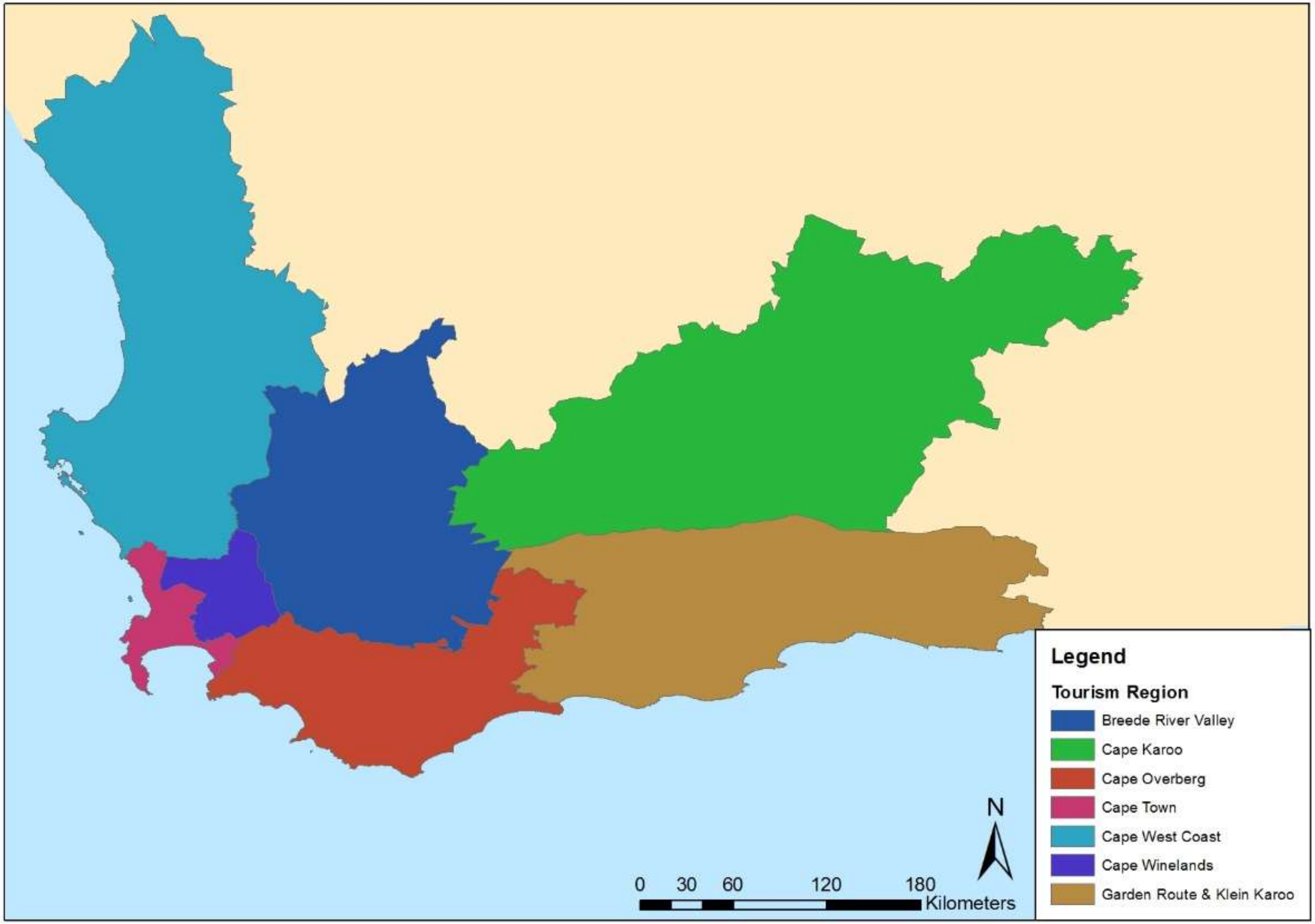


Figure 4-17.Tourism regions of the Western Cape

Variation among the tourism regions

The statistics collected in the regional offices also provide more spatial resolution on types of visitors and their activities in the different areas. Domestic visitors dominate in all the regions, but foreign tourists make up a relatively high proportion of visitors in Cape Town, the Overberg, the Winelands and the Garden Route/Klein Karoo (Figure 4-18). Reasons for visiting these different regions also differ widely (Table 4-15), but frequently include natural attractions and wine tasting as well as a host of cultural and other attractions.

Based on the percentage of beds in each of the regions (Cornelissen 2005) and the percentage frequency of different types of attractions, the tourism expenditure generated by different types of attractions in the different regions of the Western Cape are shown in Figure 4-19. The remaining tourism expenditure is shown as other expenditure, assuming that 50% of expenditure is in Cape Town (our estimates require a more conservative than that of Grant Thornton 2009 ~ 65%). Overall, the results suggest that nature-based tourism in the Western Cape generated a total expenditure of about R4490 million in 2015.

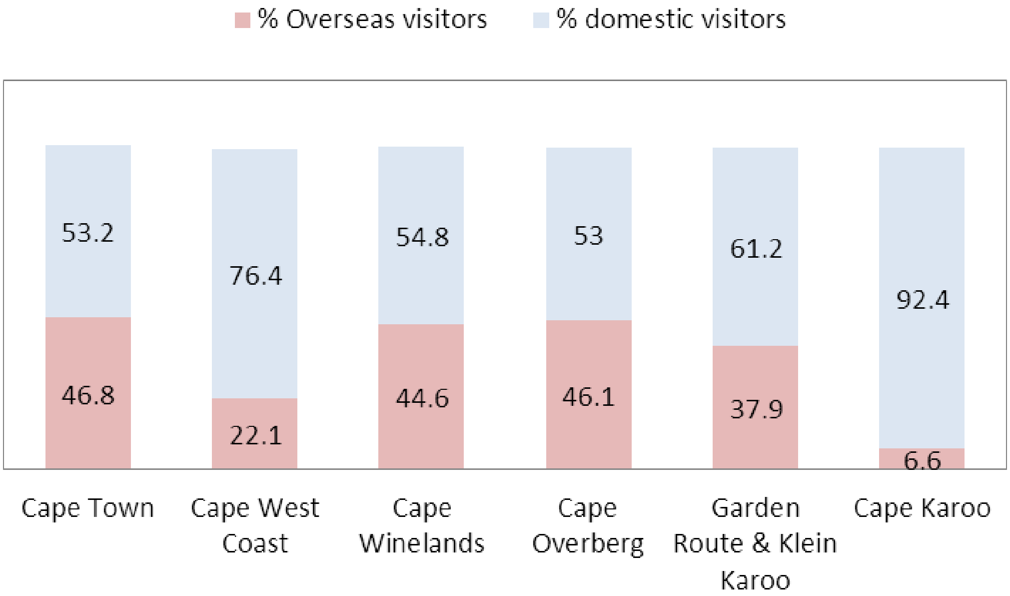


Figure 4-18. Proportion of overseas versus domestic tourists visiting each of the six tourism regions in the Western Cape

Table 4-15. Percentage frequency of main attractions

Attraction	Cape Town	Cape West Coast	Cape Winelands	Cape Overberg	Cape Karoo	Cape Garden Route & Klein Karoo
Wine tasting	11.0	2.7	19.6	2.2		9.2
Outdoor activities	20.7	11.6	13.6	2.5		12.8
Scenic drives		29.0	13.2	26.5	12.0	21.3
National Parks			4.2		4.2	2.5
Adventure	7.0	2.0	2.6		1.3	2.2
Beaches	12.1			4.4		5.3
Fishing		4.0		4.7		

Attraction	Cape Town	Cape West Coast	Cape Winelands	Cape Overberg	Cape Karoo	Cape Garden Route & Klein Karoo
Whale watching				7.4		
Ostrich farms						1.2
Golf		4.2		5.7		1.1
Culture/heritage	19.9	11.7	13.6	13.4	53.7	11.6
Gourmet restaurants	16.3	14.9	11.1	12.0	4.2	9.1
Shopping						2.8
Crafts/food markets			3.7	4.2	1.9	5.7
Nightlife/clubbing	2.5					
Expos/exhibitions		3.8	4.4			
Meetings/incentives		4.6	4.4		2.7	
Summary:						
Wine tasting	**11.0**	**2.7**	**19.6**	**2.2**	**-**	**9.2**
Nature-based attractions	**39.8**	**46.6**	**33.7**	**45.5**	**17.5**	**44.1**
Cultural & other attractions	**49.2**	**50.7**	**46.7**	**52.3**	**82.5**	**46.7**

Based on stated top 3 activities listed by overseas and domestic visitors to tourism offices in the different tourism regions (Wesgro reports), and weighted by % overseas vs domestic. These are summarised into broad categories above. Blank cells are where categories were not listed as an option or did not feature in the top 3.

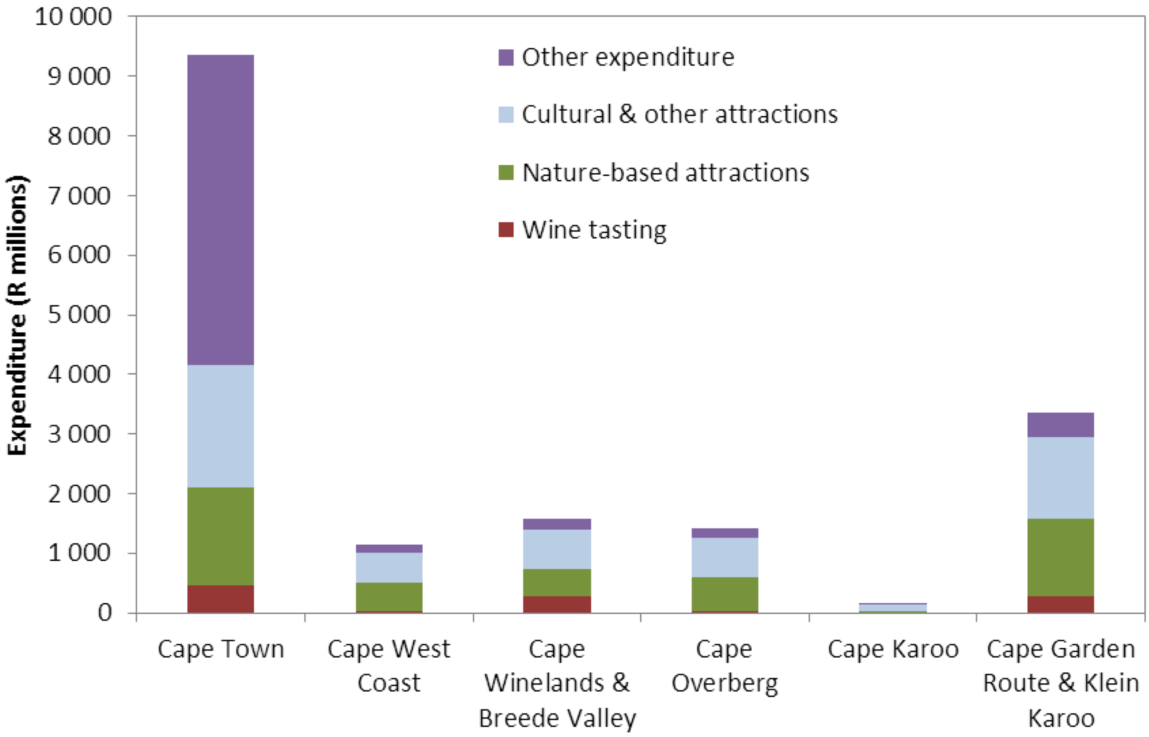


Figure 4-19. Estimated expenditure attributed to different types of attractions in different tourism regions of the Western Cape (this study)

Finer-scale geographic variation in value

In order to estimate the value of tourism in the socio-economic zones and IUAs, and potentially specific aquatic ecosystems, it would be necessary to estimate how these values are distributed at a higher level of spatial resolution than the tourism regions described above.

The spatial distribution of tourism visitation across the WMA was assessed using Google Earth Panoramio photos. Panoramio hosts photographs from all over the globe, focusing on images of landscapes, natural features and animals in their natural environment. Images that focus on people, interiors, paintings, logos and events are excluded from the website (Panoramio 2015). Geo-tagged imagery can provide information about the places depicted in the photographs, as well as the interests, behaviours and mobility of the people who took them (Andrienko *et al.* 2009). The pattern of these photographs represents where people value natural attractions. Panoramio photos were gridded to a 0.025 Decimal degree grid across the country. In the Western Cape, the numbers of photographs uploaded per tourism region were strongly correlated with the number of beds, which indicates that photo densities are a reasonable indicator of relative tourism value (Figure 4-20).

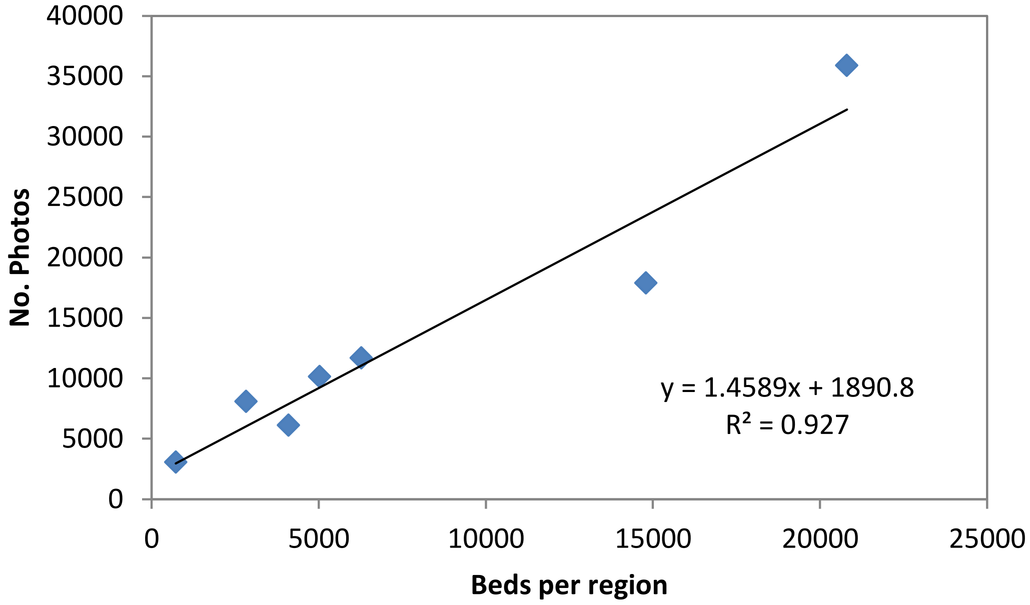


Figure 4-20.Distribution of photos uploaded to Panoramio across the Breede-Gouritz WMA

Of the Panoramio photographs uploaded within the Western Cape, 44% fell within the Breede-Gouritz WMA. Applying this percentage to the value to the estimated expenditure attributed to attractions within the entire Western Cape in 2015 gives a value of R4755 million.

The geographic pattern of photo density is shown in Figure 4-21. Within the study area, the main tourism areas are concentrated along the coast, especially in the east around Hermanus as well as in the west along the garden route from Mossel Bay to Plettenberg Bay (Figure 4-21 Figure 4-21). Other centres of tourism activity are based around towns as well as along main transport routes. Roads with especially high visitation include the N1 through Worcester, The N2 through Swellendam and George, the R62 from Oudtshoorn to Robertson as well as the routes from Prince Albert to Oudtshoorn through the Swartberg and Meiringspoort passes.

Total photograph uploads per zone were used to estimate the value of tourism attractions in each socio-economic zone (Table 4-16). Of these, the attractions of the Garden Route Coast generate the highest value, followed by the Overberg coast. Details of the IUAs within each zone are provided in the zonal summaries below.

In order to estimate the contribution of rivers and estuaries to this tourism value, the number of photos occurring close to streams, rivers and estuaries was assessed. Rivers were buffered according to their stream order with 100 m buffers for 1st order streams, 200 m for 2nd order streams and so on up to 500 m for 5th order streams. Estuaries were also buffered between 100 - 500 m according to the stream order of the main inflowing river. The number of photos occurring in grid cells that intersected these buffered areas was then summed according to the Socioeconomic Zones into which they fell and used to estimate the Gross output of rivers and estuaries to tourism (Table 4-16).

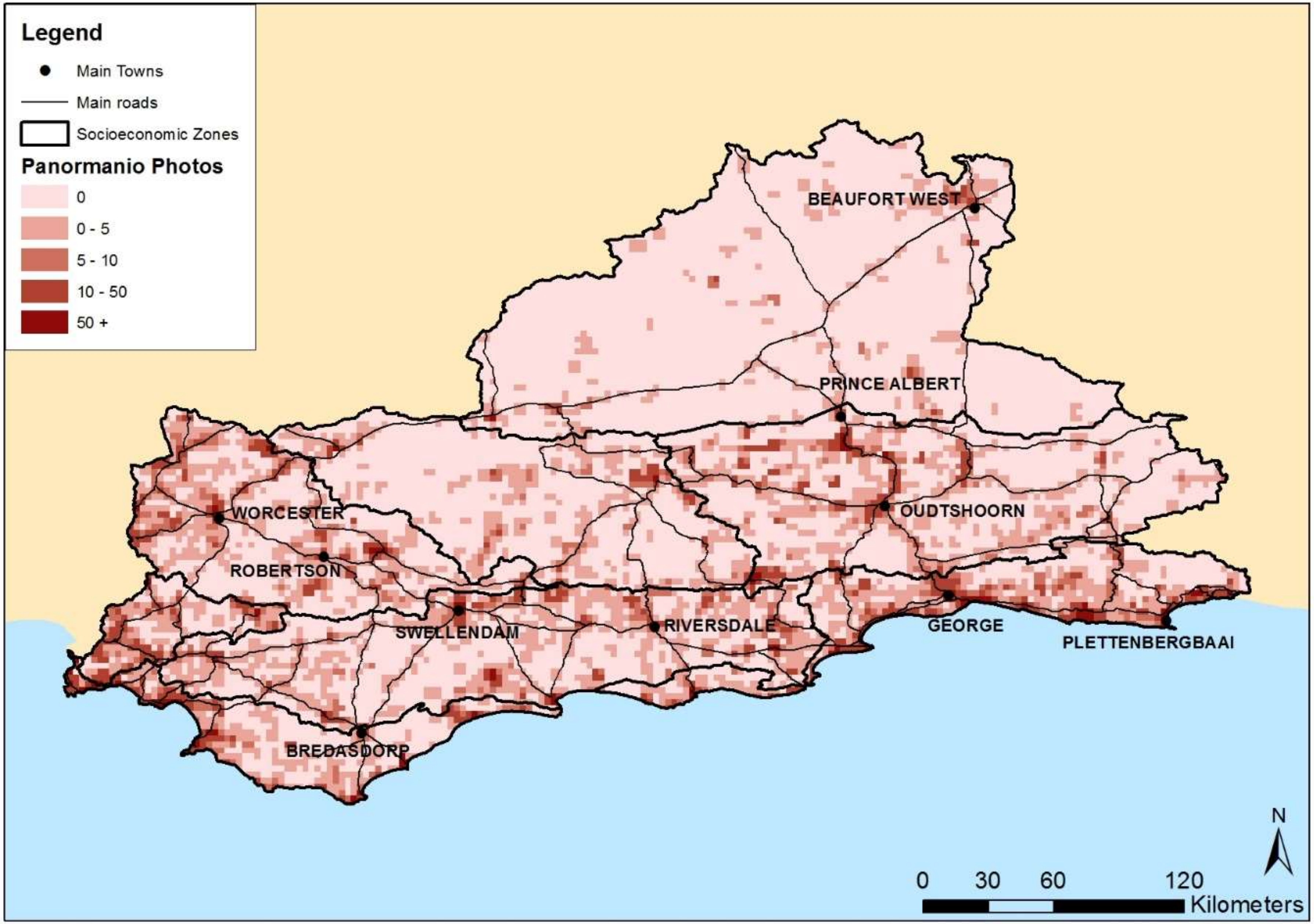


Figure 4-21. Distribution of photos uploaded to Panoramio across the Breede-Gouritz WMA

Similarly to the distribution of attractions overall, the output relating to the rivers and estuaries was greatest in the Garden Route Coast (Table 4-16). The Great Karoo, Little Karoo East also had proportionally higher numbers of the photos taken associated with rivers and estuaries. Conversely, the Overberg and Hessequa Coast had relatively few photos associated with rivers and estuaries.

Table 4-16. Estimated value of tourism attractions within each socio-economic zone

Socio-economic zone	Gross Output (R million per year)	% at/near rivers and estuaries	Estimated contribution of rivers and estuaries (R million per year)
Upper and Middle Breede	679.4	55%	370.9
Upper Riviersonderend	336.1	47%	156.5
Great Karoo	143.5	67%	96.6
Little Karoo East	598.5	61%	363.2
Little Karoo West	270.9	48%	130.9
Wheat Belt	624.6	57%	355.2
Garden Route Coast	1 163.1	63%	734.2
Overberg Coast	841.7	23%	179.2
Hessequa Coast	97.5	39%	37.9
	4 755.3		**2 442.4**

4.3.4 Property

While natural attributes may generate revenues through domestic and international tourism, they can also manifest in property values, leading to value added in the associated services and financial sectors. People not only visit pleasant environments, they may also pay a premium to live near them. This reflects additional amenity value that is not reflected in tourism expenditure. In the study area, this is particularly true for coastal areas (e.g. Turpie & de Wet 2007a, b), and estuaries (van Zyl & Leiman 2001, Turpie & Clark 2007). Very little empirical work has been undertaken to estimate these premiums in the study area, but Turpie & Clark (2007) estimated the property premium associated with estuaries on the basis of property counts and interviews with estate agents. The property premium was expressed as an annual value as direct income (value added) generated in the real estate sector, based on annual rates of property over and estimated percentage fees to agents. Values for the estuaries within the Breede-Gouritz WMA from this study were used and inflated to 2015 prices using the CPI Index as well as adjusting to the growth in the numbers of properties surrounding each estuary using Google Earth imagery. The combined recreational value of the estuaries was in the order of R3.2 billion (Table 4-17).

Table 4-17. Value generated in the financial sector through property markets attributed to estuaries

Socioeconomic Zone	Estuary	Annual value (Rands)	Socioeconomic Zone	Estuary	Annual value (Rands)
Overberg	Rooiels	2 197 650	Garden Route	Klein Brak	2 134 860
Overberg	Buffels (Oos)	2 724 120	Garden Route	Groot Brak	19 967 220
Overberg	Palmiet	0	Garden Route	Maalgate	0
Overberg	Bot/Kleinmond	25 410 630	Garden Route	Gwaing	0
Overberg	Onrus	2 588 880	Garden Route	Kaaimans	483 000

Overberg	Klein	1 545 600	Garden Route	Wilderness	10 239 600
Overberg	Uilskraals	2 009 280	Garden Route	Swartvlei	16 378 530
Overberg	Ratel	0	Garden Route	Goukamma	0
Overberg	Heuningnes	0	Garden Route	Knysna	0
Overberg	Klipdrifsfontein	0	Garden Route	Noetsie	96 600
Wheat Belt	Breede	42 943 530	Garden Route	Piesang	1 883 700
Wheat Belt	Duiwenhoks	2 395 680	Garden Route	Keurbooms	19 682 250
Hessequa	Goukou	26 719 560	Garden Route	Matjies	0
Wheat Belt	Gouritz	18 184 950	Garden Route	Sout (Oos)	0
Garden Route	Blinde	0	Garden Route	Groot (Wes)	5 940 900
Garden Route	Hartenbos	1 072 260	Garden Route	Bloukrans	0
			TOTAL		**204 598 800**

Numbers based on Turpie & Clark (2007) updated using CPI index and growth in the number of houses around estuaries.

4.3.5 Commercial fisheries

Of the commercial fisheries operating off the Breede-Gouritz WMA coast, the traditional boat-based line fishery is the only one influenced by environmental flows through their influence on the supply of ecosystem services in the form of estuarine fish nursery areas (see Box 4.2 on estuary nursery function).

This fishery dates back to the 1500s (Thompson 1913). It is a boat-based fishery in which fish are caught on lines with no more than 10 baited hooks per line. The fishery thus operates inshore where fish are accessible on day or short overnight trips and in water shallow enough to be caught using manual labour with hand lines or rods and reels. By the late 1980s, the majority of vessels were highly mobile, trailable ski-boats that could follow aggregations of shoaling species such as yellowtail, snoek, geelbek and kob. When these aggregations occur far from the fishers' base, the boats are driven up to launch sites closer to the fishing grounds. By the end of the 1990s there were approximately 3 000 fishing boats ranging from 3m dinghies to 15m deck boats carrying a total of around 3000 crew were involved in the commercial line fishery (Griffiths 2000, Mann 2000). This multispecies fishery landed about 250 species, although only about 20 were commercially important (Lamberth & Joubert 1999). Griffiths (2000) analysed fishery data over a 100-year period, and found that in spite of technological advances over this period, declines in catch rate were indicative of severe overexploitation (i.e. 75-99%). The Minister of Environmental affairs and Tourism declared an environmental emergency in the traditional line fishery in December 2000, and restricted the number of vessels and fishers in the commercial fishery, as well as bag and size limits for commercial and recreational line fishers. The commercial line fishery was split into three regional management zones, restricting the movement of vessels from one region to the next within the 2006-2013 long-term rights allocation (MCM 2006). Since 1985, all commercial line fish permit holders have had to submit catch returns to the National Marine Linefish System (NMLS) database.

After 2003 the number of licensed vessels in the commercial fleet was diminished to about a tenth of the former numbers. However, effective effort has not diminished to the same degree, since the ski boats have since became larger, with longer travel ranges, and have the ability to handle rougher weather. They are also now mostly operated and crewed by full time professional line fishers. Along with these changes, operating costs (particularly fuel and bait) have increased dramatically since 2003 (Turpie et al. 2012).

A total of 455 long-term traditional line fish rights were issued in South Africa for 2006 to 2013, in three zones[3].Then 215 were allocated for the subsequent period in a controversial process that led to 567 appeals from this fishery and is still not fully resolved. Each of these rights represents a boat with an average of 8 crew.

Effort and catch data were drawn from the National Marine Linefish System (NMLS) database for the period 2006 to 2011. Data from before 2006 do not provide a good reflection of the fishery as it is at present, as those catches included handline hake. Post 2006 data is also better since the first long term rights allocation in 2006 impacted the fishery. Spatial mapping of effort and catches in the line fishery is less accurate than in other sectors, because of the logbook method employed by fishers, which is to describe location in relation to numbered sections along the coast and estimated distance offshore. No bearings are given, and no GPS data are recorded by the fishers with which to calibrate these estimates. This means that in plotting the data, estimates of the bearings have to be made. These are done very coarsely as due east, south or southeast of the coast (for the coast east of Cape Agulhas). Nevertheless this allows estimation of the proportion of catches taking place in the study area.

[3] ZONE A: Port Nolloth to Cape Infanta; ZONE B: Cape Infanta to Port St Johns; and ZONE C: KwaZulu-Natal

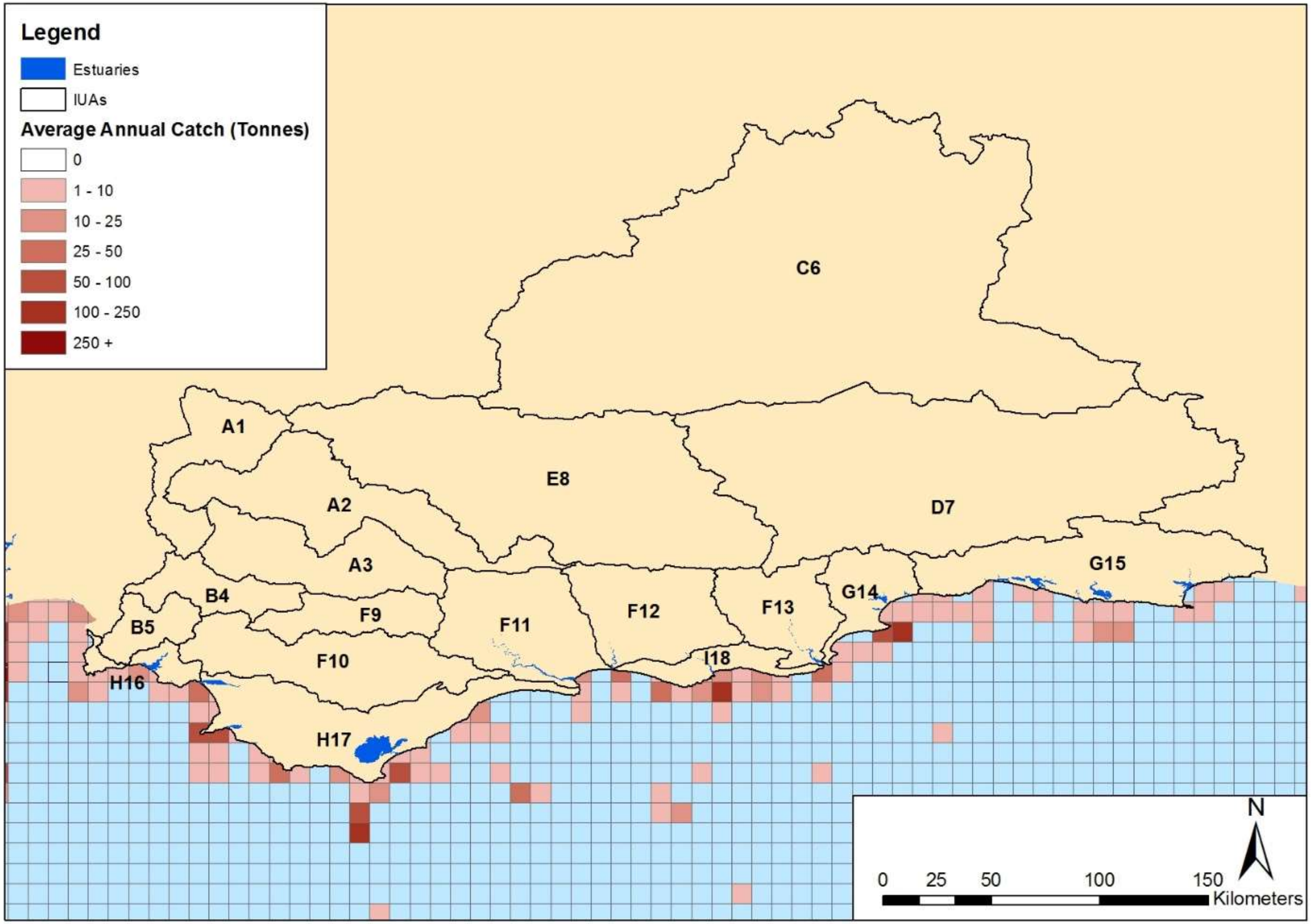


Figure 4-22.Distribution of average annual line fishery catches across the coast of the Breede-Gouritz WMA in relation to IUAs and estuaries

The South African line fishery is valued in excess of R2.2 billion per annum (Department of Agriculture, Forestry and Fisheries 2014). The sum of average annual catches in each of the grid blocks off the coastline of the Breede-Gouritz WMA was 1425 Tonnes/yr which equates to approximately 20% of the value for the whole country. This suggests that the gross output value of the traditional line fishery within the study area is approximately R440 million/year, provided the resource is managed sustainably.

Box 4.2. Nursery value of estuaries

Estuaries play an important role as nursery areas for many fish and invertebrate species that spend the rest of their life cycle in marine or freshwater habitats, including many species that are harvested for recreational or commercial purposes (Whitfield, 1994; Beck *et al.,* 2001). The quantity and quality of freshwater inflows to estuaries as well as management of habitats within them affect their capacity to function as nursery areas.

Fish species that use estuaries have been classified according to their relationships with estuaries. Of particular importance in terms of nursery value are the fish species in category I and II, for which the management of estuaries plates a crucial role in fisheries (Lamberth & Turpie 2003). Most estuary-dependent fish species enter estuaries as larvae or post larvae (Whitfield & Marais 1999) and once the estuarine dependent phase is complete, they leave the estuaries for the marine environment where they become available to marine fisheries, and upon maturity contribute to the spawning stock (Wallace 1975a,b).

The five major categories and subcategories of fish that utilize South African estuaries (Whitfield 1994)

Category	Description
I	Estuarine species that breed in southern African estuaries:
	Ia. Resident species, no record of spawning in marine or freshwater environments
	Ib. Resident species that do have marine and freshwater breeding populations
II	Euryhaline marine species that normally breed at sea, with juveniles showing varying degrees of dependence on southern African estuaries:
	IIa. Juveniles dependent on estuaries as nursery areas
	IIb. Juveniles occur mainly in estuaries, but are also found at sea
	IIc. Juveniles occur in estuaries, but are usually more abundant at sea.
III	Marine species that occur in estuaries in small numbers, but are not dependent on these systems
IV	Freshwater species, whose penetration into estuaries is determined mainly by salinity tolerance
V	Catadromous species that use estuaries as transit routes between marine and freshwater environments, but may also occupy estuaries in some regions
	Va. Obligate catadromous species that require freshwater in their development
	Vb. Facultative catadromous species that do not require a freshwater phase in their development

Fish diversity and abundance differs between estuaries of different sizes and types, with higher species richness associated with larger and permanently open systems (Lamberth & Turpie 2003), such as Knysna estuary and the Breede Estuary. However, estuary health, in particular, the quality of water and quantity of water entering an estuary can impact fish abundance and diversity significantly. Within the WMA there are a number of estuaries that have become severely degraded as a result of significant flow modifications, very poor water quality, habitat destruction and reduced food availability (van Niekerk & Turpie, 2012). The condition of each estuary needs to be taken into consideration when determining its contribution to nursery value.

Estimates of nursery value have been made for all South African estuaries, based on inshore fishery catches and the level of dependence of each species on estuaries (Lamberth & Turpie, 2003). Based on this 2003 study, it was estimated that the 50 or so estuaries in the Western Cape contribute about R250 million to the value of inshore fisheries (in 2013 Rands). However, many of the Western Cape's estuaries have become degraded as nursery habitats because of freshwater starvation and mouth manipulation. Furthermore, the fish stocks themselves have also been depleted through overfishing, both legal and illegal. Based on the scores given in a recent evaluation of the current health of fish stocks in each of South Africa's temperate estuaries (WRC and CSIR, unpublished data), in conjunction with information on estuary volumes, it is estimated that the nursery outputs from estuaries in the Western Cape are now only about 27% of their original capacity, suggesting that we have lost services to the value of R675 million (Turpie et al., 2014). This is because some of the most important nursery areas that account for much of the overall capacity have been severely degraded. Based on the above data, the most important systems to focus on in order to recover much of this value are the Olifants, Verlorenvlei, Berg, Bot/Kleinmond and Breede estuaries.

4.3.6 Other economic contributions of aquatic ecosystems

The above sections include the outputs of economic sectors for which are based on activities occurring at or in aquatic ecosystems, in the case of tourism and *in situ* recreational activities, or activities which are based on production from aquatic ecosystems in the case of marine fisheries. Even if not well quantified, these relationships are intuitively understood. In addition, aquatic ecosystems may contribute to the economy in more subtle ways, in that the absence of these services would lead to increased costs to government or the private sector, effectively resulting in lower value added. These cost-savings can therefore be thought of as economic benefits.

In the case of aquatic ecosystems, such benefits are associated with the regulation of **hydrology-associated processes**, such as flood attenuation, sediment retention and water quality amelioration, as well as **climate-associated processes**, such as carbon sequestration. In the latter case, this is considered to be negligible for aquatic ecosystems in the study area and is not dealt with further. The hydrological functions and their value are briefly reviewed and assessed below, based on available information.

4.3.6.1 Flood attenuation

Wetlands can be important for flow regulation, through flood attenuation, groundwater recharge and the maintenance of base flows. Rivers will also perform these roles to some extent, but the bulk of research has focussed on wetlands. Flood attenuation occurs when wetlands ameliorate the potential impacts of flood events by absorbing the flood peaks and lengthening the flood period at a lower level. The benefits of this may be in reduced flood damages and/or avoided expenditure on flood protection infrastructure. This service can also have significant benefits for the insurance industry.

The capacity for wetlands to attenuate flows is influenced by their holding capacity (available surface water volume and soil porosity) and resistance due to habitat 'roughness' (Ogawa & Male 1986, Smithers & Schulze 1993, Jothiyangkoon *et al.* 2001, Krasnostein & Oldham 2004), as well as the prior degree of saturation or inundation (Potter 1994). It also depends on its location in the catchment (Kotze & Breen 1994) and season (Krasnostein & Oldham 2004).

There has been relatively little quantitative description of the hydrological functions performed by wetlands (Smakhtin & Batchelor 2005), particularly in South Africa. Methods to assess the extent to which wetlands provide flow regulation functions range from low-cost rapid methods to expensive, issue specific and data intensive modelling approaches (Kusler 2004, Thiesing 2001). Flood attenuation can be quantitatively assessed through the application of hydrological models that simulate catchment rainfall-runoff processes and wetland and river channel hydraulics (e.g. Kleynhans *et al.* 2009). Such an approach is highly data-intensive, time consuming and expensive, and has limited potential for application to large wetland populations.

DWAF (2010) carried out an assessment of the role of wetlands in the Olifants, uMkomati and Usutu to Umhlathuze WMAs. The 1:20 year flood peaks, flood volumes and durations were derived at the outlets of all quaternaries in the study area, for the total catchment upstream of the outlet (i.e. including all quaternaries upstream of the quaternary under consideration). The flood hydrograph was then routed through a lumped storage representing an "effective" storage volume of all main stem wetlands in the quaternary under consideration. Attenuation storage volumes (i.e. the maximum volume of water in storage during passage of the flood – which could be less than the total available storage in the wetland) were then determined. These volumes were used as proxies for the flood attenuation capacity of the main stem wetlands.

In Breede-Gouritz Classification study, none of the scenarios are expected to have an impact on the storage capacity of wetlands in the WMA. Therefore it was not considered essential to quantify this function. Nevertheless, it is possible to generate a ball-park estimate of the potential value of these systems using a simplified version of the above approach (without hydrological modelling). Approximate estimates of wetland volumes were derived by assuming typical shapes and maximum surface water depths for each wetland type, and taking effective soil moisture storage depth into account. Soil moisture storage depths were estimated for individual wetlands by intersecting wetlands with the South African Atlas of Climatology and Agrohydrology layers (Schulze & Horan 2007) to determine topsoil and subsoil depths and porosities, while maximum surface water depths were assumed to be constant for each wetland type. The volume equations that were used were:

Valley bottom: $V = 1/3 \times (d_{water} + d_{soil}) \times area$ (triangular prism), $d_{water} = 0.5$ m

Floodplain: $V = (d_{water} + d_{soil}) \times area$ (disc), $d_{water} = 0.8$ m

Pans: $V = 2/3 \times (d_{water} + d_{soil}) \times area$ (bowl), $d_{water} = 0.8$ m

Seeps and Flats: $V = (d_{water} + d_{soil}) \times area$ (disc), $d_{water} = 0$ m

Seasonal variations of water stored in wetlands play a determining role in flood attenuation capacity. Large recurrence interval floods typically occur after days, or even weeks of wet conditions when catchments are saturated. Under these conditions, wetland storage available for flood attenuation could be limited. In addition, and unlike artificial impoundments that can be drawn down prior to a flood event, outflows from natural wetlands are unregulated. For these reasons, it was conservatively assumed that a maximum of 30% of total wetland volume is available for flood attenuation storage. Based on this, it was estimated that natural wetlands in the study area contribute about 220 million m^3 in terms of flood attenuation storage (Table 2-18).

Flood attenuation generates value through reducing the risk of flood damage. Given the rapid nature of this assessment, the most practical way to value this function is using the replacement cost method using simple assumptions to estimate values within a plausible range. In this case the engineering solution to replace the service would be the construction of dams of equivalent attenuation capacity. The cost of doing this was estimated based on data from DWAF on the capital replacement costs of dams. Assuming that the service if fully demanded, the replacement cost method yields an estimated value of R522 million (capital, not annual, value). As a lower bound estimate, the costs per quaternary were modified using an index of demand for flood attenuation. Demand for the service was assessed based on GIS data of land use and infrastructure in the downstream quaternary catchment. If urban areas or mines occurred within 100 m of rivers then the service was considered fully demanded, if irrigated agriculture was present, the service was considered 50% demanded and if neither occurred then the service was considered not demanded. This yielded an estimated value of R255 million. The true value is likely to lie somewhere in between, as the benefits of wetlands may be felt within their own quaternary (including in coastal quaternaries) and also in quaternaries beyond the next downstream quaternary. Values were highest in the Upper and Middle Breede and Wheat Belt area which have upper catchments in the mountainous areas that provide the services to the towns and irrigated areas below (Figure 4-23).

Table 4-18. Natural wetland areas, estimated effective storage values and approximate value of flood retention value within the Breede-Gouritz WMA

Socio-economic zone	Wetland area (km^2)	Effective storage capacity (Million m^3)	Approximate value (R millions)	
			Lower bound	Upper bound
Upper and Middle Breede	374.29	48.13	85.69	114.07
Upper Riviersonderend	182.66	27.95	50.79	66.24
Great Karoo	75.90	8.98	4.66	21.40
Little Karoo East	53.51	3.77	3.65	8.82
Little Karoo West	84.95	6.24	5.95	14.80
Wheat Belt	627.31	72.27	87.93	180.5
Garden Route Coast	136.13	9.58	7.12	22.71
Overberg Coast	362.35	42.66	9.27	91.83
Hessequa Coast	7.67	0.65	0	1.55
TOTAL	**1 904.76**	**220.24**	**255.05**	**521.98**

4.3.6.2 Sediment retention

Sediment yield from catchment areas is accelerated by land disturbance, elevating the sediment loads carried by rivers. Wetlands can trap some of these extra sediments, thus reducing the potential damage caused by elevated sediment loads downstream. These damages would include the costs associated with increased turbidity of aquatic systems, siltation of aquatic habitats and siltation of water supply infrastructure and monitoring weirs. Higher silt loads in rivers may decrease light penetration and thus primary productivity, which in turn affects fisheries. Silt deposition within rivers decreases habitat and hence biodiversity in these systems. Siltation of dams and weirs reduces their capacity and lifespan, incurring costs through increased maintenance and/or augmentation schemes.

The ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity, and is thus closely related to a wetlands flow regulation capacity. Slope of the wetland is obviously a key factor (Novitzki 1979), as well as the roughness and holding capacity of the wetland. As the water slows down, the energy required to keep sediments in suspension is lost, and deposition occurs (Vellidis *et al.* 2003).

The value of sediment retention can be measured using the replacement cost method or a damage costs avoided method. Damage costs of sedimentation are difficult to estimate in the absence of detailed studies, though preliminary estimates have been made in the international literature.

The ability of wetlands to remove excess sediment loads is related to their ability to reduce water velocity, and is thus closely related to a wetlands flow regulation capacity. Therefore the value of the sediment retention service is at least partly captured when valuing the flood attenuation service of wetlands.

4.3.6.3 Water quality amelioration

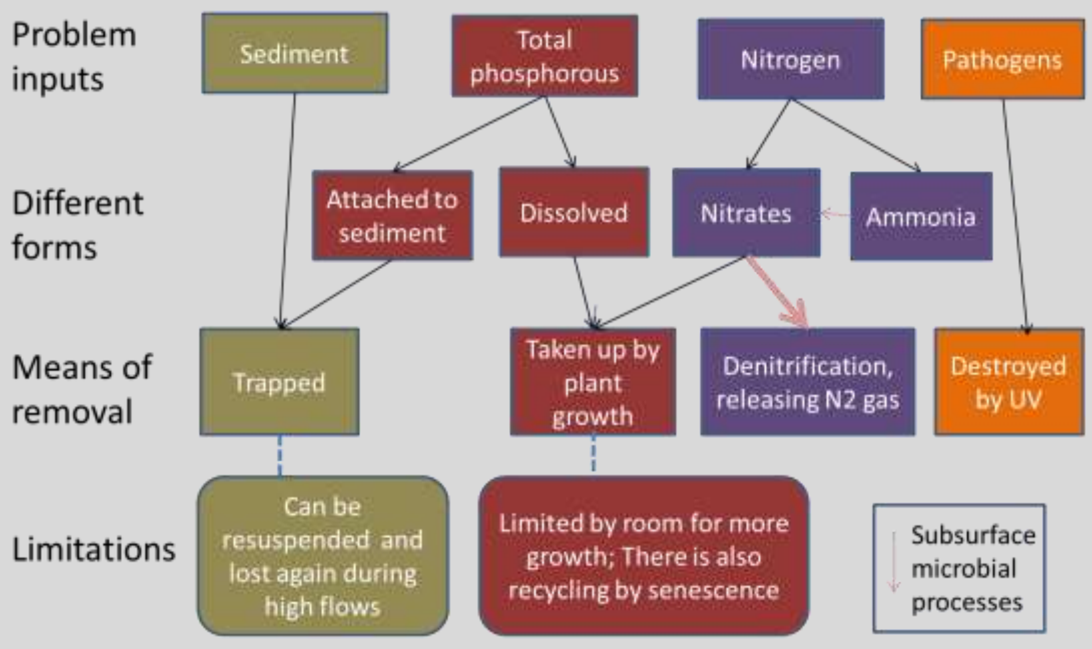
Water entering wetlands from developed catchments generally has elevated amounts of sediments, nutrients and pollutants from catchment activities, industrial effluents, treated and untreated sewage and other wastes. Excess phosphorous tends to stimulate algal growth in freshwater ecosystems and dams, while excess nitrogen would have this effect in estuarine and marine systems. This leads to deterioration in ecosystem health and capacity to deliver ecosystem services. Toxic algal blooms, heavy metals and pathogens pose a risk to human health. Thus the services provided by wetlands can save on water treatment costs and/or human health costs, as well as avoiding losses in fisheries, tourism and other ecosystem values described in the preceding sections. The way in which aquatic ecosystems perform this service is described in Box 4.3.

A number of studies have been carried out on the waste treatment function in natural and created aquatic habitats (e.g. Peltier *et al.* 2003, Thullen *et al.* 2005, Batty *et al.* 2005), but most research has been carried out in treatment wetlands. In South Africa there are data on the capacity of artificial wetlands to treat wastewater (e.g. Rogers *et al.* 1985), but little data exists on natural systems, which are generally less efficient. In natural systems, landscape processes also need to be taken into account, as waste uptake does not only occur within aquatic ecosystems, but also occurs during the drainage process, as waste-water runs through various habitats *en route* to streams and rivers.

Turpie et al. (2010) undertook a preliminary study on the role of wetlands in determining water quality in a selection of 100 sub-catchments in the Western Cape, including in the study area (Figure 4-24). Wetlands in these catchments were found to play a significant role in the reduction of nitrates, nitrites, and ammonium, but not dissolved phosphorus or suspended solids (which carry most of the phosphorous), probably due to the temporal nature of the study. Estimated removal rates ranged from 307 to 9 505 kg N/ha/y, with an average of 1 594 ± 1 375 kg N/ha/y. Further research is required to understand this service and its value.

Box 4.3. Water quality amelioration by wetlands

There are a number of different process through which wetlands remove sediments, nutrients and pollutants from the inflowing water. Nutrients that are introduced in dissolved form can be taken up directly by plants and incorporated into plant tissue as they grow. Most of the phosphorous that is introduced to wetlands is attached to sediment and settles to the bottom, where it can remain inactive (Brinson 2000). However, if sediments are stirred up then some of this phosphorous can go back into solution and become available for use by plants. The uptake of dissolved phosphorous will continue as long as there is room for further plant growth (in terms of space, oxygen or plant size limits), after which the system will reach some kind of equilibrium in which the uptake is balanced by the senescence, death and rotting of plant material which reintroduces nutrients into the water column (remineralisation). At this point there would be no further net uptake of nutrients by the wetland unless nutrients are being exported out of the system (e.g. by harvesting plants or dredging and removal of sediments), or unless there is a natural process of peat formation.



Summary of water quality amelioration services by natural systems (Source: Turpie 2015)

Nitrogen is removed in wetlands mainly by the nitrification–denitrification process (Saunders & Kalff 2001). Nitrification is the microbially-mediated oxidation of ammonium (NH4) to nitrite (NO2) and then nitrate (NO3). This process consumes oxygen and thus occurs in aerobic areas of the wetland. Nitrate then diffuses to anaerobic areas of the wetland where it may be denitrified. This is the rate-limiting step in the removal of nitrogen from flooded systems. In the denitrification process nitrate (NO_3) is reduced to gaseous nitrous oxide (N_2O) and nitrogen gas (N_2), which are then released to the atmosphere (Mitsch & Gosselink 1993). This occurs mainly in sediments with abundant organic matter that provides a carbon source for denitrifying bacteria. Bacteria concentrations are reduced in wetlands by exposure to UV-light. The degree to which this occurs is linked to the duration of water retention within the system.

The ability of wetlands to perform water quality amelioration services depends on their area and type of vegetation as well as to their overall health and management. Hydraulic efficiency, which is the degree to which a wetland disperses inflow over its area, is also important (Jordan *et al.* 2003). This maximizes contact area and it can be assumed that it serves to increase detention time as well. There is an upper limit to the amount of pollution that a wetland can remove, as well as to the amount of pollution that can be added to a wetland without having a significant impact on its functioning and biodiversity. At high phosphorus loading rates wetlands may eventually become a phosphorus source rather than a sink (Tilton & Kadlec 1979, Forbes *et al.* 2004). This also varies seasonally. Wetlands are thought to be better at removing total suspended solids, phosphorus and ammonia during high flow periods (when sediment loads entering the wetland increase), but better at removing nitrates during low flow periods (Johnston *et al.* 1990, McKee *et al*. 2000).

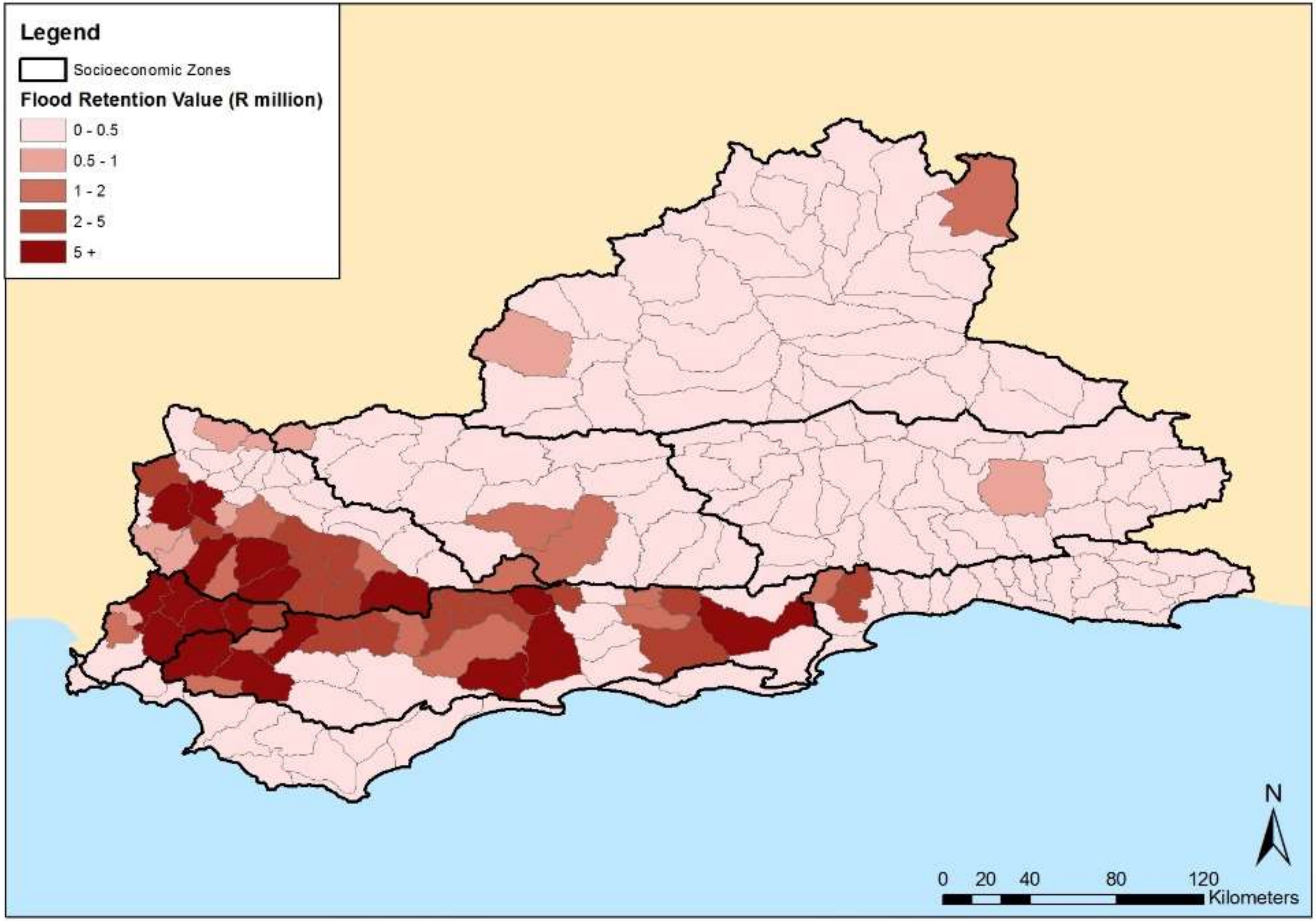


Figure 4-23.Lower bound estimate of flood retention value of wetlands across the Breede-Gouritz WMA

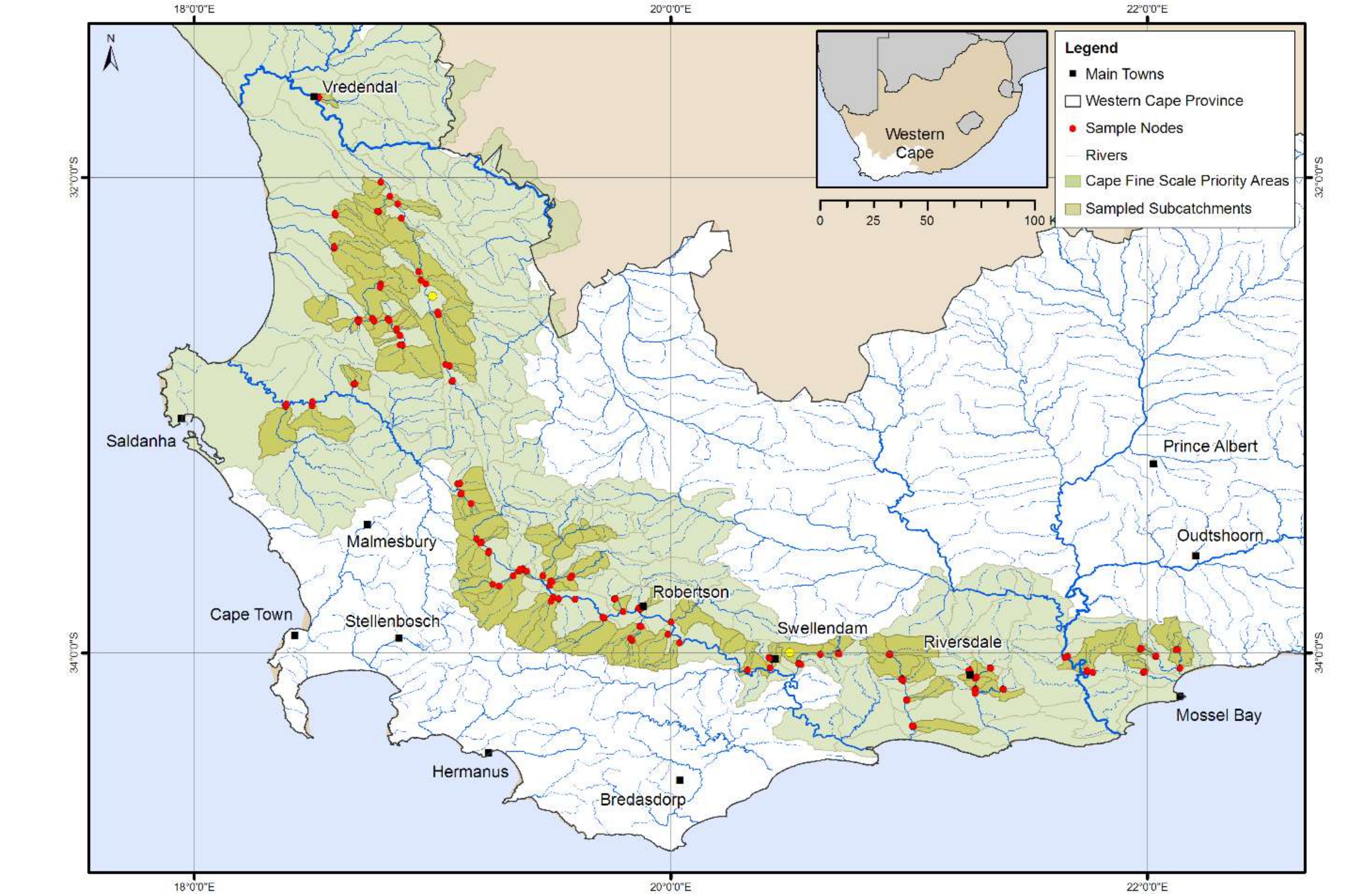


Figure 4-24. Sampling localities used by Turpie et al. 2010 (red dots) and their subcatchment areas (dark green shading), within the area of the Western Cape Province that has been mapped at a fine scale (light green shading)

4.3.7 Population, income and living conditions

4.3.7.1 Population

A total of 1.2 million people lived within the Breede-Gouritz WMA in 2011 (Figure 4-25). The population has grown significantly since 1996, with a 20% increase between 1996 and 2011, and a 23% increase between 2001 and 2011 (Figure 4-25).

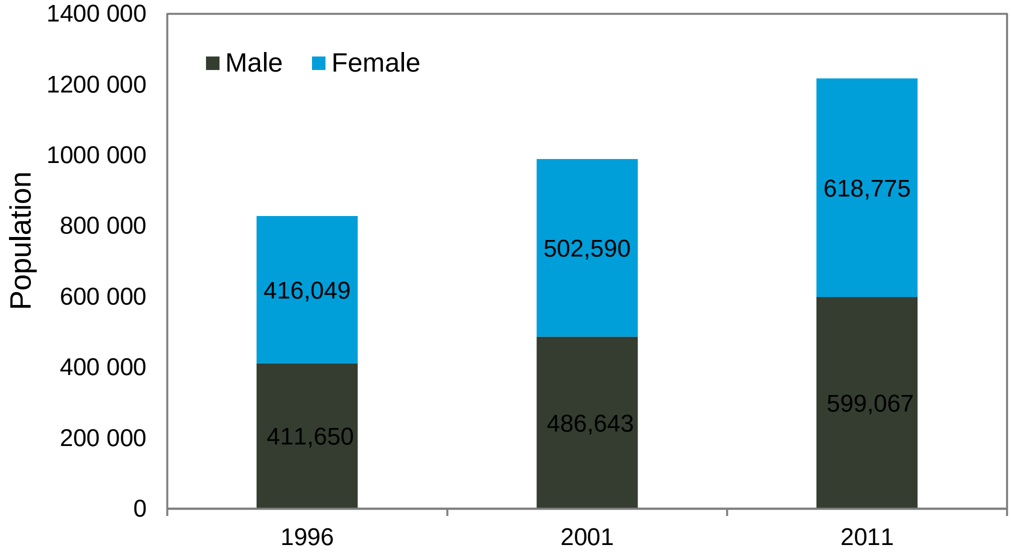


Figure 4-25. Population statistics for the Breede-Gouritz WMA 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

Population growth has been the highest in the three coastal regions, with the population of the Overberg Coast increasing by 39%, the Garden Route Coast by 36%, and the Hessequa Coast by 27% between 2001 and 2011 (Figure 4-26). The inland zones had a much lower population growth across the same period, with an average increase of only 15%. The Little Karoo East and West had the smallest percentage population growth of 13%.

The most populated socio-economic zones were the Garden Route Coast followed by the Upper and Middle Breede in 2011. Together these two zones accounted for 58% of the total population in the WMA (Figure 4-26 and Table 4-19). There were just under 340 000 households in the WMA, with an average household size of 3.6 in 2011 (Table 4-19). The Little Karoo East has an average household size of 4.3, the highest in the WMA, and the Hessequa Coast Region has the lowest household size of 2.6 (Table 4-19).

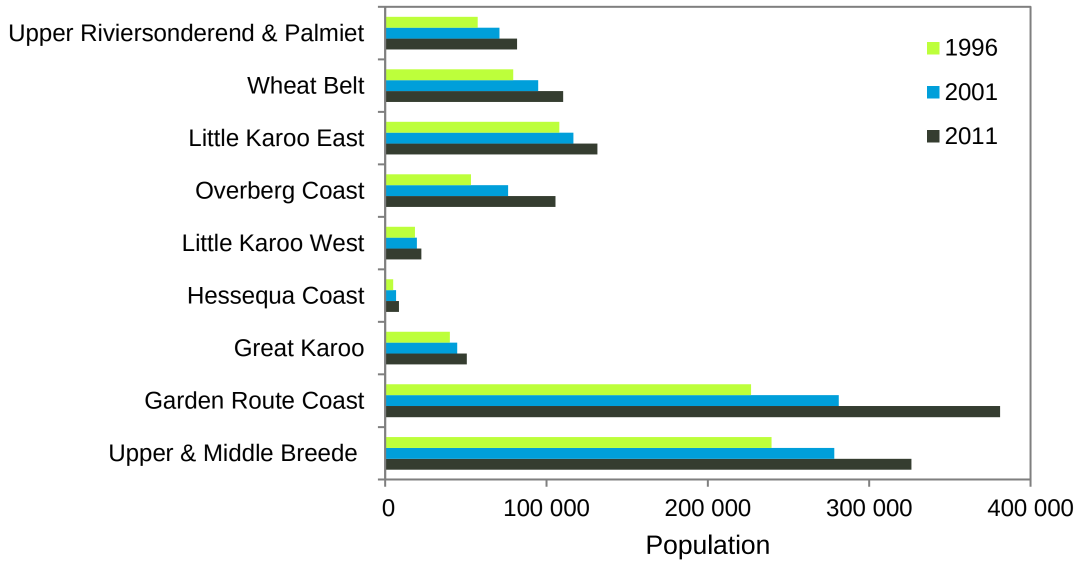


Figure 4-26.Population in each socio-economic zone in the Breede-Gouritz WMA in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

Table 4-19. Total population, number of households and average household in each socio-economic zone in 2011 (Source: StepSA 2015 based on StatsSA 2011 Census data)

Socio-economic zone	Population 2011	Number of households	Average household size
Upper & Middle Breede	326 137	82 803	3.9
Garden Route Coast	381 171	115 047	3.3
Great Karoo	50 656	13 539	3.7
Hessequa Coast	8 487	3 207	2.6
Little Karoo West	22 341	5 574	4.0
Overberg Coast	105 582	35 734	3.0
Little Karoo East	131 491	30 873	4.3
Wheat Belt	110 275	31 214	3.5
Upper Riviersonderend & Palmiet	81 701	21 797	3.7
Total	**1 217 842**	**339 788**	**3.6**

There are no extensive metropolitan areas in the WMA, rather numerous coastal and inland towns and villages. More than half of the WMA population is located along the Garden Route Coast and inland along the Breede River Valley. The area is characterized by large variations in population densities (0 – 2160 people/km^2). The most densely populated areas include the Garden Route Coast with the towns of George, Mossel Bay and Knysna, the Oudtshoorn Valley, the Breede River Valley with the towns of Worcester and Robertson, and the Overberg Coast with the town of Hermanus being densely populated (Figure 4-27). The 'building boom' that occurred in the mid-2000s is believed to have led to significant in-migration into the coastal towns in the Breede-Gouritz WMA (Golder Associates 2016).

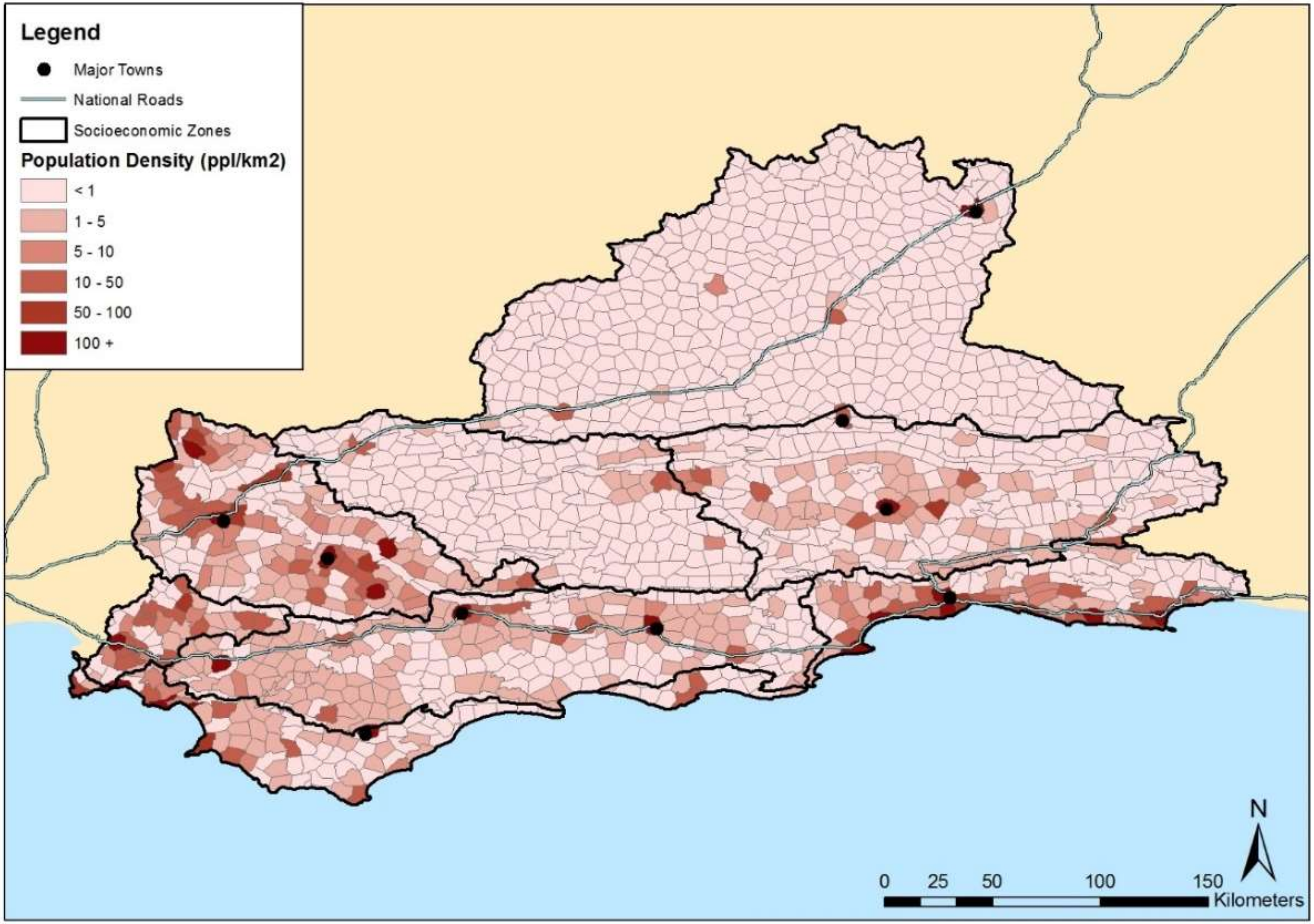


Figure 4-27.Population density in the Breede-Gouritz WMA, by mesozone. (Source: StepSA 2015 based on StatsSA Census data)

Income, poverty and unemployment

The average household income for the WMA was R141 915 in 2011 (Table 4-20). The Little Karoo East and Little Karoo West had the lowest average household incomes, and the Garden Route Coast, Upper Riviersonderend and Palmiet, and the Overberg Coast had the highest household incomes (Table 4-20).

Table 4-20. Number of households, average household income and percentage of poor households in each socio-economic zone in 2011 (Source: StepSA 2015 based on StatsSA 2011 Census data)

Socio-economic zone	Number of households	Average household income (R)	% of poor households
Upper & Middle Breede	82 803	141 419	13%
Garden Route Coast	115 047	230 482	19%
Great Karoo	13 539	102 100	12%
Hessequa Coast	3 207	167 908	9%
Little Karoo West	5 574	95 437	13%
Overberg Coast	35 734	170 395	18%
Little Karoo East	30 873	85 619	11%
Wheat Belt	31 214	111 623	10%
Upper Riviersonderend & Palmiet	21 797	172 255	15%
Total	**339 788**	**141 915**	**15%**

Of the 340 000 households in the WMA, just over 50 000 were considered to be poor[4], or living in poverty, in 2011 (Table 4-20, Figure 4-28). The number of poor households in the WMA have increased from 6% in 1996 to 13% in 2001 and 15% in 2011 (Figure 4-28).

[4] Determining the proportion of poor households in the WMA was based on household income and expenditure patterns in South Africa, developed by the Bureau of Market Research (BMR 2013). The 'poor' income category (R0 – R54 344 per household per annum) as defined by the BMR was used to establish the proportion of households living in poverty (StepsSA 2015). As this income category did not align directly with the 'poor' income category in the StatsSA Census data of R0 – R48 000, a proportional number of households from the R48,000 - R96,000 category were added together to bring this in line with the BMR cut off of R54,355 (StepsSA 2015). To calculate this for 1996 and 2001 years, the CPI was used to inflate 1996 and 2001 prices to establish the equivalent income category cut off for the census data in these years.

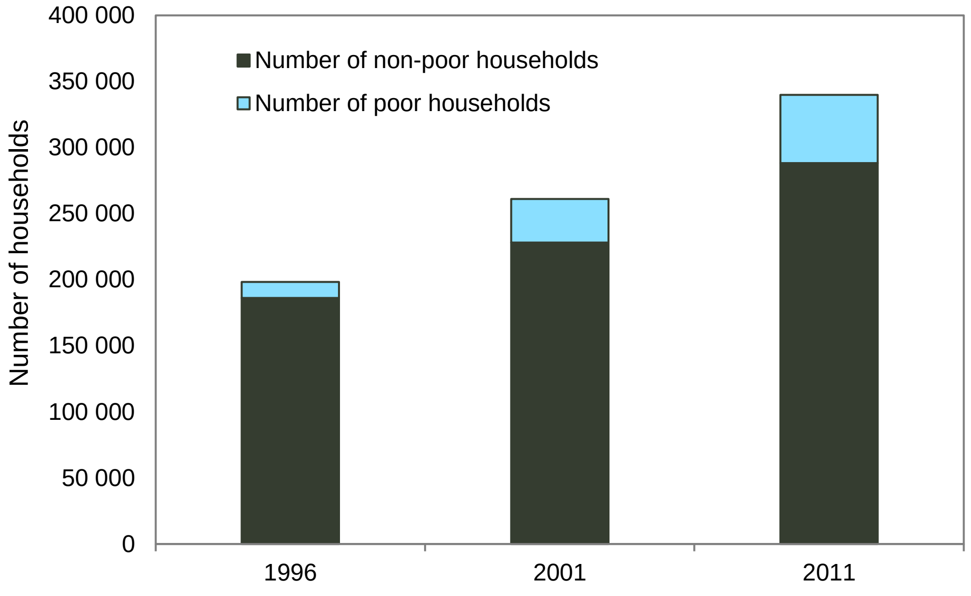


Figure 4-28. The number of non-poor households and the number of poor households within the WMA in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

The Garden Route Coast and the Overberg Coast have the highest percentage of poor households in the WMA (Figure 4-30) and have also experienced the highest percentage increase in households living in poverty since 2001, with an increase of 4% and 6% in these regions respectively (Figure 4-29). The Little Karoo West and Great Karoo are the only two regions that have seen a decrease in the percentage of poor households since 2001 (Figure 4-29). The number of poor households tends to increase in and around urban settlements (Figure 4-30).

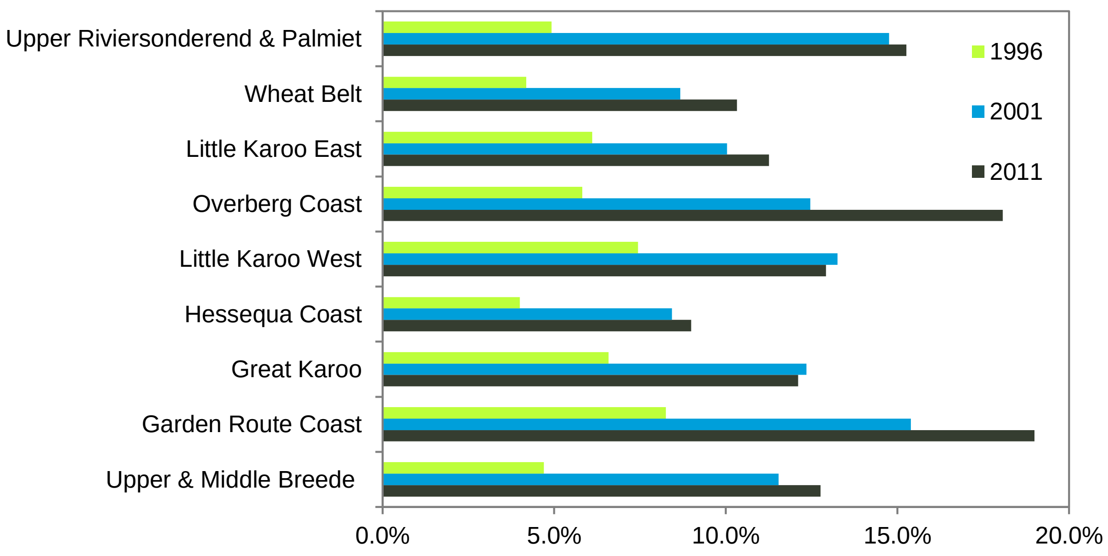


Figure 4-29. Percentage of poor households in each socio-economic zone in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

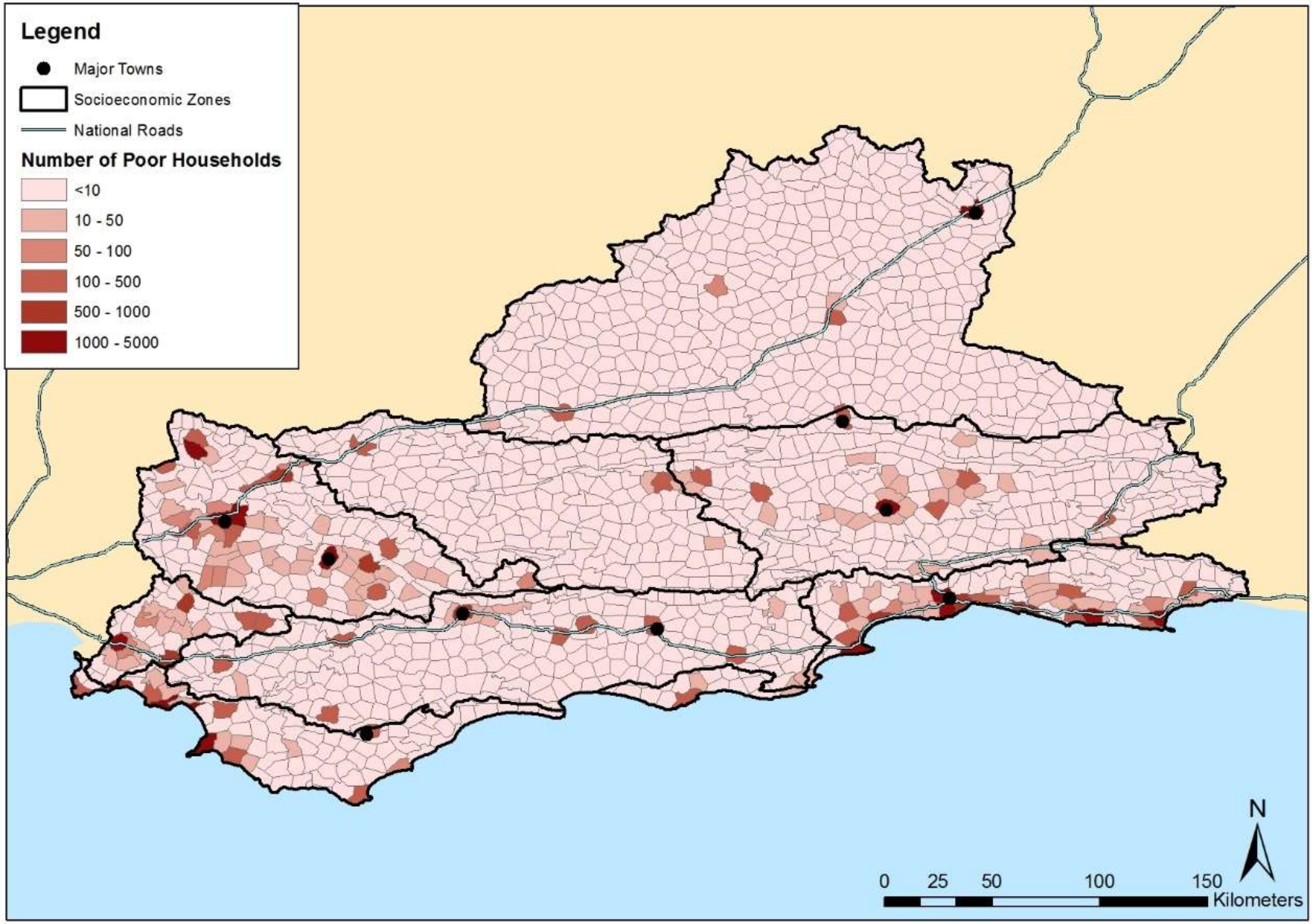


Figure 4-30. The number of poor households in each mesozone in the Breede-Gouritz WMA (Source: StepSA 2015 based on StatsSA Census data)

Unemployment across the WMA has decreased on average by 1% between 1996 and 2011 (Figure 4-31). Socio-economic zones with the highest proportion of households living in poverty, also have the highest increase in unemployment rates between 1996 and 2011 (Figure 4-31). The Upper Riviersonderend and Palmiet, the Wheat Belt, the Overberg Coast, and the Garden Route Coast have all experienced increases in unemployment since 1996. Whilst the Little Karoo East and the Great Karoo Region have the highest percentage unemployment (Figure 4-32), these figures have improved since 1996. Unemployment was lowest in 2011 in the Hessequa Coast and Upper and Middle Breede at 4% and 11%, respectively (Figure 4-31, Figure 4-32).

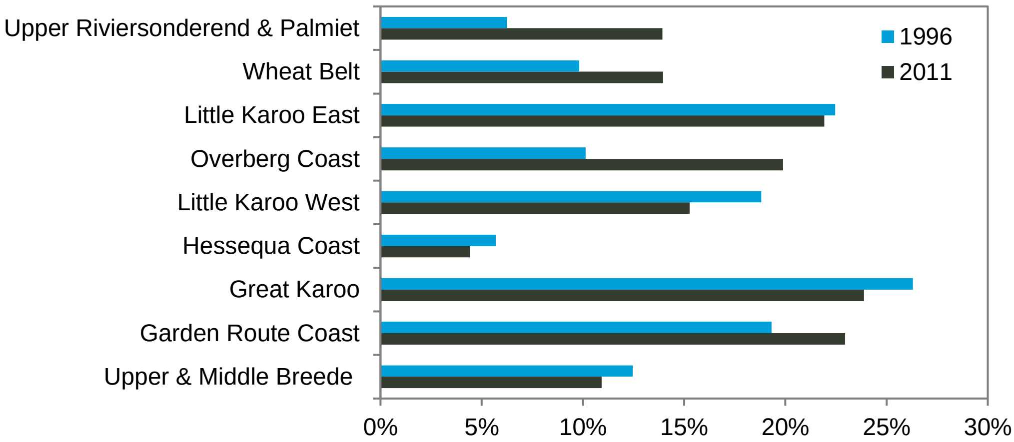


Figure 4-31. Percentage unemployment in each socio-economic zone in 1996 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

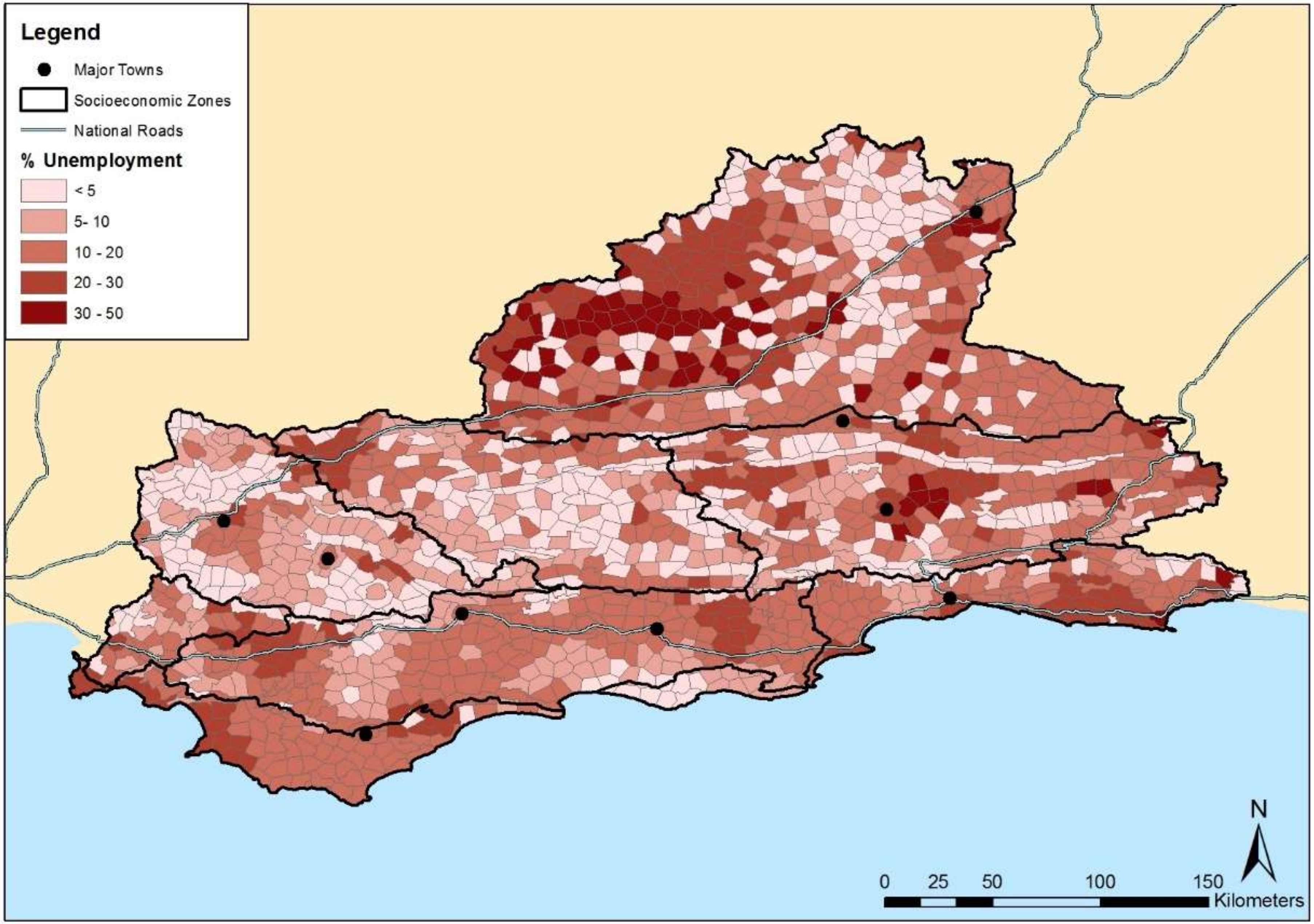


Figure 4-32.Percentage unemployment in 2011 in each mesozone in the Breede-Gouritz WMA (Source: StepSA 2015 based on StatsSA Census data)

4.3.7.2 Access to electricity

In 2011 92% of households in the WMA were using electricity as their main source of energy for lighting, compared to 89% of households in 2001 and 83% of households in 2003. The use of other forms of lighting, such as candles, gas and paraffin are highest in the Little Karoo East (13%), the Great Karoo (11%) and the Upper Riviersonderend and Palmiet (10%) (Figure 4-33).

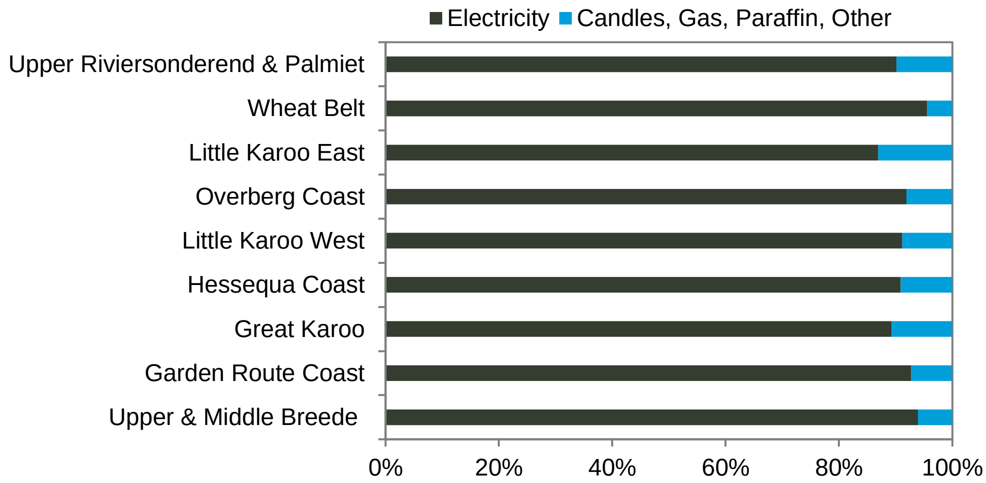


Figure 4-33. Percentage of households using electricity as a main source of lighting, compared to other sources (Source: StepSA 2015 based on StatsSA Census data)

4.3.7.3 Water and sanitation

The number of households in the WMA with access to piped water has increased significantly over the period 1996 to 2011 (Figure 4-34). Between 1996 and 2011 the percentage of households with access to piped water in the dwelling had increased by 9%.

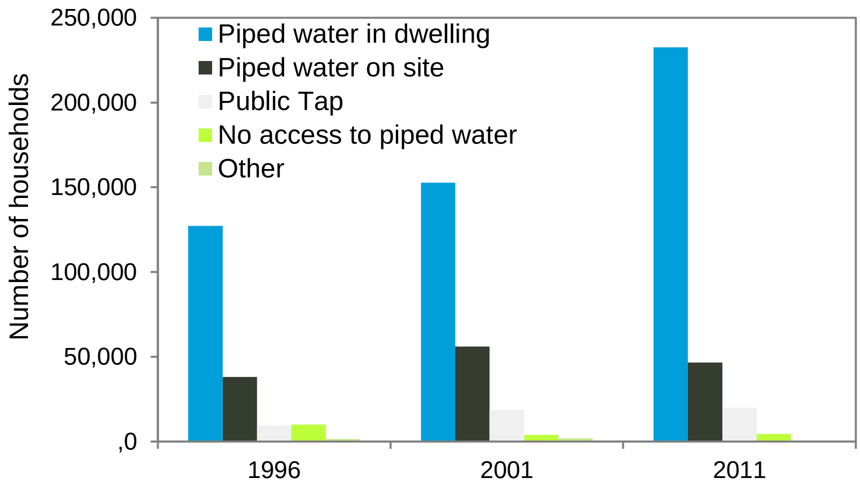


Figure 4-34. The number of households in the WMA with different sources of water supply in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

Access to water is variable across socio-economic zones (Figure 4-35). Poor access to water is highest in the Upper Riviersonderend and Palmiet with almost 13% of households having poor access to water (Figure 4-35). This figure is lowest in the Great Karoo (2.7%), Wheat Belt (5.8%), and Upper and Middle Breede (6.0%).

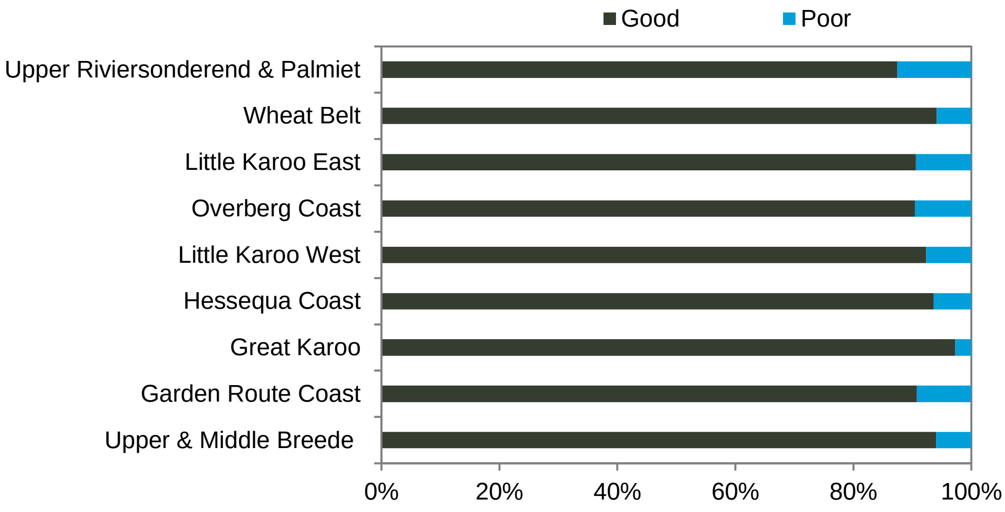


Figure 4-35. Percentage of households with good access or poor access to water in 2011. Good access = Piped water into the dwelling or on dwelling site. Poor access = either no access to piped water, use of a communal tap or other (Source: StepSA 2015 based on StatsSA Census data)

The percentage of households with poor access to water has decreased in most of the socio-economic zones in the WMA (Figure 4-36). However, in the Upper Riviersonderend and Palmiet the opposite is observed and the percentage of households with poor access to water has increased substantially over the years (Figure 4-36). The only other zone that has seen an increase in poor access to water since 2001 is the Overberg Coast. The Little Karoo West has experienced the highest percentage change between 1996 and 2011, with an 8.8% improvement in the percentage of households with poor access to water.

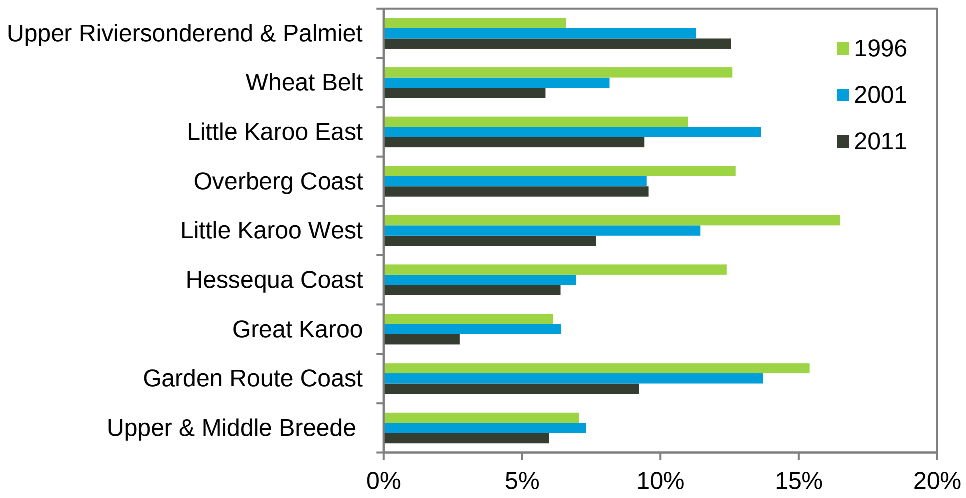


Figure 4-36. Percentage of households with poor access to water in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

In 1996, 5% of households in the WMA had no access to piped water but in 2011 this figure had decreased to 1.5% of households in the WMA (Table 4-21). The Little Karoo West, Hessequa Coast and Little Karoo East have the highest proportion of households with no access to piped water (Table 4-21).

Table 4-21. Percentage of households with no access to piped water in each socio-economic zone in 1996, 2001 and 2011 (Source: StepSA 2015 based on StatsSA Census data)

Socio-economic zone	2011	2001	1996
Upper & Middle Breede	0.7%	1.2%	3.7%
Garden Route Coast	1.8%	2.0%	5.8%
Great Karoo	0.6%	0.4%	2.9%
Hessequa Coast	3.7%	2.2%	11.3%
Little Karoo West	3.8%	3.6%	13.9%
Overberg Coast	0.5%	0.4%	2.9%
Little Karoo East	3.3%	3.6%	6.3%
Wheat Belt	1.4%	2.1%	9.8%
Upper Riviersonderend & Palmiet	0.8%	0.6%	2.1%
Total	1.5%	1.7%	5.4%

The number of households with flush toilets has increased considerably over the period 1996 – 2011 (Figure 4-37). In 2011 89% of households in the WMA had flush toilets[5], up from 79% in 1996 (Figure 4-37).

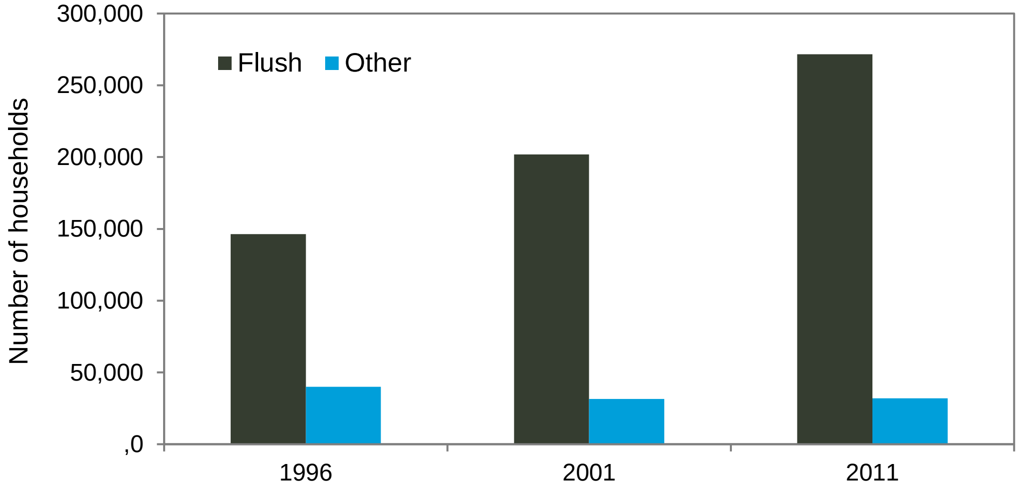


Figure 4-37. Number of households with a flush toilet compared to households using other types of toilets in 1996, 2001, 2011 (Source: StepSA 2015 based on StatsSA Census data)

The households in the Little Karoo East and the Little Karoo West have the highest percentage usage of other types of sanitation, with 20% and 19% of all households not having a flush toilet, respectively (Figure 4-38). This figure was lowest in the Overberg Coast and the Upper and Middle Breede, with only 7% and 8% of households in these regions not having a flush toilet, respectively.

[5] Flush toilets include the use of chemical toilets which made up only 1% of the total

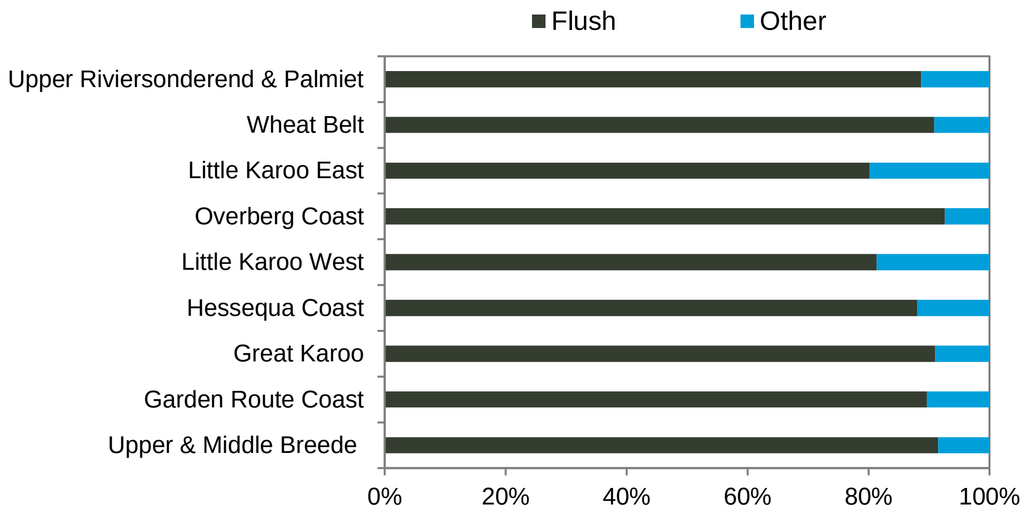


Figure 4-38.Percentage of households with a flush toilet and the percentage of households using other types of toilets in 2011 (Source: StepSA 2015 based on StatsSA Census 2011)

In 2011 85% of households in the WMA had access to good refuse removal, which includes the weekly or monthly collection of refuse by local authority. Poor refuse removal includes no refuse disposal or the use of a communal or private dump. More than 20% of households in the Wheat Belt, Little Karoo East, Little Karoo West, Hessequa Coast, and Upper and Middle Breede had poor refuse removal in 2011 (Figure 4-39).

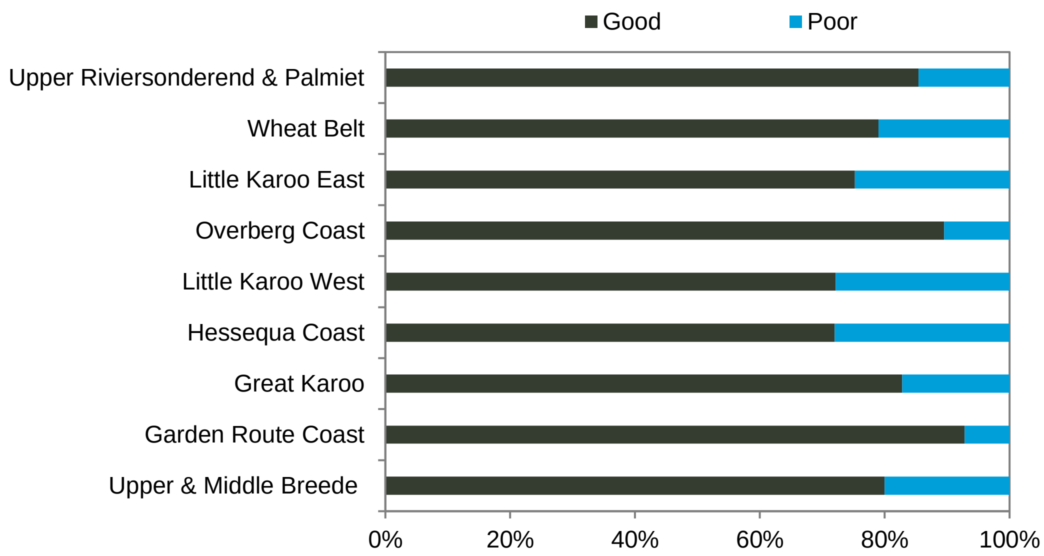


Figure 4-39.Percentage of households with poor refuse removal and good refuse removal in 2011 (Source: StepSA 2015 based on StatsSA Census data)

4.3.7.4 Reliance on aquatic natural resources

In many parts of the country, rivers, estuaries and wetlands play a significant role in supporting livelihoods. This is mostly associated with people living in traditional households within former homeland areas (DWAF 2010), where poverty levels tend to be highest. Use of natural resources can also be important for poor households living in peri-urban areas (Lannas & Turpie 2009). There are no former homelands within the Breede-Gouritz Water Management Area, although there is some communal land area around Elim established by the Moravian Church. Nevertheless, there are numerous poor communities living within farms, around farming towns, and larger urban areas, that are reliant to some extent on natural resources.

Thus it is expected that there is some level of collection of plant and fish resources, and collection of river water for domestic use. In the latter, case, it is necessary to determine the amount required to meet Basic Human Needs, as per the Water Act.

Water for Basic Human Needs

It was estimated that in 2011 a total of 5 498 households in the WMA were reliant on rivers and streams as their main source of domestic water (Table 4-22). This equates to 1.5% of all households in the WMA. The Little Karoo West, Wheat Belt, and Little Karoo East had the highest percentage of households reliant on river water (Table 4-22). This figure was lowest in the Overberg Coast, Garden Route Coast and Great Karoo. Whilst the highest number of households reliant on river water was in the Upper and Middle Breede socio-economic zone, this represented only 1.9% of all households in this zone.

Based on 2011 data, and the requirement of 25 litres per person per day for households depending on river flows as their source of domestic water, the Basic Human Needs requirement is in the order of 521 m^3 per day, which amounts to an annual allocation of about 190 000 m^3 for the WMA as a whole. It is assumed that numbers of households relying on rivers for basic human needs will diminish, rather than grow, over time.

Table 4-22. The number and percentage of households within each socio-economic zone that are collecting water from rivers and streams (Source: StatsSA Census 2011)

Socio-economic zone	Number of households collecting river water (2011)	% of households collecting river water	Minimum daily flow required to meet Basic Human Needs m^3/day
Upper & Middle Breede	1 718	1.9%	169
Garden Route Coast	745	0.6%	62
Great Karoo	106	0.6%	10
Hessequa Coast	32	1.1%	2
Little Karoo West	622	4.3%	62
Overberg Coast	148	0.4%	11
Little Karoo East	814	2.5%	87
Wheat Belt	942	2.9%	83
Upper Riviersonderend & Palmiet	370	1.4%	35
Total	**5 498**	**1.5%**	**521**

Other river and wetland resources

The majority of inland freshwater fisheries across South Africa are recreational (McCafferty et al 2012). However, since the 1990s there has been an increase in the utilisation of freshwater aquatic resources for providing food security; although this has been mainly concentrated in impoundments like large dams (McCafferty et al. 2012). While the participation in the inland subsistence fishery is likely under-reported, there is very little data and few publications concerning subsistence inland fisheries across the country and the few that do exist seem to be located outside of the Western Cape (e.g. Weyl et al. 2007, Andrew et al. 2000, Rouhani 2003).

Estimates of the value of subsistence fisheries along rivers in the Olifants, Inkomati and Usutu to Mhlatuze WMAs ranged from <R2 000 – R28 000/km/year which was based on household survey data and %traditional land use. Even in these traditional rural areas, fishing was a marginal activity with only 4% of households participating the in previous year (DWA 2010). Within the Breede-Gouritz WMA there are however no former homelands/traditional areas and most of the rivers are only accessible through private

land. Because of these mitigating factors, the value of inland subsistence fishing is assumed to be much lower than that reported elsewhere.

Estuary resources

Estuaries provide a value resource to both subsistence and recreational fishers. Subsistence fishers are considered to be those who fish or collect bait personally, use low technology gear, live near to the resource and either use the catches to meet basic food requirements or sell the catches locally to gain income to allow them to meet basic food requirements. The subsistence fishery consists primarily of bait collection as well as well as fishing. The predominant species that make up bait collection is the mudprawn *Upogebia africana* which made up 94.6% of subsistence bait catches in Knysna estuary (Napier et al. 2009). In the same study, subsistence fish catches were also dominated by a few species, namely Cape stumpnose *Rhabdosargus holubi* and strepie *Sarpa salpa*, while other larger species like spotted grunter *Pomadasys commersonnii* were also heavily targeted.

Turpie & Clark (2007) estimated that close to 500 subsistence fishers were operating within the Breede-Gouritz WMA estuaries on a day-to-day basis. A more focused study in Knysna estuary estimated that over 200 full and part-time subsistence fishers utilised that estuary (Napier et al. 2009), though there would be fewer than this operating on an average day.

Subsistence fishing and bait collection does not, however, occur in all estuaries along the coast and is related to the size of the estuary as well as its degree of accessibility and enforcement of conservation within protected areas. Turpie & Clark (2007) estimated the annual catches and values for subsistence fisheries in South African estuaries using data collected as part of the Subsistence Fisheries Task Group assessment (Clark et al. 2002) and interpolating using expert knowledge for estuaries for which no data were available. These data for estuaries were updated to 2015 Rands and are presented in Table 4-23. This suggests that the total subsistence value for the Breede-Gouritz WMA coastline could be in the region of **R 4.8 million per year**.

Table 4-23. Estimates of the value of the subsistence fishery within estuaries along the Breede-Gouritz WMA coastline

Socioeconomic Zone	Estuary	Harvest value R/year	Socioeconomic Zone	Estuary	Harvest value R/year
Overberg Coast	Rooiels	11 000	Garden Route Coast	Blinde	30 000
	Buffels (Oos)	11 000		Hartenbos	32 000
	Palmiet	78 000		Klein Brak	207 000
	Bot/Kleinmond*	679 000		Groot Brak*	441 000
	Onrus*	30 000		Maalgate	37 000
	Klein	136 000		Gwaing	78 000
	Uilkraals	37 000		Kaaimans	37 000
	Ratel	20 000		Wilderness	96 000
	Heuningnes	20 000		Swartvlei	96 000
	Klipdrifsfontein	11 000		Goukamma	20 000
Wheat Belt	Breede	193 000		Knysna	1 266 000
	Duiwenhoks	136 000		Noetsie	11 000
Hessequa Coast	Goukou	193 000		Piesang	20 000
Wheat Belt	Gouritz	222 000		Keurbooms	610 000
				Matjies	43 000
				Sout (Oos)	11 000

Socioeconomic Zone	Estuary	Harvest value R/year	Socioeconomic Zone	Estuary	Harvest value R/year
				Groot (Wes)	27 000
				Bloukrans	0

Values are from Turpie & Clark (2007) and are updated to 2015 Rands using the CPI index.

** Estuaries with 'poor' health ratings according to NBA 2012 indicating possible overexploitation of resources.*

A more recent study of the Knysna estuary estimated that the value of subsistence fishing in Knysna Estuary (including both bait, handline and setline fisheries) amounted to between R1.1 and R1.8 million per year (when updated to 2015 Rand using CPI index; Napier et al. 2009). The values for Knysna in the Turpie & Clarke (2007) study fall within this range, which adds confidence to their estimates for other estuaries along the coast.

The majority of the estuaries and hence the values fall into the Garden Route Coast socioeconomic zone. Within the Overberg Coast socioeconomic zone, the only estuaries with substantial value were the Bot/Kleinmond estuary and the Klein estuary. Other estuaries with high values included those along the Wheat Belt and Hessequa Coast socioeconomic zones.

Note that the estimates of values for subsistence fishing do not necessarily represent the sustainable yield that can be harvested without causing detriment to the ecosystem. There are however, not many good estimates on what the sustainable yield is for the species targeted by subsistence fishers along this coastline. One study indicated that mud prawns are likely to be sustainably harvested within Knysna Estuary (Napier et al. 2009). The bulk of subsistence catches of estuary fish are species like mullet, with a significant bycatch of estuary dependent line fish. While the catches of mullet might be sustainable, the latter are thought to be unsustainable in many cases, and affect the nursery value of the estuary.

5 STATUS QUO PER IUA: GOURITZ

The approach we followed in the provisional delineation of the IUAs is described in the companion document to this Status Quo Report, namely the *Resource Unit Delineation and Integrated Units of Analysis Report* (DWS, 2016).

The final delineation of 8 IUAs for the Gouritz is presented in Figure 5-1.

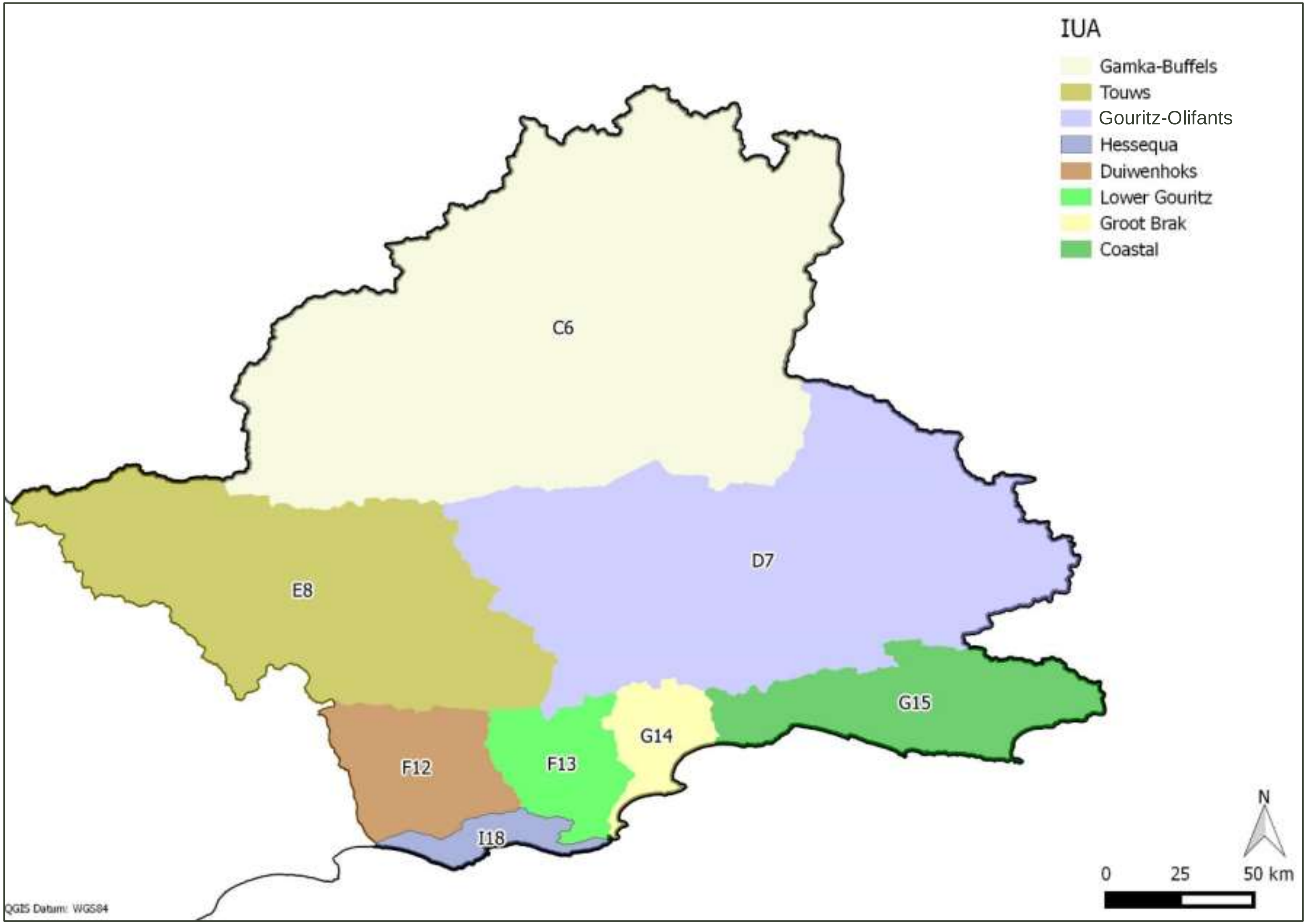


Figure 5-1. Locations of IUAs delineated for the Gouritz component of the WMA

Table 5-1. Composition of IUAs delineated for the Gouritz component of the WMA

Socio-economic Zone	Zone Code	River Resource Unit	IUA Name	IUA Code	Quaternary Catchments
Great Karoo	C	Groot/Touws (part 1 of 2) Gamka (part 1 of 2)	Gamka-Buffels	C6	J22G J22H J22B J22A J21A J22C J22J J22K J21B J22D J22E J24A J21D J24B J21C J22F J11B J11A J21E J23A J24C J11D J23B J24D J11C J32A J23G J23C J11G J11E J23D J24E J11F J23F** J23H**
Swartberg	D	Lower Gouritz (part 1 of 2) Olifants	Gouritz-Olifants	D7	J23F** J23H** J23E J32E J33C J24F J23J J25A J33D J35A J25B J35D J31C J33F J35F J33E J31D J25D J33A J33B J31A J31B J25E J35E J25C J35B J34A J34B J34F J34D J34C J35C J34E J40A J40B J32D J32C J32B
Little Karoo	E	Groot/Touws (part 2 of 2)	Touws	E8	J12C J12E J12A J12B J12G J11H J12D J11J J12F J11K J12H J12L J12K J13A J12M J13B J13C J12J
Wheatbelt	F	Duiwenhoks (1 of 2)	Duiwenhoks	F12	H80B H80A H90B H90A H80C H90C H90D H80D H80E
		Lower Gouritz (2 of 2)	Lower Gouritz	F13	J40C J40D J40E
Garden route coast	G	Coastal Rivers (1 of 2)	Groot Brak	G14	K10E K10C K20A K10D K10F K10B K10A
		Coastal Rivers (2 of 2)	Coastal	G15	K60A K60B K60D K50A K40E K40B K40A K60C K40C K30D K30C K70B K30B K30A K70A K60E K60F K40D K50B K60G
Hessequa coast	I	Duiwenhoks (2 of 2)	Hessequa	I18	H90E H80F

**: J23F and J23H shared between Gamka-Buffels and Gouritz-Olifants provisional IUAs

5.1 IUA C6: Gamka-Buffels

Socio-economics and ecosystem services

There are just over 2 000 ha of irrigated and dryland crops in the Gamka-Buffels IUA with planted pasture and stone fruit being the principal crops. Gross economic output of water affected activities was estimated to be R239 million in 2015 with tourism representing more than half of this. The population of the IUA is approximately 64 000 people and 17 000 households of which less than 1% are dependent upon river water.

Water resources

Three significant dams, Floriskraal (50.4 million m^3) and Leeu-Gamka (14.6 million m^3), as well as a number of smaller dams, reside in this IUA. Floriskraal supplies water to the Buffels River Irrigation Scheme (2200 ha) and Laingsburg, while a further 400 ha is irrigated from various tributaries. Leeu-Gamka Dam provides water to the 700 ha Leeu-Gamka Irrigation Scheme. In general, surface water resources are over-allocated and a number of towns are experiencing a water deficit.

The upper Gamka catchment is dominated by rocks of the Dwyka and Ecca Groups of the Karoo Supergroup. The GRU GGa-2a, 2b and 2c occur within this region, with settlements in this sub-catchment using groundwater as “sole-supply”. Registered groundwater use has centred around the towns of Beaufort West and Leeu Gamka. The Dwyka sub-catchment has similar geology, with GRU GGa-1 occurring within this region. Both settlements in this region also rely solely on groundwater. GGa-4 GRu comprises the central parts of the Swartberg Mountain range, with the Peninsula Formation outcropping within GRU GO-4 recharging deep Peninsula groundwater. Prince Albert receives one third of its supply from groundwater within this GRU. The upper Olifants catchment occurs within GRU GO-1. The small town within this region relies solely on groundwater.

Water quality in the upper reaches of the Gamka River (J2H018Q01) is generally good (Table 5-1). On average salinity is Acceptable although high concentrations in the Tolerable category has been observed. Nitrogen concentrations are low and in the Ideal category, and phosphates are low (average in the Ideal category) although some elevated concentrations (Acceptable category) have been observed from time to time. Water quality downstream of Floriskraal Dam (J1H028Q01) is generally poorer and varies between Acceptable to Tolerable categories. Salinities are elevated, resulting in Tolerable to Unacceptable, resulting in the water being Acceptable for irrigation (SAR). High phosphate concentrations have been observed although it is mostly in an Ideal category.

Table 5-2. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Gamka-Buffels IUA (C6)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J1H028Q01	C6	Green	Yellow	Yellow	Yellow	Yellow	Red	Blue	Green	Blue	Blue	Green	Yellow	Blue	Red	Green	Green	Blue	Blue
J2H018Q01	C6	Blue	Blue	Green	Yellow	Green	Yellow	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Green	Blue	Blue	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-3. Present day "fitness for use" categories for reservoirs in the Gamka-Buffels IUA (C6)

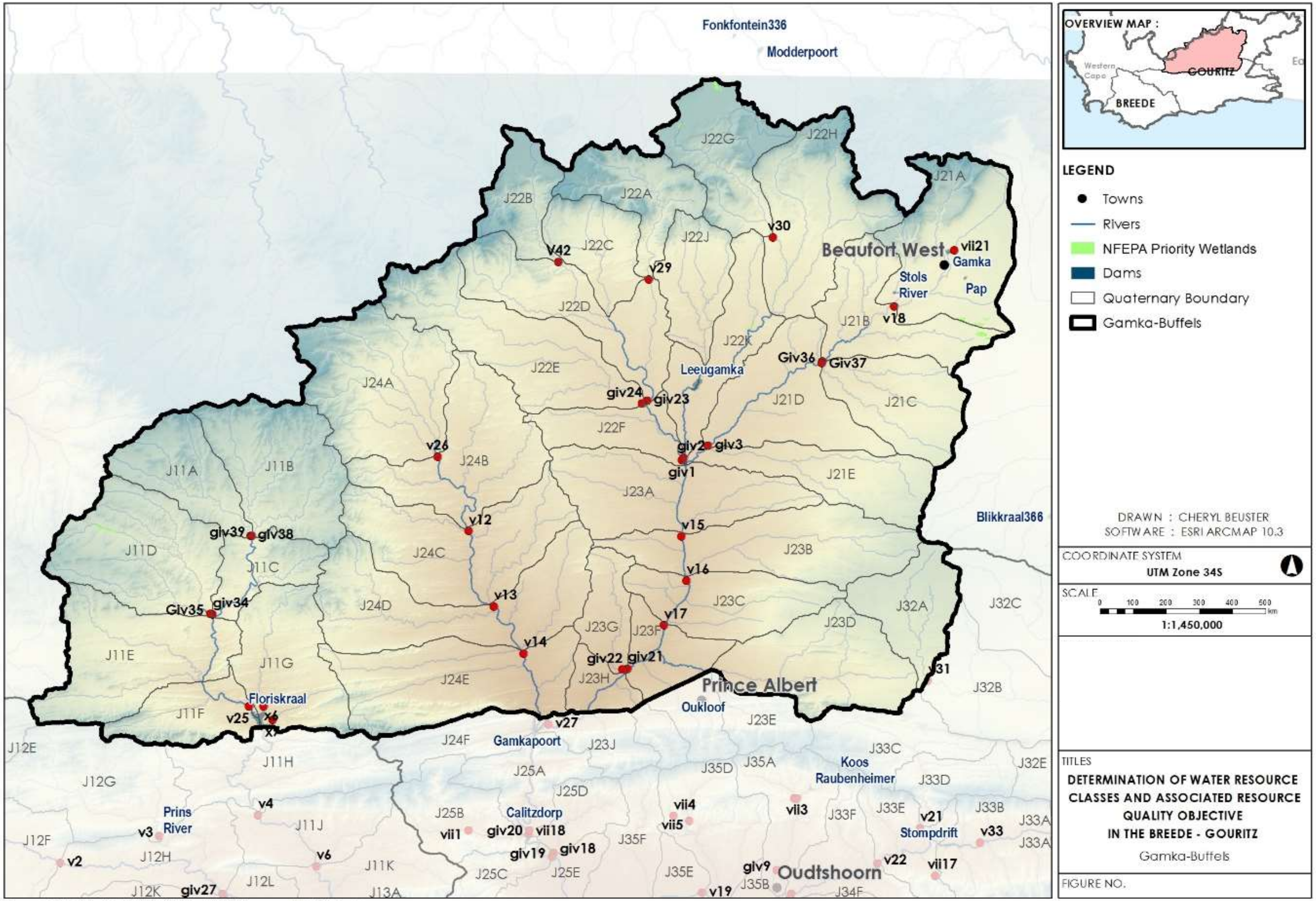
		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J2R001Q01	C6	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Green	Blue	Yellow	Blue	Blue	Blue	Blue
J2R002Q01	C6	Blue	Green	Green	Yellow	Green	Yellow	Blue	Red	Blue	Blue	Green	Yellow	Green	Red	Blue	Blue	Blue	Green

Ecology

The majority of the rivers in the Gamka-Buffels IUA are located in the Great Karoo and are non-perennial. The small rivers are relatively steep, comprising Upper and Lower Foothills that are all considered to be of High or Very High Ecological Importance and Sensitivity. The ecological condition 2014 is higher than was scored during 1999, now mostly A and B-category rivers, being natural or slightly modified. The reasons for the condition assessment are due to few impacts present, some farm dams, some cultivation along river edges; some channel manipulation, infilling to create fields, moderate abstraction and manipulation of low flows; and presence of stock-paths for livestock and some eutrophication from cattle paths. This likely is the reason for the concentration of FEPAs with every single quaternary allocated to either, in decreasing order of incidence, an Upstream, FEPA, Phase 2 FEPA, Fish Support Area or Fish Corridor conservation area of importance. Examples of the kinds of rivers in the Gamka-Buffels are shown in Figure 5-2.

The wetlands from WRU1 Nama Karoo and WRU2 Great Karoo occur within IUA C6. The typical wetlands within this area are depression or seep wetlands, with wetlands in the low lying areas being associated with main channels. WRU1 depression wetlands are dominantly saline, relying on seasonal inundation (DWS, 2015). Impacts to depression and seep wetlands in this region are dam and cultivation transformation, invasive alien *Prosopis glandulosa*.

Figure 5-2. Rivers typical of Gamka-Buffels; J11D-8162 Roggeveld (left) and J11E-8244 Wilgehout (right)



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5.2 IUA D7: Gouritz-Olifants

Socio-economics and ecosystem services

There are over 67 000 ha of irrigated and dryland crops in the Gouritz-Olifants IUA with planted pasture making up almost 80%. Gross economic output of water affected activities was estimated to be R1 791 million in 2015 with irrigated fruit representing almost half of this. The population of the IUA is approximately 171 000 people and 39 000 households of which almost 23% are dependent upon river water.

Water resources

Various significant dams, Stompdrift (55.3 million m^3), Kammanassie (35.8 million m^3) Gamkapoort (36.0 million m^3) and Koos Raubenheimer (9.2 million m^3), as well as a number of smaller dams, reside in this IUA. Stompdrift and Kammanassie supply water to the largest irrigation scheme in the Gouritz component of the WMA, namely the Olifants River Government Water Scheme (13600 ha). The largest town, Oudtshoorn, is experiencing an increasing water deficit.

Water quality monitoring in the Gouritz-Olifants IUA (middle reaches of the Gouritz River and the Olifants catchment) has a better spatial coverage (Table 5-4) than in the Gamka-Buffels IUA. The present status classification illustrates the elevated salinities at some of the river and reservoir sampling points (Table 5-4 and Table 5-5).

Table 5-4. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Gouritz-Olifants IUA (D7)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J2H005Q01	D7	Red	Red	Yellow	Red	Red	Red	Blue	Green	Blue	Blue	Green	Yellow	Green	Red	Green	Green	Blue	Blue
J2H006Q01	D7	Green	Yellow	Green	Yellow	Green	Yellow	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Blue	Blue	Green	Blue	Blue
J2H007Q01	D7	Green	Red	Green	Red	Green	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Blue	Blue	Green	Blue	Blue
J2H010Q01	D7	Green	Yellow	Yellow	Yellow	Yellow	Red	Blue	Green	Blue	Blue	Green	Yellow	Blue	Yellow	Green	Green	Blue	Blue
J2H016Q01	D7	Green	Green	Yellow	Yellow	Yellow	Yellow	Blue	Blue	Blue	Blue	Green	Yellow	Green	Red	Green	Green	Blue	Blue
J3H011Q01	D7	Red	Red	Red	Red	Red	Red	Blue	Green	Blue	Blue	Green	Yellow	Blue	Red	Red	Red	Blue	Blue
J3H012Q01	D7	Green	Green	Green	Green	Green	Yellow	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue
J3H013Q01	D7	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue
J3H014Q01	D7	Blue	Blue	Green	Yellow	Blue	Green	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Green	Blue	Blue	Blue	Blue
J3H015Q01	D7	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Red	Blue	Blue	Blue	Blue
J3H016Q01	D7	Blue	Green	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Green	Blue	Blue
J3H017Q01	D7	Green	Red	Green	Red	Yellow	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Green	Green	Green	Blue	Blue
J3H018Q01	D7	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue
J3H020Q01	D7	Blue	Green	Blue	Green	Green	Yellow	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-5. Present day "fitness for use" categories for reservoirs in the Gouritz-Olifants IUA (D7)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J2R003Q01	D7	Green	Green	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Green	Blue	Blue
J2R006Q01	D7	Green	Green	Yellow	Yellow	Yellow	Yellow	Blue	Blue	Blue	Blue	Green	Yellow	Green	Red	Green	Green	Blue	Blue
J3R001Q01	D7	Green	Yellow	Green	Yellow	Green	Yellow	Blue	Green	Blue	Blue	Blue	Green	Blue	Red	Green	Green	Blue	Blue
J3R002Q01	D7	Green	Yellow	Yellow	Yellow	Yellow	Red	Blue	Yellow	Blue	Blue	Green	Yellow	Blue	Red	Green	Green	Blue	Green

The middle Olifants catchment is represented by the GO-2 GRU. The unit is bounded in the south and north along the contact zone of the Peninsula Formation and is limited to the east and west by catchment boundaries. Towards the southeast the boundary deviates from the catchment boundary following the northern contact zone of the Peninsula Formation (coinciding with the Kamanassie Mountain Range). Buried TMG may discharge deep groundwater towards the Olifants River Catchment. Groundwater flow of the TMG will be linked between unit GC-2, CO-3 and GO-2. No settlements are reliant on groundwater within this region.

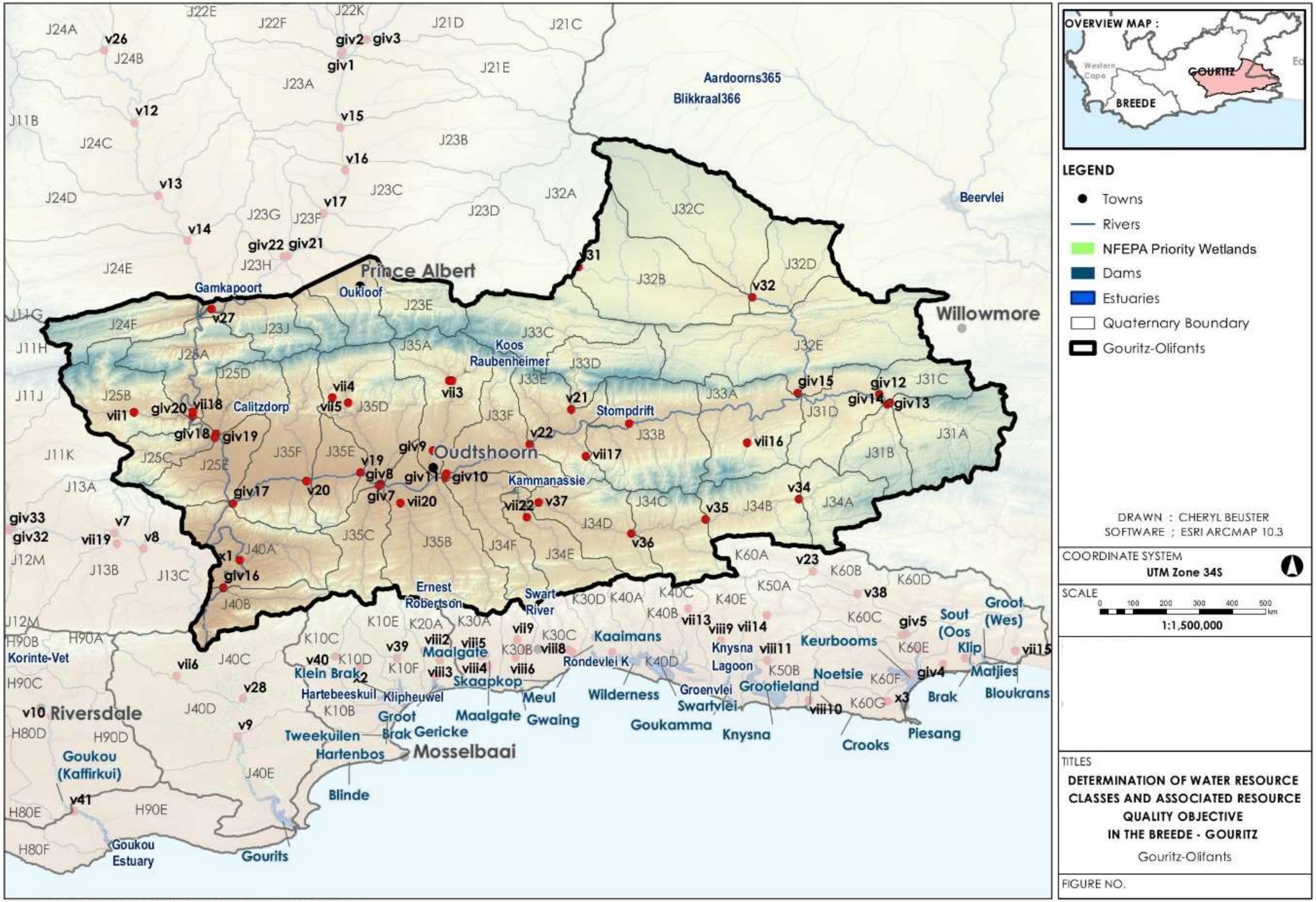
GO-4 GRU is characterised as the Central and Eastern Karoo Basin, with deposits of the Uitenhage Group overlying rocks of the Cape Supergroup. Deep groundwater flow of the Peninsula Formation within the unit will be recharged by or linked to the Peninsula Formation within unit GC-1. The Klein Karoo Rural Water Supply Scheme (Klein Karoo RWSS) relies totally on groundwater, which supplies various surrounding areas. Oudtshoorn Local Municipality has a licence to abstract from up to two wellfields but the infrastructure to connect wellfield to supply has not been developed.

Ecology

All the rivers in the Gouritz-Olifants IUA are located in the South Western Fold Mountains, some are perennial and others non-perennial. The small rivers are relatively steep, comprising Upper and Lower Foothills that are mostly considered to be of High or Very High Ecological Importance and Sensitivity. The ecological condition 2014 is probably the same as scored 1999 being generally poor as there have been roughly an equal number of improvements as deteriorations. The majority of the quaternaries were largely modified 1999 and there have been improvements to C and B-categories, some sub-quaternaries 2014 being moderately or slightly modified, while others were now seriously modified, in an E-category. The reasons for the condition assessment include clearing of riparian areas for cultivation and presence of exotics; intensive cultivation, presence of livestock and possible overgrazing; and large dams, farms dams, and their possible sedimentation impacts. Despite the poor condition of some of the rivers many of the sub-quaternaries are allocated as Upstream conservation areas to support FEPAs and Fish Corridors and there are also a number of Fish Support Areas. Examples of the kinds of rivers in the Gouritz-Olifants are shown in Figure 5-3.

The South Cape Fold Mountains WRU support small seep wetlands on quartzitic, sandstone-derived acid sands associated with groundwater-fed springs (DWS, 2015). The typical wetlands associated with IUA D7 are non-perennial, saline systems associated with rivers and drainage lines, named by Mucina and Rutherford (2006) as Muscadel riviere valley bottom wetlands. Other wetlands are seeps with a high degree of direct and indirect groundwater dependence (DWS, 2015). The major threats to this wetland type is groundwater abstraction as altered water availability results in the rapid degradation of this habitat, due to the narrow groundwater preference range of many of the plants dependent on it (Volk et al., 2005). Other key threats are transformation of wetlands for building roads and for cultivation; increased nutrient inputs and invasive alien plants.

Figure 5-3. Rivers typical of Gouritz-Olifants; Gamka J25A-8567 (left) and Kobus J25B-8591 (right)



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5.3 IUA E8: Touws

Socio-economics and ecosystem services

There are over 11 000 ha of irrigated and dryland crops in the Touws IUA with planted pasture and vegetables making up the majority. Gross economic output of water affected activities was estimated to be R1 787 million in 2015 with irrigated fruit representing over half of this. The population of the IUA is approximately 16 000 people and almost 4 000 households of which almost 16% are dependent upon river water.

Water resources

Two significant dams, Bellair (10.0 million m^3) and Verkeerdevlei (5.5 million m^3), as well as two smaller dams, reside in this IUA. Between these two dams (and various minor ones), some 600 ha is supplied with irrigation water. The largest town, Touws River, is experiencing an increasing water deficit.

High salinities occur almost throughout the Touws IUA (Table 5-6 and Table 5-7) except in its headwaters making the water less suitable for agricultural purposes. This is also reflected in the SAR categories. Moderately high pH values were recorded in the IUA.

Table 5-6. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Touws IUA (E8)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J1H015Q01	E8																		
J1H016Q01	E8																		
J1H017Q01	E8																		
J1H018Q01	E8																		
J1H019Q01	E8																		
J1H022Q01	E8																		
J1H031Q01	E8																		

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-7. Present day "fitness for use" categories for reservoirs in the Touws IUA (E8)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J1R002Q01	E8																		
J1R003Q01	E8																		
J1R004Q01	E8																		
J2R004Q01	E8																		

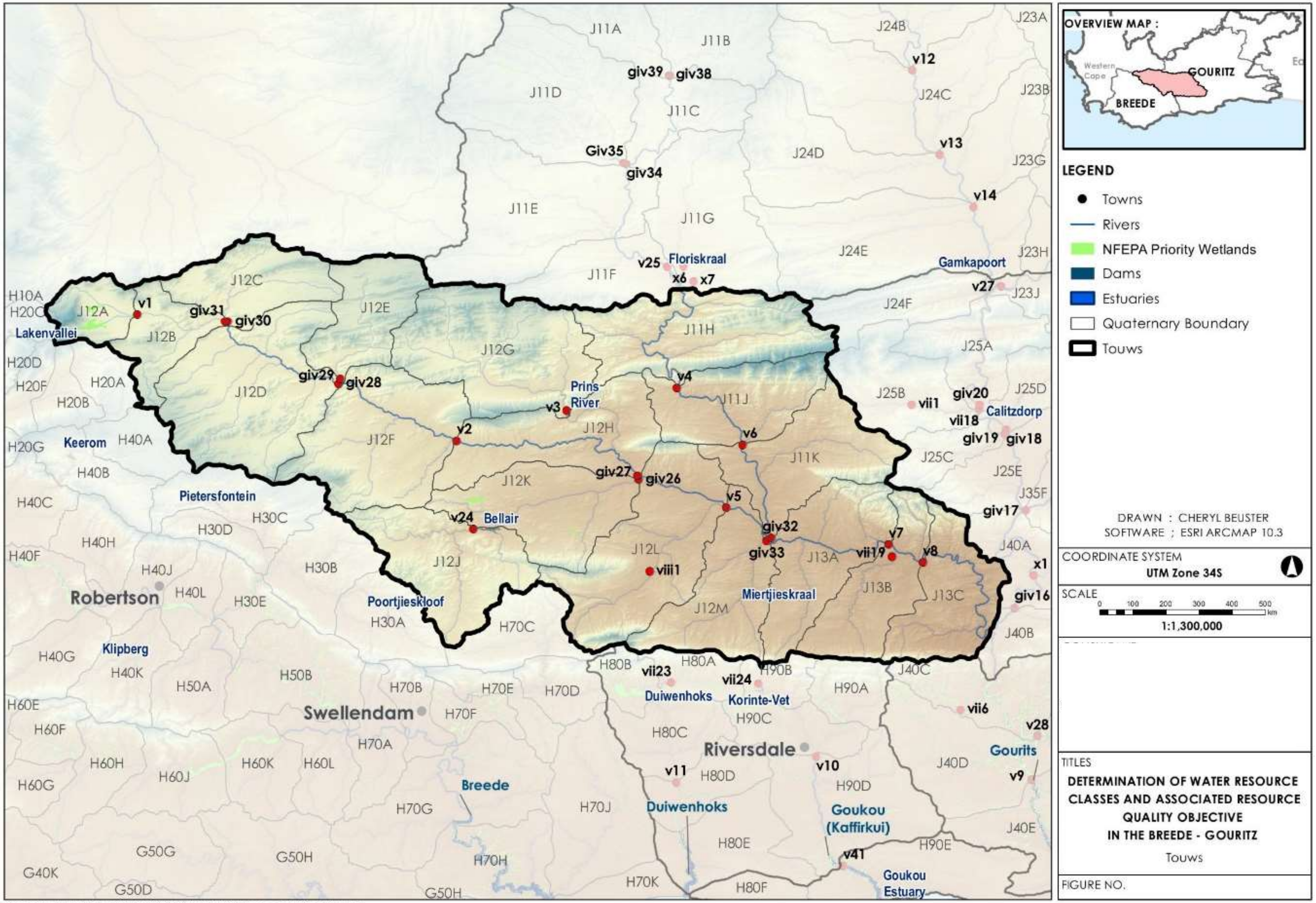
The area of IUA E8 is dominated mainly by Bokkeveld and Witteberg Group outcrops with cenzoic cover occurring over much of the area and alluvial materials in river valleys, or screes and other slope materials, which could result in moderate groundwater resources. Groundwater provides the Touws River with 35% of its supply source in GGr-1. Within GGr-3 both settlements are solely dependent on groundwater, and within GGr-4 Ladismith is currently in the process of establishing a wellfield. The town in GGr-5 also relies solely on groundwater, with up to two thirds being abstracted from boreholes.

Ecology

Apart from the upper Donkies River, all the rivers in the Touws IUA are located in the South Western Fold Mountains, some are perennial and others non-perennial. The small rivers are relatively steep, comprising mostly Upper Foothills that are of High EIS. The ecological condition 2014 is approximately the same as scored 1999 being generally poor as there have been roughly an equal number of improvements as deteriorations. The majority of the quaternaries were moderately modified 1999 and there have been some improvements to a B-category 2014 (slightly modified), while others were now largely, in a D-category. The reasons for the condition assessment include moderate to poor water quality; clearing for fields, channel manipulation and infilling of channels; cultivation along river banks, livestock and possible overgrazing; and the presence of farms dams and some exotic vegetation. Due to the poor condition of some of the rivers some of the sub-quaternaries are allocated Phase 2 FEPAs, presumably as conservation targets after some attention toward restoration may be paid, and there are also a number of Upstream conservation areas to support FEPAs and Fish Corridors. Examples of the kinds of rivers in the Touws are shown in Figure 5-4.

IUA E8 has similar wetlands as described in IUA D7.

Figure 5-4. Rivers typical of Touws; Donkies J12B-8556 (left) and Groot J13B-8938 (right)



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5.4 `IUA F12: Duiwenhoks

Socio-economics and ecosystem services

There are almost 75 000 ha of irrigated and dryland crops in the Duiwenhoks IUA with planted pasture and grain making up the vast majority, almost all of which are drylands crops. Gross economic output of water affected activities was estimated to be R221 million in 2015 with tourism and recreation representing over half of this. The population of the IUA is approximately 29 000 people and almost 8 000 households of which only 1.6% are dependent upon river water.

Water resources

Two major water supply dams reside in this IUA sub-zone, namely the Korinte–Vet Dam (8.3 million m^3) and Duiwenhoks Dam (6.3 million m^3). The Duiwenhoks Dam supplies Heidelberg and the Duiwenhoks Rural Water Supply Scheme as well as the Duiwenhoks River Government Water Scheme (1300 ha). The Korinte-Vet Dam supplies water to Riversdale and the Korente-Vette Irrigation Scheme (900 ha). A further 400 ha is irrigated by direct abstraction from the Goukou River.

Water quality in the Duiwenhoks IUA tends to be good except for the lower reaches of the Duiwenhoks River at H8H001, and the lower Goukou River at H9H005 (Table 5-8). Water quality in the Korentepoort Dam (H9R001) was in an ideal category (Table 5-9).

Table 5-8. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Duiwenhoks IUA (F12)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H8H001Q01	F12	Red	Red	Yellow	Red	Yellow	Red	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Green	Green	Blue	Blue
H8H003Q01	F12	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue
H9H002Q01	F12	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue
H9H004Q01	F12	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue
H9H005Q01	F12	Green	Red	Green	Yellow	Green	Red	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Green	Green	Blue	Blue
H9H010Q01	F12	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-9. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Duiwenhoks IUA (F12)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H9R001Q01	F12	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue

The GRU GGo-2a and 2b occur within this IUA. The northern boundary follows the Peninsula Formation outcrop and the remaining rocks of the TMG and underlying Bokkeveld Group. Mesozoic Uitenhage Group deposits also occur north of this area and Cenzoic covers the TMG and Bokkeveld Group rocks closer to the coast.

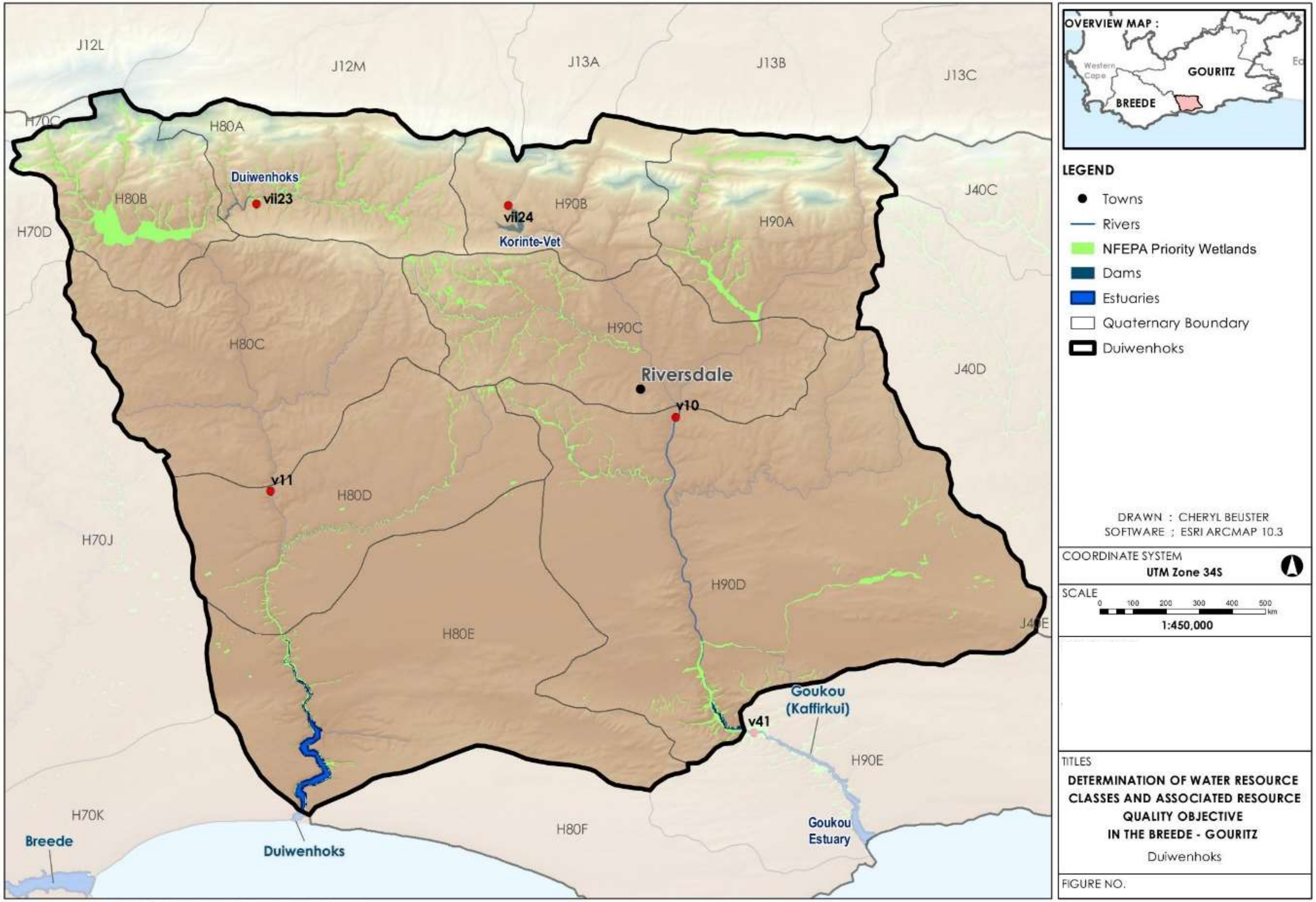
Ecology

All the rivers in the Duiwenhoks IUA are located in the Southern Coastal Belt and flow perennially. The small rivers are relatively steep, comprising Upper and Lower Foothills that are mostly of Very High Ecological Importance and Sensitivity. The ecological condition 2014 has worsened since 1999 with most rivers now being largely modified, ecological condition category D. The reasons for the condition assessment include numerous small farm dams; urban and agricultural runoff; clearing for fields, channel manipulation and infilling of channels; and cultivation along river banks, livestock and possible overgrazing.

The moderately modified tributaries are assigned as FEPAs while those in a poorer condition are assigned as Phase 2 FEPAs, presumably for focus upon once restoration efforts may be undertaken. There are also a Fish Support Area and an Upstream conservation area. Examples of the kinds of rivers in the Duiwenhoks are shown in Figure 5-5.

IUA F12 lies within the South Coastal Belt and Coastal Sediment Deposit Wetland RUs. The upper part of the IUA occurs within the South Coastal Belt WRU, and as such consists of mainly seepage wetlands (especially in granite areas) and valley bottom wetlands (DWS, 2015). Permanently wet valley bottom types are typically located at the base of the sandstone mountain range, and are likely fed by overland flow off the mountains as well as constant groundwater contribution from the adjacent quartzitic sandstone (DWS, 2015). The Goukou wetland is one such wetland and consists of a large palmiet-dominated valley-bottom system with peat that may be up to 7 m deep in places (Malan et al., 2015). Part of the wetland is conserved within the Kruis River Nature Reserve, and the rest is privately owned. The wetland has a high EIS score due the presence of Palmiet, its support of the surrounding critically endangered (Mucina & Rutherford, 2006) vegetation type Mossel Bay Shale Renosterveld, and the fact that it is a peatland. It has a PES score of B - largely natural and C – moderately modified due to inflow reductions from upstream dams and abstraction for irrigation, invasion of alien trees in some parts, infilling and trenching for agriculture in others and headcut erosion in the wetland headwaters (Malan et al., 2015). Another such wetland is the Duiwenhoks wetland, at the foot of the Langeberg Mountains, which originally supported palmiet vegetation before an actively eroding donga removed most of the peatlands. The wetland has been assessed as being of Moderate EIS, and a PES score of D- Largely Modified (DWS, 2015).

Figure 5-5. Rivers typical of Duiwenhoks; Spieels H80C-0920-9 (left) and Duiwenhoks H80C-09208 (right)



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5.5 IUA F13: Lower Gouritz

Socio-economics and ecosystem services

There are over 47 000 ha of irrigated and dryland crops in the Lower Gouritz IUA with planted pasture and grain making up the vast majority, almost all of which are drylands crops. Gross economic output of water affected activities was estimated to be R159 million in 2015 with tourism and recreation representing over half of this. The population of the IUA is approximately 11 000 people and 3 500 households of which only 4.4% are dependent upon river water.

Water resources

There are no major water supply dams in this IUA. The small towns of Herbertsdale and Albertinia and the resort town of Gouritzmond, located in this IUA, all obtain their water supplies from boreholes and/or springs. Some private irrigation takes place on the banks of the Gouritz River.

Water Quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort (J4H002) had very high salinities making it almost unsuitable for agricultural use (Table 5-10). This was also reflected in the SAR categories. Water quality in the Weyers River (J4H003) was only moderately impaired. No reservoir monitoring data were available in this IUA.

Table 5-10. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Lower Gouritz IUA (F13)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Sta..	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
J4H002Q01	F13	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Green	Yellow	Red	Blue	Blue
J4H003Q01	F13	Green	Yellow	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

The GRU GGo-1 falls within the Lower Gouritz. The northern boundary of the unit follows the contact between the TMG and overlying Bokkeveld Group. Only Albertinia relies solely on groundwater.

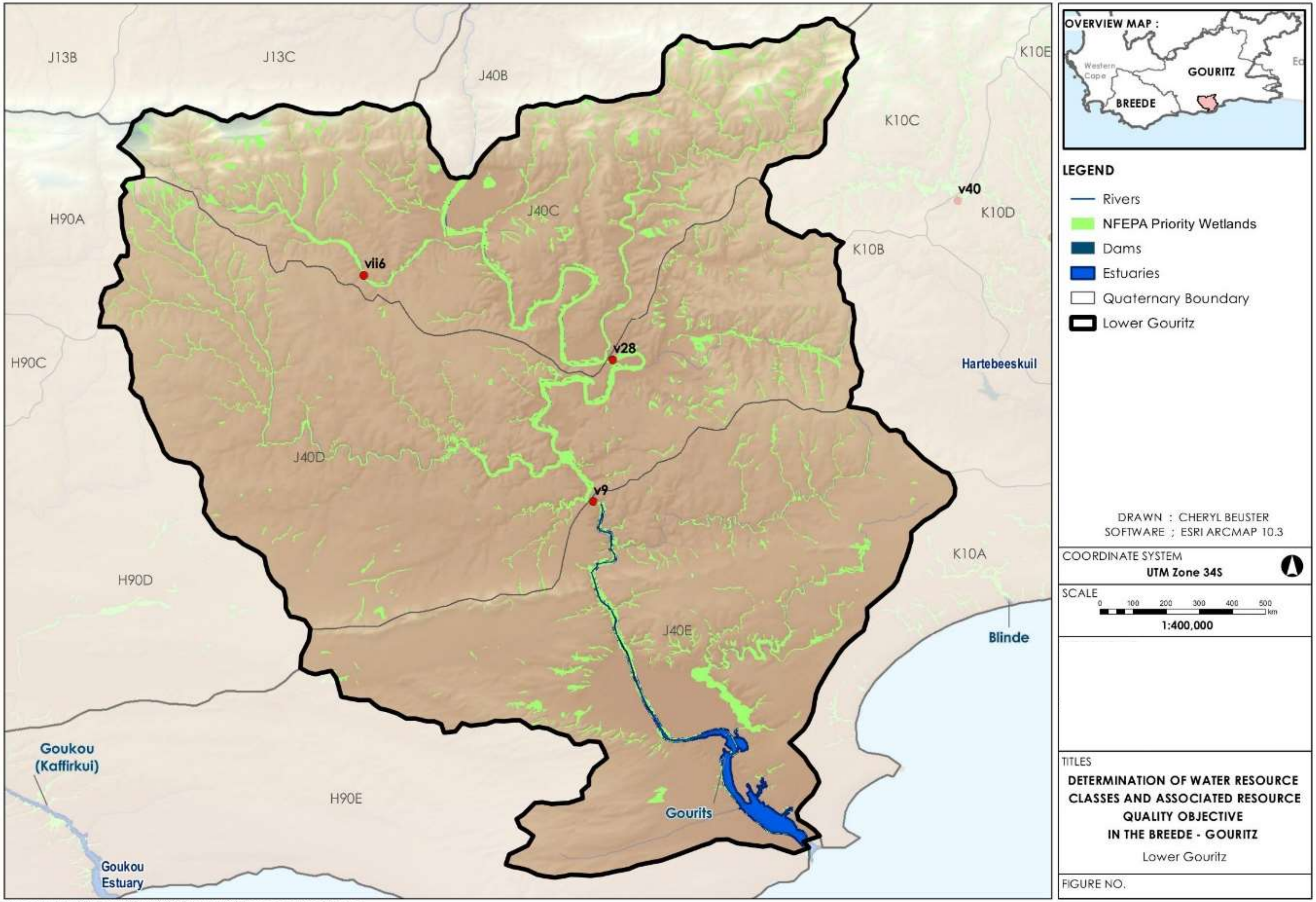
Ecology

All the rivers in the Lower Gouritz IUA are located in the Southern Coastal Belt and flow perennially. The large rivers are low lying, generally being Lowlands, which are of Very High or High Ecological Importance and Sensitivity. The ecological condition 2014 remains much the same as at 1999 with one sub-quaternary being in a worsened largely modified condition, D-category. The reasons for the condition assessment include numerous small farm dams and flow regulation by large dams upstream; urban and agricultural runoff; clearing for fields, channel manipulation and infilling of channels; and cultivation along river banks, livestock and possible overgrazing. Few FEPAs are assigned, most notable are the Fish Support Areas along the Weyers and Langtou Rivers. Examples of the kinds of rivers in the Lower Gouritz are shown in Figure 5-6.

Wetlands of the Lower Gouritz IUA are mainly associated with the WRU8 Southern Coastal Belt, with the main floodplain wetland being associated with the Gouritz River.

The Gouritz estuary has the second largest catchment and MAR within the WMA as is classified as permanently open. The status of the hydrology, physical habitat, macrophytes and invertebrates are assessed as poor, but overall the estuary health status is fair.

Figure 5-6. Rivers typical of Lower Gouritz; Weyers J40C-9156 (left) and Gouritz J40C-9169 (right)



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5.6 IUA G14: Groot Brak

Socio-economics and ecosystem services

There are over 21 000 ha of irrigated and dryland crops in the Groot Brak IUA with planted pasture and grain making up the vast majority, almost all of which are drylands crops. Gross economic output of water affected activities was estimated to be R474 million in 2015 with tourism and recreation representing over half of this. The population of the IUA is approximately 85 000 people and over 26 000 households of which only 0.5% are dependent upon river water.

Water resources

Mossel Bay, Great and Little Brak and Hartenbos are primarily supplied from the Wolwedans (23.0 million m^3) and Klipheuwel (4.2 million m^3) Dams. The Hartebeeskuil Dam (7.2 million m^3) is primarily utilised for irrigation water supplies.

Water quality in the Groot Brak IUA also exhibit elevated salinities, especially in the Hartebeestkuil Dam on the Hartenbos River – downstream weir (K1H017), Hartbeeskuil Dam (K1R001) and at Wolwedans on the Groot-Brak River (K2H002) (Table 5-11 and Table 5-12).

Table 5-11. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Groot Brak IUA (G14)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
K1H004Q01	G14	Green	Yellow	Green	Green	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue
K1H005Q01	G14	Green	Green	Blue	Green	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue
K1H017Q01	G14	Red	Red	Yellow	Yellow	Red	Red	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Green	Green	Blue	Blue
K2H002Q01	G14	Yellow	Red	Yellow	Red	Yellow	Red	Blue	Green	Blue	Blue	Blue	Yellow	Blue	Green	Green	Red	Blue	Blue
K2H006Q01	G14	Green	Red	Blue	Yellow	Blue	Yellow	Blue	Blue	Blue	Blue	Blue	Green	Blue	Yellow	Green	Green	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-12. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Groot Brak IUA (G14)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
K1R001Q01	G14	Red	Red	Yellow	Yellow	Red	Red	Blue	Green	Blue	Blue	Blue	Green	Blue	Red	Green	Green	Blue	Blue
K1R002Q01	G14	Green	Yellow	Blue	Green	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue
K2R001Q01	G14	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Red	Blue	Blue	Blue	Blue

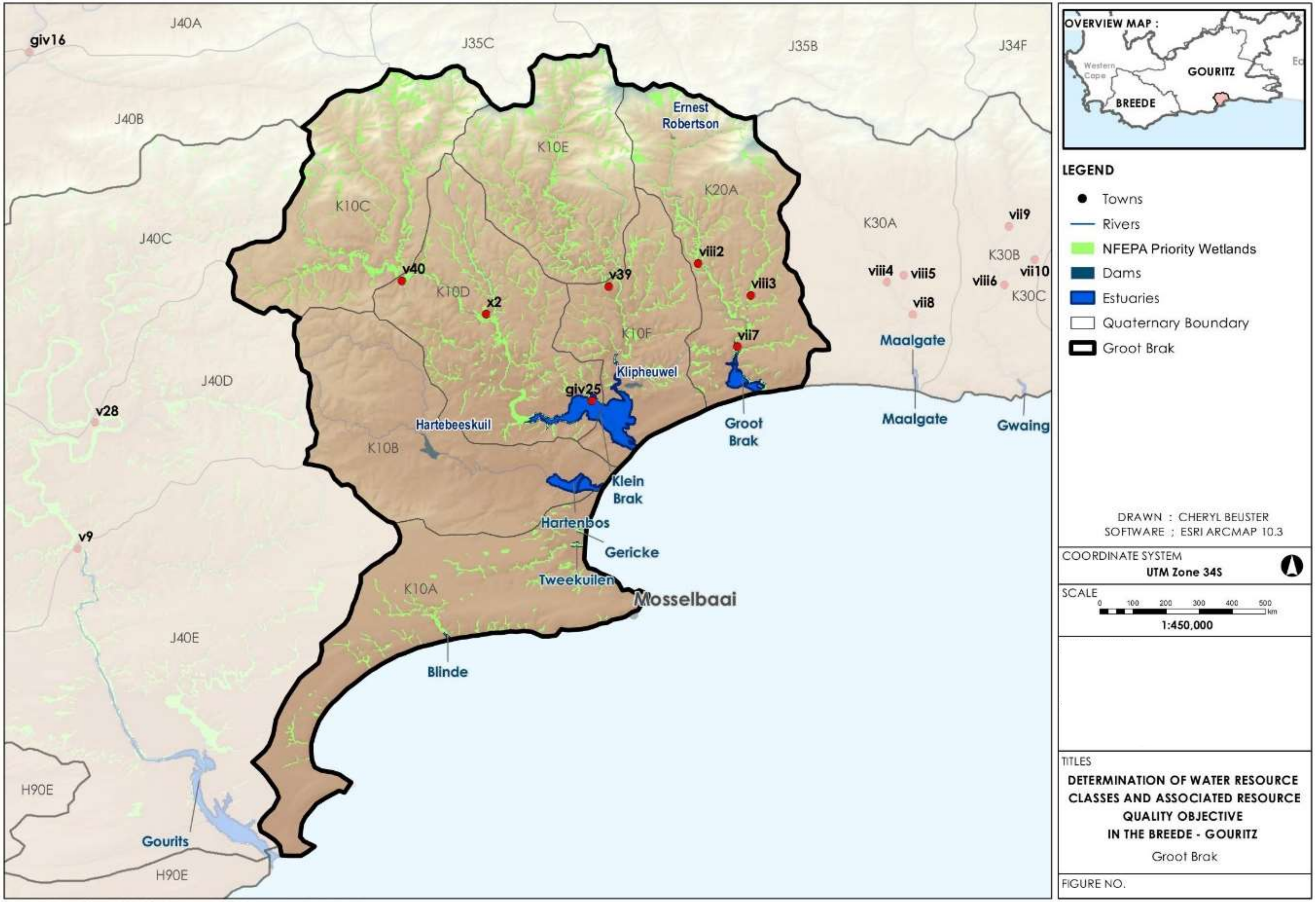
GC-1 occurs to the north of the Groot Brak, following the contact of the Peninsula Formation and the remaining rocks of the TMG. The western boundary of this unit follows the contact zone of the Cape Granite Suite north of Brak River. The argillaceous character of the Kaaimans Groups renders it less favourable for groundwater development than other aquifer types in the study area. Cape Granite Suite aquifers owe their water-bearing properties to both fracturing and weathering, and typical drilling targets include zones of deep weathering, contact zones with the Kaaimans Group and dyke contacts. Groundwater is expected to flow southwards and towards the nearest surface water bodies and the coast. Mossel Bay occurs within GCo-1 GRU, where Mesozoic Uitenhage Group deposits occur and overlie the TMG. Together with the Bokkeveld Group the TMG underlie the Bredasdorp Cenzoic cover to the south west. Mossel Bay and Great Brak are supplied by surface water.

Ecology

All the rivers in the Groot Brak IUA are located in the Southern Coastal Belt and apart from two tributaries flow perennially. The small rivers are generally steep, being Upper and Lower Foothills that are of Very High or High Ecological Importance and Sensitivity. The 2014 ecological condition of each sub-quaternary has worsened since 1999 from moderately (C-category) to largely (D-category) modified, with one sub-quaternary being in an intermediate but still lower CD-category. The reasons for the condition assessment include high abstraction and several small farm dams with severe impacts of low flows; pollution impacts from livestock farming and fodder crops; extensive infilling of channels, clearing of riparian areas and channel manipulation; and cultivation along river banks and presence of exotic woody vegetation. Few FEPAs are assigned, most notably are the Fish Support Areas along the Groot Brak and Kouna Rivers and the Phase 2 FEPAs of the Klein Brak and Hartenbos Rivers. Examples of the kinds of rivers in the Groot Brak are shown in Figure 5-7.

The three estuaries within IUA G14 are all classified as temporarily closed (Hartenbos, Klein Brak and Groot Brak). Within the Breede-Gouritz WMA, these systems can be considered as small-medium sized estuaries with the relatively low MAR. Overall the estuary health state is considered fair, but the Hartenbos and the Groot Brak are in a D ecological category with the Hartenbos having significant water quality problems due to inputs of WWTW effluent. None of these estuaries are formally protected.

Figure 5-7. Rivers typical of Groot Brak; Ruiterbos K10D-9121 (left) and Palmiet K10D-9159 (right) IUA G15: Coastal



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5.7 IUA G15: Coastal

Socio-economics and ecosystem services

There are over 23 000 ha of irrigated and dryland crops in the Coastal IUA with planted pasture and grain making up the vast majority, almost all of which are drylands crops. Gross economic output of water affected activities was estimated to be R1583 million in 2015 with tourism and recreation representing over half of this. The population of the IUA is approximately 300 000 people and over 88 000 households of which only 0.7% are dependent upon river water.

Water resources

Utilisation of the surface water resources of this IUA are primarily focused on water supplies to the many towns and resorts in this IUA. Most of Plettenberg Bay's water supply comes from run-of-river abstractions from the Keurbooms River diversion weir located downstream of the Keurbooms-Palmiet confluence. These supplies are augmented from Roodefontein Dam (2.0 million m^3). The Knysna area is supplied with raw water from several different surface sources, namely abstractions from the Knysna River, Gouna River, Akkerkloof Dam (0.8 million m^3) and a 2 Ml/d desalination plant. Sedgefield obtains its water supplies from separate abstraction points on the nearby Karatara River as well as from a new off-channel storage dam. George and the surrounding towns (Pacaltsdorp, Herolds Bay, Victoria Bay and Wilderness) are mainly supplied from the Garden Route Dam (10.3 million m^3).

Water quality in the Coastal IUA is generally good although some of the sampling points in the lower reaches of river may be affected by seawater intrusions (Table 5-13). Water quality in the Garden Route Dam (K3R002) is good (Table 5-14).

Table 5-13. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Coastal IUA (G15)

		Chloride		**TDS**		**EC**		**NH_3-N**		**NO_3+NO_2-N**		**pH**		**PO_4-P**		**SAR**		**SO_4**	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
K6H019	G15	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Green	Blue	Blue
K3H001Q01	G15	Green	Green	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Green	Blue	Blue
K3H002Q01	G15	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Blue	Blue	Blue	Blue
K3H003Q01	G15	Red	Red	Green	Red	Yellow	Red	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Green	Blue	Blue
K3H004Q01	G15	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Red	Blue	Green	Blue	Blue
K3H005Q01	G15	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Green	Blue	Blue
K3H007Q01	G15	Green	Green	Blue	Green	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Red	Green	Green	Blue	Blue
K3H011Q01	G15	Red	Red	Yellow	Red	Red	Red	Blue	Blue	Blue	Blue	Blue	Green	Green	Red	Green	Yellow	Blue	Blue
K4H001Q01	G15	Green	Red	Blue	Yellow	Blue	Red	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Red	Blue	Blue
K4H002Q01	G15	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue
K4H003Q01	G15	Green	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue
K5H002Q01	G15	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Green	Blue	Blue
K6H001Q01	G15	Green	Green	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Green	Blue	Blue
K7H001Q01	G15	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue

Note: 50 = median or 50^{th} percentile, 95 = 95^{th} percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 5-14. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Coastal IUA (G15)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
K3R002Q01	G15																		

GC-1 occurs to the west of the Coastal IUA, following the contact of the Peninsula Formation and the remaining rocks of the TMG and being bounded by Wilderness in the east. The George batholith outcrops west and south of George, which intruded into the Kaaimans Group. The argillaceous character of the Kaaimans Groups renders it less favourable for groundwater development than other aquifer types in the study area. Groundwater is expected to flow southwards and towards the nearest surface water bodies and the coast. George has boreholes that can provide 24% of its supply, although they are not routinely used and require licencing. GC-2 and GC-3 are associated with the northern boundary of the Peninsula Formation. Kynsna has some boreholes, making up 7% supply, Plettenberg Bay has boreholes capable of providing 10% supply, and Sedgefield has a wellfield with a current operational yield of less than 50% water requirements. Kurland and Natures Valley are supplied solely by surface water.

Ecology

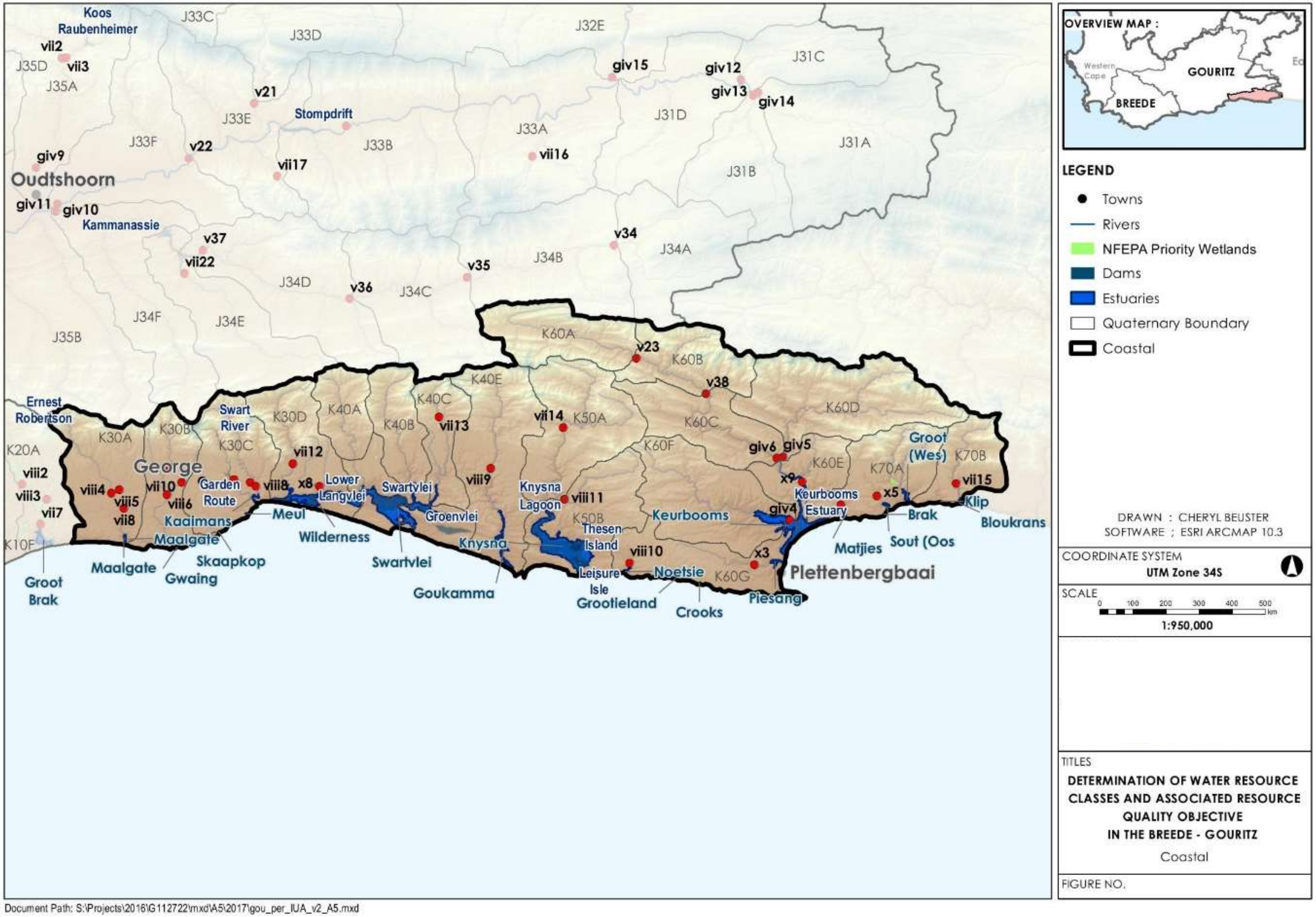
All the rivers in the Coastal IUA, apart from the Maalgate and Moeras, are located in the South Eastern Coastal Belt and apart from four tributaries flow perennially. The small rivers are generally steep, being predominantly Upper Foothills that are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers here generally remains good, with most rivers being slightly to moderately modified (C-category), as was the case 1999. There are a few sub-quaternaries where the ecological condition has deteriorated to being largely modified (D-category). The reasons for the condition assessment include moderate to high abstraction and several small farm dams with moderate to high impacts on low flows; pollution impacts from agricultural return flows; relatively undisturbed bed and banks in places, infilling in urban areas; and cultivation along river banks with mostly natural vegetation, some woody exotics. Almost all the quaternaries are assigned as FEPAs, this being an extremely well known area of freshwater conservation importance, along with Fish Support Areas and Upstream Conservation areas. Examples of the kinds of rivers in the Groot Brak are shown in Figure 5-8.

IUA G15 consists of relatively steep gradient streams. Where these gradients flatten out there are floodplain wetlands or side seep wetlands present. Land use change in this area has led to increased pressure on these wetlands, with many seeps having been ploughed or drained in agricultural areas or under threat of urban expansion in the coastal areas. The Bitou Floodplain Wetland in particular is under extensive agricultural cultivation in its upper reaches (DWS, 2015). The PES of the wetland was scored C - Moderately modified (DWS, 2015).

The Sedimentary Coastal Lakes WRU consist of very large fresh to brackish water lakes and other depression wetlands including Groenvlei, Wilderness Lakes (Eilandvlei, Bo-Langvlei and Rondevlei) and Sedgefield. The Wilderness Lakes are formally protected through designation as a National Park, and are also a RAMSAR site. The coastal lakes have been impacted by changes to hydrology due to upstream activities, as well as manipulation of the estuary (DWS, 2015). Key threats to these wetlands include changes to hydrology and salinity, high nutrient and sediment inputs, harvesting of fauna and flora and development encroachment.

This IUA includes two open estuaries (Keurbooms and Kaaimans), two large estuarine lakes (Wilderness and Swartvlei), the only estuarine Bay (Knysna)) and six temporarily open estuaries (Maalgate, Gwaing, Goukamma, Noetsie, Piesang, Groot (Wes)). These estuaries are all in a good or excellent state of health. Many of these estuaries (Wilderness, Swartvlei, Goukamma, Knysna, Keurbooms, Groot and Bloukrans) are formally protected within Cape Nature or SAN parks reserves. Knysna is rated as the most important estuary nationally from a conservation planning perspective.

Figure 5-8. Rivers typical of Groot Brak; Ruiterbos K30B-9082 (left) and Kaaimans K30C-9065 (right)


OVERVIEW MAP :
GOURITZ
BREEDE
LEGEND
Towns
Rivers
NFEPA Priority Wetlands
Dams
Estuaries
Quaternary Boundary
Coastal
DRAWN : CHERYL BEUSTER
SOFTWARE ; ESRI ARCMAP 10.3
COORDINATE SYSTEM
UTM Zone 34S
SCALE
1:950,000
TITLES
DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVE IN THE BREEDE - GOURITZ
Coastal
FIGURE NO.
Oudtshoorn
George
Plettenbergbaai
Koos Raubenheimer
Stompdrift
Kammanassie
Ernest Robertson
Swart River
Garden Route
Kaaimans
Maalgate
Skaapkop
Gwaing
Groot Brak
Meul
Wilderness
Lower Langvlei
Swartvlei
Groenvlei
Goukamma
Knysna
Knysna Lagoon
Thesen Island
Leisure Isle
Grootieland
Noetsie
Crooks
Piesang
Keurbooms
Keurbooms Estuary
Matjies
Sout (Oos
Brak
Groot (Wes)
Klip
Bloukrans
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5.8 IUA I18: Hessequa

Socio-economics and ecosystem services

There are less than 800 ha of irrigated and dryland crops in the Hessequa IUA with dryland planted pasture making up the majority. Gross economic output of water affected activities was estimated to be R240 million in 2015 with fisheries representing over half of this. The population of the IUA is approximately 8 000 people and over 3 000 households of which only 1.1% are dependent upon river water.

Water resources

There are no significant surface water resources in this IUA. The main town, Stilbaai, has an annual water requirement of 2.8 million m^3 which it supplies from springs, boreholes and a small unregistered dam.

There were no suitable river or reservoir monitoring points to assess the water quality status in the Hessequa IUA.

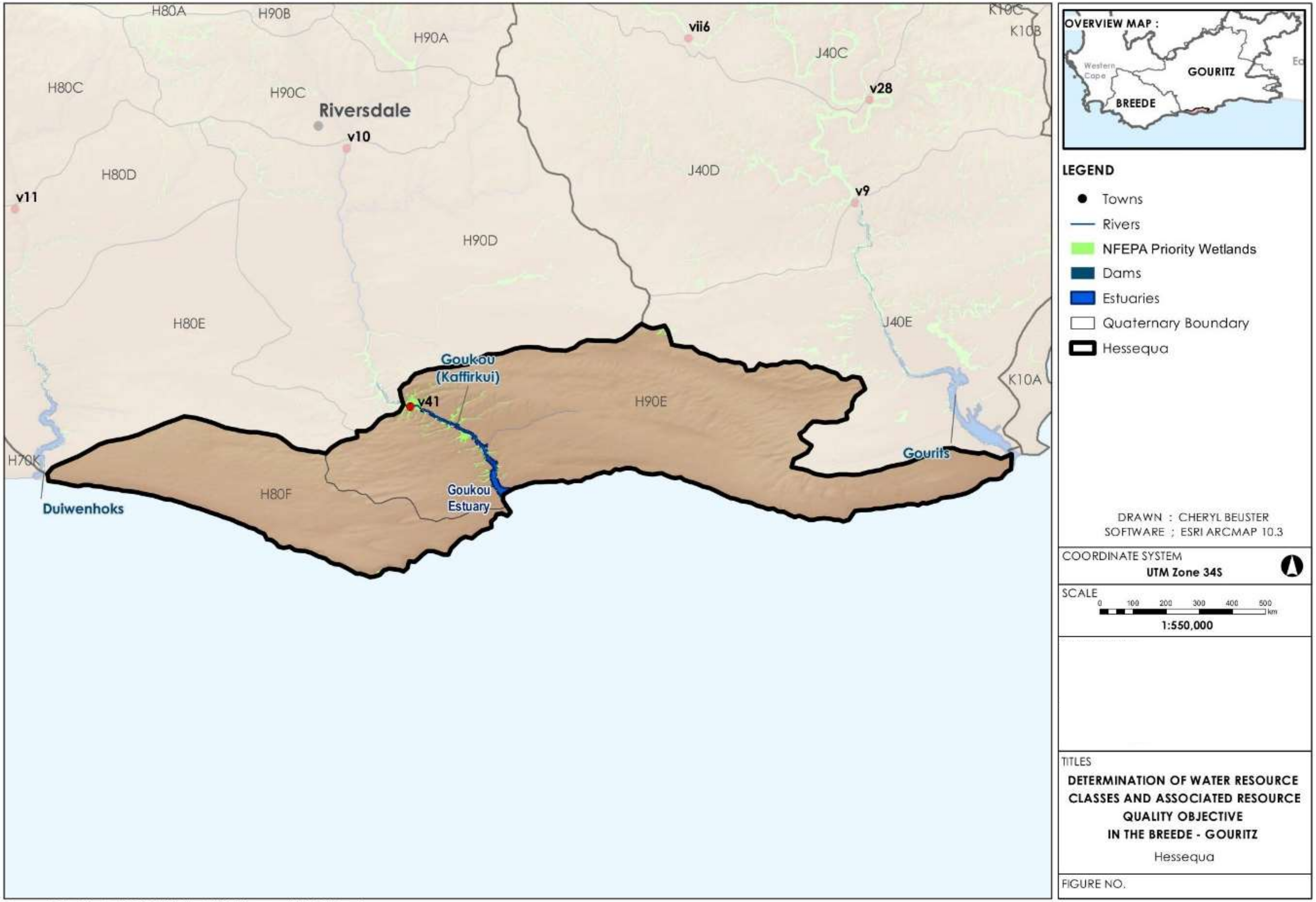
The GRU GGo-2a and 2b occurs within this IUA. The southern part of this GRU occurs whereby the TMG and Bokkeveld Group rocks are underlain by Cenzoic cover. Groundwater discharge will occur to rivers and the ocean. Several settlements rely solely on groundwater in this areas, Gouritzmond and Stilbaai are solely reliant on groundwater.

Ecology

There is one node on the perennial Goukou River in the Hessequa IUA that is located in the South Eastern Coastal Belt. This small river is moderately steep through Lower Foothills and is of High Ecological Importance and Sensitivity. The ecological condition of the river has remained the same 1999-2014, being moderately modified (C-category). The reasons for the condition assessment include high abstraction and small farm dams with moderate to high impacts on flows; pollution impacts from agricultural return flows; infilling where cultivation occurs; and removal and some exotic plants where cultivation occurs. There is one FEPA on the inflowing tributary.

IUA I18 occurs within the section of the study area underlain with limestones (within the Coastal Sedimentary Deposits WRU). Due to the deep, free-draining soils and lack of a perched water table there are limited wetlands, with most occurring primarily as interdune depression wetlands (DWS, 2015). The Gouriqua wetland consists of a series of freshwater springs and seeps on the coastal plain, which is now conserved as part of a private nature reserve (Malan *et al.,* 2015). The wetland EIS score is high as coastal seeps such as these are a unique habitat type, and the wetland was given a PES score of B – largely natural (Malan *et al.,* 2015).

Two medium sized, permanently open estuaries (Duiwenhoks and Goukou) are found within IUA I 18. The Duiwenhoks is considered to be in a Good ecological state whilst the Goukou is assessed as Fair. Part of the Goukou is protected in a no take Marine Protected Area.



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6 STATUS QUO PER IUA: BREEDE-OVERBERG

The approach we followed in the provisional delineation of the IUAs is described in the companion document to this Status Quo Report, namely the *Resource Unit Delineation and Integrated Units of Analysis Report* (DWS, 2016b).

During the preparation of this Status Quo Report we reviewed the provisional IUA delineations, which then resulted in the final delineation of 10 IUAs for the Breede-Overberg presented in Figure 6-1. The composition of the IUAs for the Breede-Overberg is presented in Table 6.2.

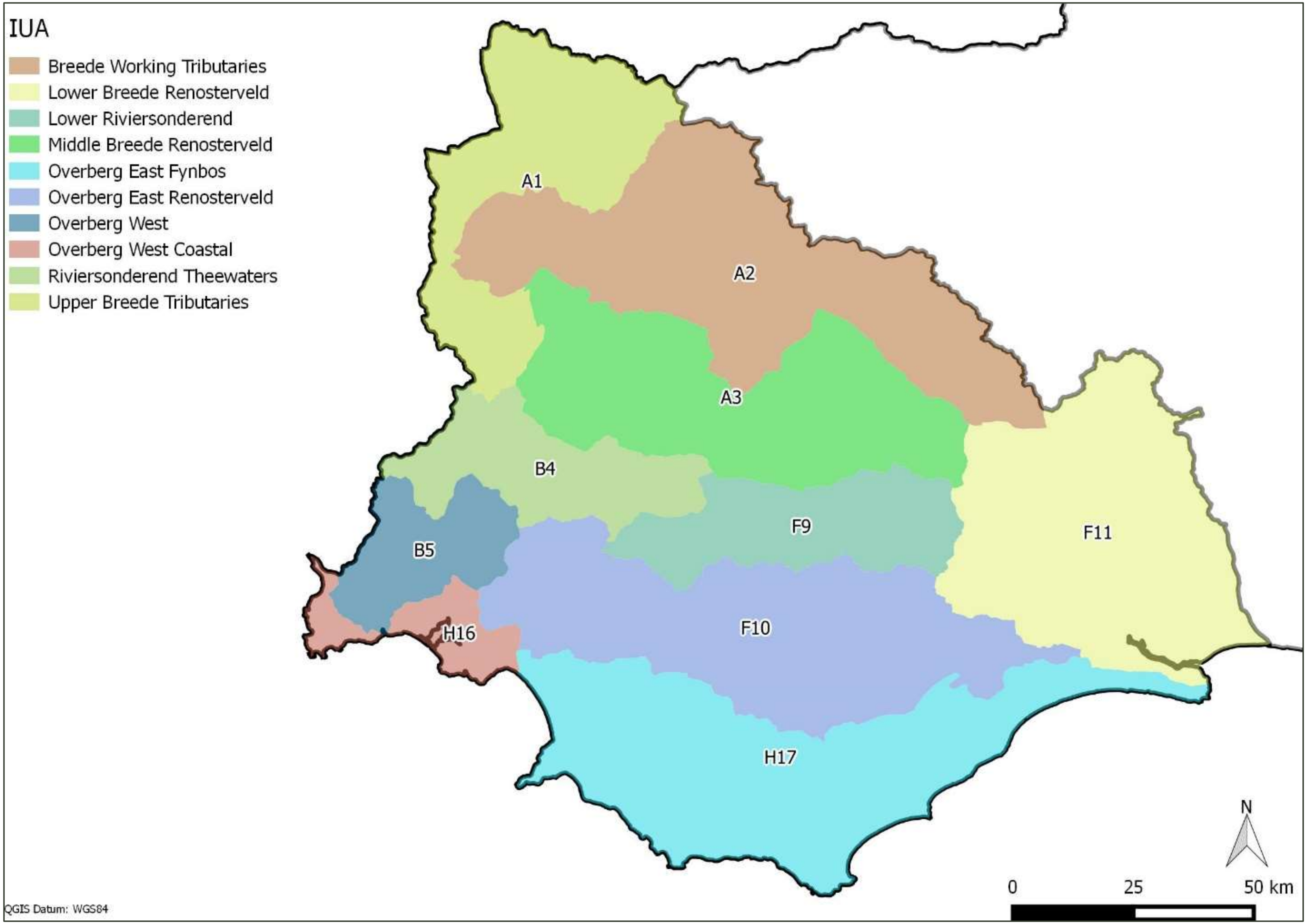


Figure 6-1. Locations of IUAs delineated for the Breede-Overberg component of the WMA

Table 6.2: Composition of IUAs delineated for the Breede-Gouritz WMA

Socio-economic Zone	Zone Code	River Resource Unit	IUA Name	IUA Code	Quaternary Catchments
Breede wine & fruit region	A	Upper Breede Tributaries	Upper Breede Tributaries	A1	H10C H10A H20C H10B H20D H10D H10F H20E H10E H10J H10K
		Breede Working	Breede Working Tributaries	A2	H20A H20F H20B H40A H10H H10G H20G H40B H40C H20H H30C H40H H10L H30D H30B H40J H30A H80D
		Middle Breede Renosterveld	Middle Breede Renosterveld	A3	H40E H40F H40L H30E H40D H40G H40K H50A H50B
Theewaterskloof fruit region	B	Riviersonderend Upper	Riviersonderend Theewaters	B4	H60B H60C H60E H60D H60A H60F
		Overberg West (part 1 of 3)	Overberg West	B5	G40E G40C G40D
Wheat belt	F	Riviersonderend Lower	Lower Riviersonderend	F9	H60L H60K H60H H60J H60G
		Overberg West (part 2 of 3) Overberg East Renosterveld (part 1 of 2)	Overberg East Renosterveld	F10	G40F G40K G50H G50G G40J G50D
		Lower Breede Renosterveld	Lower Breede Renosterveld	F11	H70D H70A H70B H70C H70A H70J H70G H70H H70K H70F H70E
Overberg coast	H	Overberg West (3 of 3)	Overberg West Coastal	H16	G40B G40H G40G
		Overberg East (Fynbos)	Overberg East Fynbos	H17	G40L G50K G50J G40M G50E G50B G50C G50F G50A

6.1 IUA A1: Upper Breede Tributaries

Socio-economics and ecosystem services

There are over 23 000 ha of irrigated and dryland crops in the Upper Breede Tributaries IUA with pome fruit, grains and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R2 830 million in 2015 with irrigated fruit representing over half of this. The population of the IUA is approximately 46 000 people and over 10 000 households of which 9.5% are dependent upon river water.

Water resources

The major dams in this IUA are Ceres-Koekedouw (22.5 million m^3), Stettynskloof (15.4 million m^3) and Fairy Glen (0.5 million m^3). Ceres and the Koekedouw IB (900 ha) share the yield of Ceres-Koekedouw Dam about 50/50, while the other two dams provide water to Worcester and Rawsonville. A large number of run-of-river schemes also provide water to a range of Irrigation Boards, namely, to 1760 ha in the Ceres region through the Warm Bokkeveld, Titus River and Rooikloof IBs and to 4035 ha in the Mitchell's Pass-Worcester region, through the Darlingbrug, Wagenbooms River, Waaihoek, Jan du Toits, Olifantsberg, Brandwag, Groot Eiland-Klipdrif, Smalblaar and Holsloot IBs as well as the Wolseley WUA.

Water quality in the Upper Breede Tributaries was ideal except at the Breede River at Ceres (H1H003) which had slightly elevated salts, probably as a result of return flows and treated wastewater effluents in the Ceres area (Table 6-1). Water quality in Brandvlei Dam (H1R001) and Roode Elsberg Dam (H2R002) was very good (Table 6-2).

Table 6-1. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Upper Breede Tributaries IUA (A1)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H1H003Q01	A1																		
H1H006Q01	A1																		
H1H007Q01	A1																		
H1H012Q01	A1																		
H1H013Q01	A1																		
H1H018Q01	A1																		
H1H033Q01	A1																		
H2H015Q01	A1																		
H2H016Q01	A1																		

Note: 50 = median or 50^{th} percentile, 95 = 95^{th} percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 6-2. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Upper Breede Tributaries IUA (A1)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H1R001Q01	A1																		
H2R002Q01	A1																		

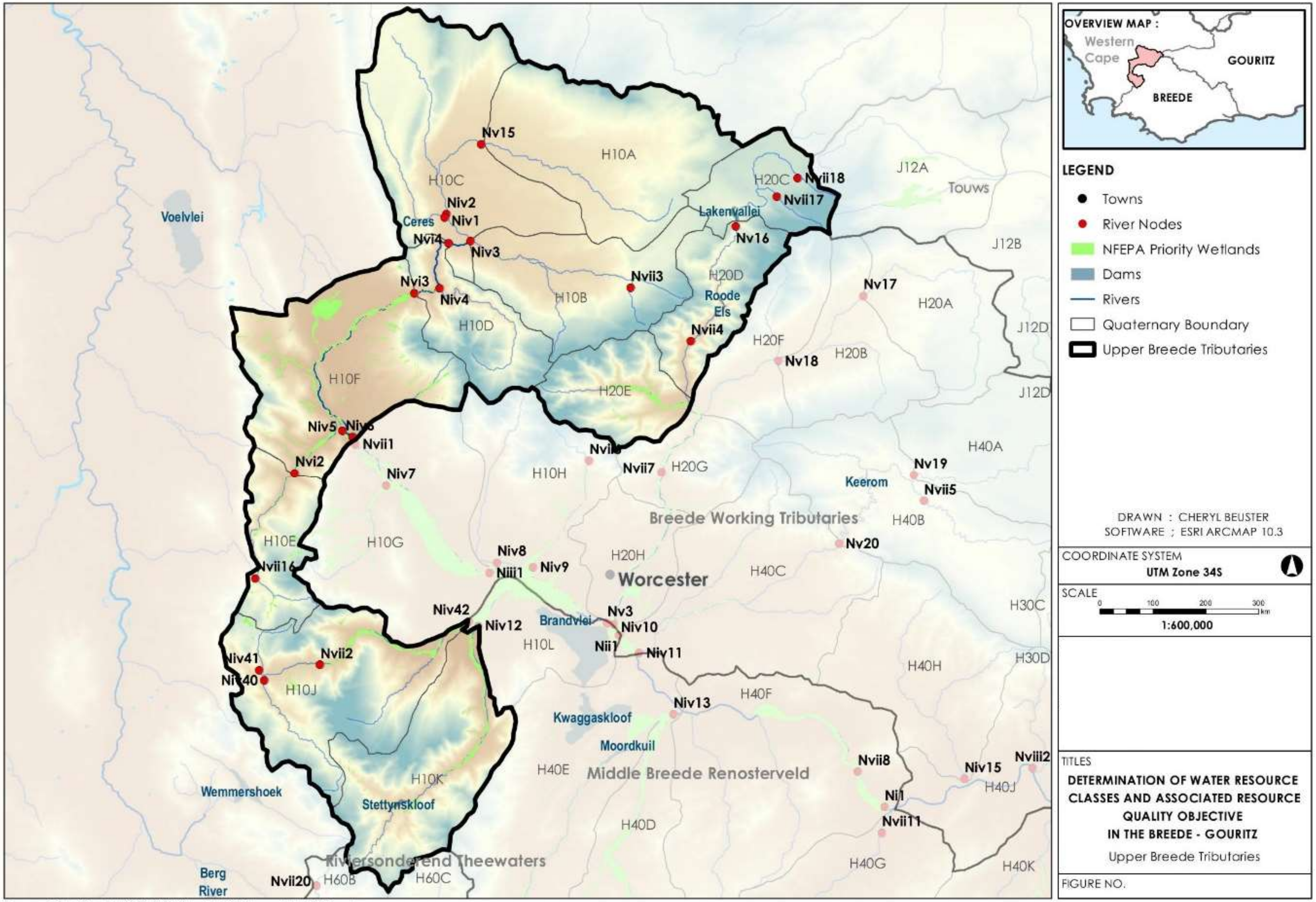
The Upper Breede Valley is an anticline with TMG rocks forming mountainous limbs to the south-west and north-east, and the core of the valley exposing older Malmesbury rocks. The valley is also infilled with Quaternary and Tertiary deposits. Groundwater flows within the Breede Alluvial aquifer rom GRU BB-3 to BB-5. The GRU BB-1 follows the axis of the Hansiesberg Anticline, and it was assumed that the major groundwater will flow towards the Berg WMA along the Agter-Witzenberg Syncline axis. No settlements within the Upper Breede IUA are reliant on groundwater for sole supply.

Ecology

All the rivers in the Upper Breede Tributaries IUA are located in the Western Cape Fold Mountains Belt and, apart from one small headwater tributary, flow perennially. The small rivers are generally steep, being predominantly Transitional and Upper Foothills that are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers 1999 was moderate to poor but there have been improvements since with the conditions reported 2014 being moderate to slightly modified (B and C-categories). There are still a few sub-quaternaries in a largely modified condition (D-category) where improvements could be made. The reasons for the condition assessment include high abstraction and numerous small farm dams with moderate to high impacts on low flows, zero flow in tributaries in summer; pollution impacts from agricultural and urban return flows; some bed and bank manipulation where farming occurs; and cultivation along river banks varies concomitant with clearing of riparian areas and the presence of exotic woody vegetation, in some is high and rampant, elsewhere is natural. Many of the quaternaries are assigned as FEPAs, this being a well-known area of freshwater conservation importance, along with some Fish Support Areas, Upstream Conservation areas and Phase 2 FEPAs. Examples of the kinds of rivers in the Upper Breede Tributaries are shown in Figure 6-2.

Die Vlakte and Kluitjieskraal are wetlands which occur within IUA A1 and the WRU6 Western Folded Mountains. Die Vlakte wetland has a PES of C – Moderately modified with some loss of natural habitats (Malan et al., 2015). The wetland provides important nutrient removal for downstream users in the Breede River catchment, as well as important ecosystem services. Extensive wetland transformation and loss have taken place within this IUA, largely a result of cultivation within wetlands and the modification of remaining wetlands through dams and elevated nutrient and toxicant loads (DWS, 2016). Working for Wetlands (WfW) have focused efforts on the Kluitjieskraal wetland, thought to be the only remaining functional wetland in the Wolseley area (Malan et al., 2015).

Figure 6-2. Rivers typical of Upper Breede Tributaries; Witels H10D-08755 (left) and Breede H10D-08702 (right)



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6.2 IUA A2: Breede Working Tributaries

Socio-economics and ecosystem services

There are over 33 000 ha of irrigated and dryland crops in the Breede Working Tributaries IUA with grapes (mainly for wine) representing the majority. Gross economic output of water affected activities was estimated to be R3 513 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 220 000 people and almost 55 000 households of which only 0.8% are dependent upon river water.

Water resources

These tributaries lie to the north-east of the Breede River mainstem and include the Hex, Sanddrift, Nuy, Koo, Cogmanskloof, Pieterfontein, Keisers and Kingna Rivers. The major water supply schemes are as follows: (i) Lakenvallei (10.4 million m^3) and Roode Elsberg (7.7 million m^3) Dams in the Hex catchment which supply water to De Doorns and for irrigation by members of the Hex Valley WUA (1500 ha). (ii) Keerom Dam (10.4 million m^3) in the Nuy catchment which supplies part of the irrigation water required by the Worcester-East WUA (6070 ha). The rest of the latter WUA's irrigation water supply comes from a number of run-of-river diversions and pumping from the Breede main-stem. (iii) A total of approximately 800 ha of deciduous fruit is irrigated in the Koo-Nuy Valley which is dependent on a number of small abstraction structures on mountain streams, boreholes and farm dams. A groundwater supply scheme consisting of a number of boreholes and a distribution system is operated by the Koo IB. (iv) Water supplies to the Cogmanskloof, Dwariga, Kingna and Baden IBs, as well as to Montague and Ashton, are derived from Poortjieskloof Dam (9.9 million m^3), Pietersfontein Dam (2.1 million m^3), numerous run-of-river diversions, boreholes, springs and pumping from the Breede River main-stem.

Water quality in the Breede Working Tributaries IUA exhibited good quality in the upper reaches of the tributaries, and high salinities in the lower reaches of the tributaries due to agricultural return flows and intensive irrigation practices (Table 6-3).

Table 6-3. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Breede Working Tributaries IUA (A2)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H1H015Q01	A2	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue
H2H005Q01	A2	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
H2H006Q01	A2	Blue	Green	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue
H2H010Q01	A2	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Green	Red	Green	Green	Yellow	Red
H3H005Q01	A2	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Yellow	Yellow	Blue	Blue	Green	Green	Yellow	Red
H3H015Q01	A2	Green	Yellow	Yellow	Yellow	Yellow	Red	Blue	Blue	Blue	Green	Green	Yellow	Blue	Red	Green	Green	Blue	Blue
H4H019Q01	A2	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Blue	Green	Yellow	Yellow	Yellow
H7H004Q01	A2	Green	Yellow	Green	Yellow	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Green	Green	Blue	Blue

Note: 50 = median or 50^{th} percentile, 95 = 95^{th} percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

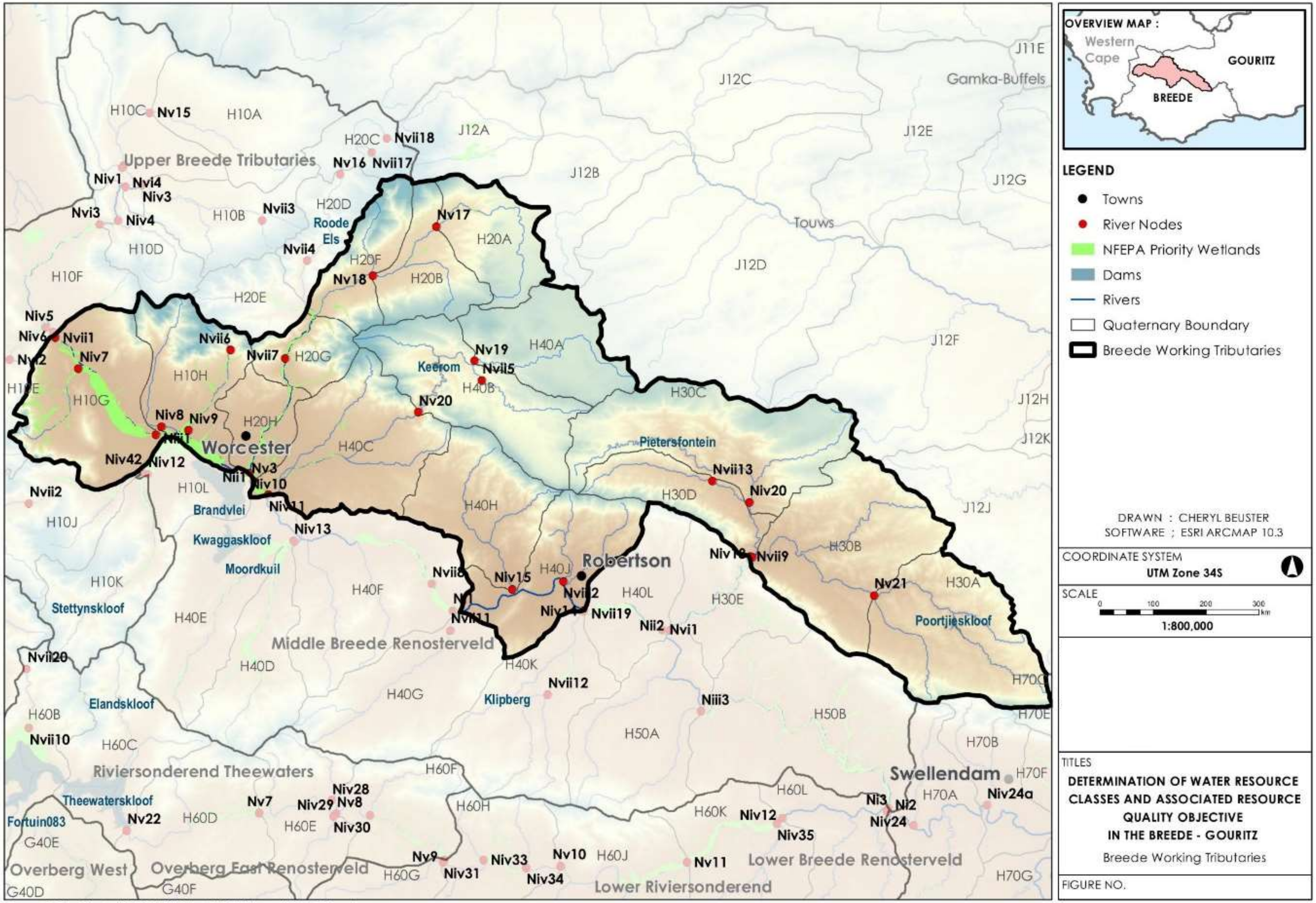
The northern boundary of BB-5 (below BB-3 of the Upper Breede) follows the contact between the Peninsula Formation outcrop and the remaining rocks of the TMG. The overlying Bokkeveld Group. Sediments overlie these rocks and alluvium borders the Breede River, which is connected to BB-4. Groundwater flow occurs in the Peninsula and Nardouw Aquifers into deep confinement below rocks of the Bokkeveld and Witteberg. BB-2, which contains the Hex River Valley, is bounded by the TMG-dominated Hex River Mountains and the Kwadouwsberge. Groundwater flow from the Peninsula Formation in the south from unit BB-5 is likely, and groundwater flow is also possible from the Hex River Mountains into the Ceres valley (linking BB-2 and BB-1 units). Groundwater discharges into river systems within this region. The Upper Koo valley is a syncline structure with TMG buried beneath the Bokkeveld Group sustaining abstraction. Groundwater flow in the Nardouw Aquifer will discharge to the Nuy River, while flow will occur from the Peninsula Formation outcropping in unit BB-5 to BB-4. BB-6 extends from BB-4 to Barrydale. The area has minor to moderate groundwater resources occurring in the Bokkeveld Group sandstone units. Major groundwater resources are available at depth in the TMG, which is recharged in the surrounding mountains. Deep groundwater flow of the TMG links the Peninsula Formation within BB-7 and BB-8. All towns (except Rawsonville) are solely reliant on surface water.

Ecology

Some of the rivers in the Breede Working Tributaries IUA are located in the Western and others in the Southern Cape Fold Mountains Belt and, apart from two small headwater tributaries, flow perennially. The small rivers are generally steep, comprising mainly Transitional, Upper and Lower Foothills that are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers 1999 was mostly moderate with some rivers being largely modified and this has worsened since being reported 2014 that some rivers are now moderate while most are largely modified (C and D-categories) and two tributaries have dropped to a severely modified condition (E-category). The reasons for the condition assessment include high abstraction and numerous small farm dams with high impacts on low flows, zero flow in summer; pollution impacts from agricultural and urban return flows; extensive infilling and channel manipulation, bed and bank stabilisation, straightening; and extensive removal of riparian vegetation, presence of exotic woody vegetation. There are some FEPAs and Fish Support Areas but predominantly Upstream conservation areas and Phase 2 FEPAs. Examples of the kinds of rivers in the Breede Working Tributaries are shown in Figure 6-3.

Papenkuils Wetland occurs within IUA A2, of WRU6 Western Folded Mountains. It is located below the confluence of the Breede and Molenaars Rivers and forms part of the Breede River floodplain. It has been scored a PES Category B – largely modified with few modifications, with some loss of habitats (Malan et al., 2015).

Figure 6-3. Rivers typical of Breede Working Tributaries; Jan Du Toit H10H-08826 (left) and Breede H40C-08935 (right)


OVERVIEW MAP :
Western Cape
GOURITZ
BREEDE
LEGEND
Towns
River Nodes
NFEPA Priority Wetlands
Dams
Rivers
Quaternary Boundary
Breede Working Tributaries
DRAWN : CHERYL BEUSTER
SOFTWARE ; ESRI ARCMAP 10.3
COORDINATE SYSTEM
UTM Zone 34S
SCALE
0 100 200 300 km
1:800,000
TITLES
DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVE IN THE BREEDE - GOURITZ
Breede Working Tributaries
FIGURE NO.
Upper Breede Tributaries
Middle Breede Renosterveld
Riviersonderend Theewaters
Overberg West
Overberg East Renosterveld
Lower Breede Renosterveld
Lower Riviersonderend
Gamka-Buffels
Worcester
Robertson
Swellendam
Roode Els
Keerom
Pietersfontein
Brandvlei
Kwaggaskloof
Moordkuil
Stettynskloof
Elandskloof
Klipberg
Theewaterskloof
Fortuin083
Poortjieskloof
Touws

6.3 IUA A3: Middle Breede Renosterveld

Socio-economics and ecosystem services

There are over 40 000 ha of irrigated and dryland crops in the Middle Breede Renosterveld IUA with grapes (mainly for wine) and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R2 373 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 52 000 people and 13 000 households of which 2.3% are dependent upon river water.

Water resources

The primary surface water resource in this IUA is the Breede River reach from Brandvlei Dam (460 million m^3) to the confluence of the Riviersonderend River. Managed by the Central Breede WUA, canal and main-stem releases from Brandvlei Dam are allocated to a wide range of users along the Middle Breede River. In total, four canal schemes and five pump schemes, as well as several private pumps provide water for irrigation of about 17600 ha. The town of Robertson obtains potable water from small dams in the Langeberg Mountains and has a share of the Brandvlei water diverted into the Robertson Canal. McGregor receives water from the Houtbaais River which is managed by the McGregor WUA. Bonnievale's water supply is from Brandvlei Dam via the Zanddrift WUA canal system.

Water quality in the Middle Breede Renosterveld IUA also exhibited high salinities as a result of the geology of the area, intensive irrigation practices, and saline irrigation return flows (Table 6-4). Water quality in the middle Breede River mainstem is managed by freshening releases from Brandvlei Dam to maintain a quality suitable for irrigation agriculture up to the Sanddrift Canal. Water quality in Klipberg Dam (H4R003) and Kwaggaskloof Dam (H4R004) was very good (Table 6-5).

Table 6-4. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Middle Breede Renosterveld IUA (A3)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H3H011Q01	A3	Red	Red	Red	Red	Red	Red	Blue	Yellow	Blue	Blue	Green	Yellow	Yellow	Red	Yellow	Yellow	Yellow	Red
H4H015Q01	A3	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue
H4H016Q01	A3	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Yellow	Green	Yellow	Green	Yellow
H4H017Q01	A3	Blue	Green	Blue	Green	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Green	Blue	Blue
H4H018Q01	A3	Red	Red	Red	Red	Red	Red	Blue	Green	Blue	Blue	Green	Yellow	Blue	Green	Yellow	Yellow	Red	Red
H4H020Q01	A3	Red	Red	Red	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Yellow	Yellow	Yellow	Red	Red
H5H003Q01	A3	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue
H5H004Q01	A3	Red	Red	Yellow	Red	Red	Red	Blue	Blue	Blue	Blue	Blue	Yellow	Blue	Yellow	Green	Green	Blue	Green
H5H005Q01	A3	Red	Red	Yellow	Red	Red	Red	Blue	Blue	Blue	Blue	Green	Yellow	Blue	Yellow	Green	Green	Blue	Green

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 6-5. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Middle Breede Renosterveld IUA (A3)

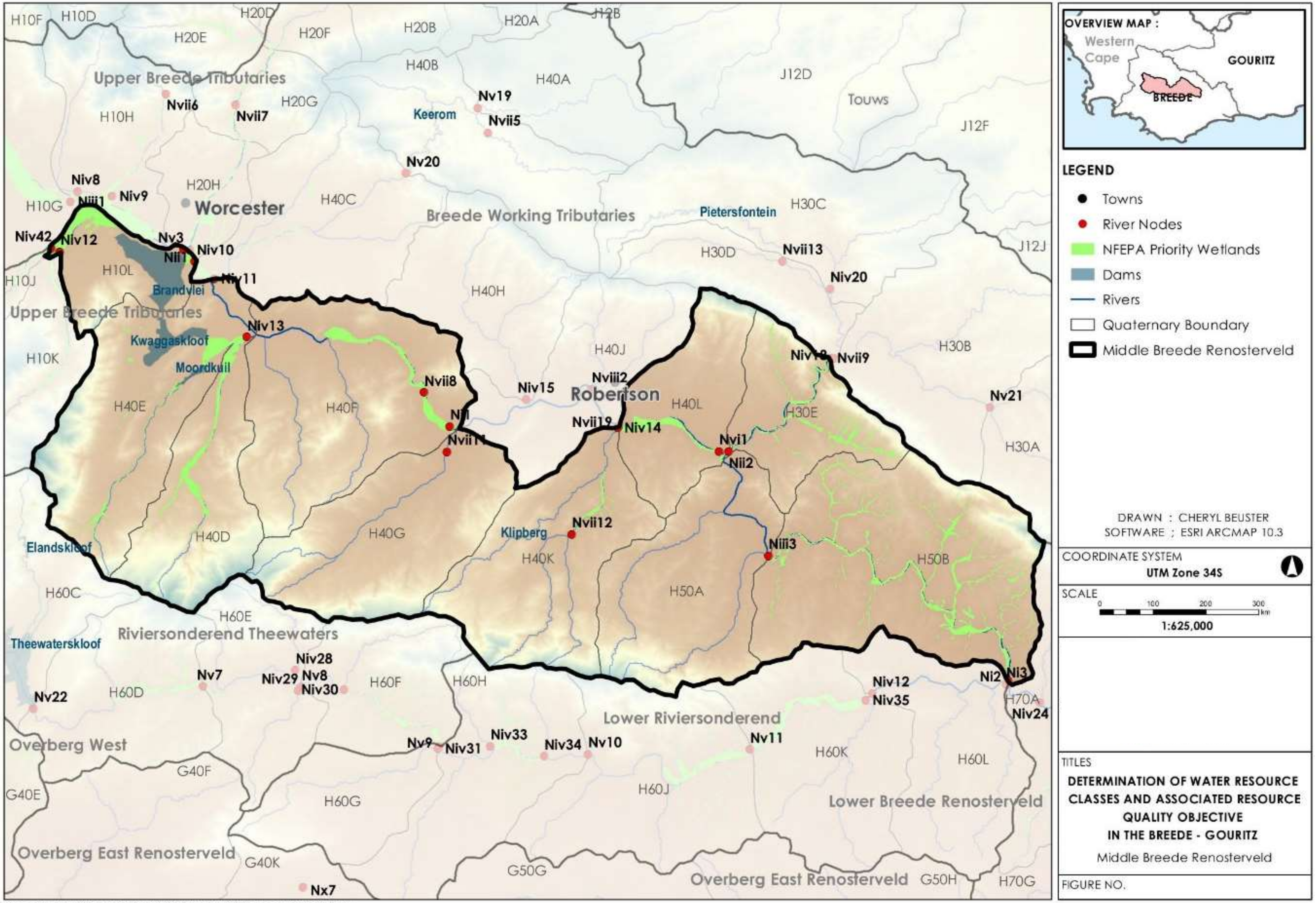
		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H4R003Q01	A3	Green	Yellow	Blue	Green	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Green	Blue	Blue
H4R004Q01	A3	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

IUA A3 has BB-7 GRU occurring over its whole area. This unit follows the contact between the Peninsula Formation outcrop and the remaining rocks of the TMG and overlying Bokkeveld Group. Deep groundwater flow of the TMG links the Peninsula Formation within BR-2. All settlements in this area are solely dependent on surface water.

Ecology

One of the rivers in the Middle Breede Renosterveld IUA is located in the Western Cape Fold Mountains, the others are located either in the Southern Cape Fold Mountains or the Southern Coastal Belt, or, apart from one small headwater tributary, flow perennially. The tributaries are small rivers and moderately steep, comprising mainly Lower and Upper Foothills while the Breede River is larger now and flows through Lower Foothills, all which are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers 1999 was either moderate or largely modified (Categories C-D) and although there have been some improvements since to a slightly modified condition (B-category) there have also been some deteriorations to a severely modified condition (E-category). The reasons given for the condition assessment include high abstraction and numerous small farm dams with high impacts on low flows, zero flow in summer; pollution impacts from agricultural and urban return flows; extensive infilling and channel manipulation, bed and bank stabilisation, straightening; and extensive removal of riparian vegetation, presence of exotic woody vegetation. There are some FEPAs, two Fish Support Areas and three Phase 2 FEPAs. Examples of the kinds of rivers in the Middle Breede Renosterveld are shown in Figure 6-4. The wetlands within IUA A3 are mainly floodplain wetlands associated with the Breede River main channel.

Figure 6-4. Rivers typical of Middle Breede Renosterveld; Doring H40D-09051 (left) and Breede H40F-09026 (right)



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6.4 IUA B4: Riviersonderend Theewaters

Socio-economics and ecosystem services

There are over 22 000 ha of irrigated and dryland crops in the Riviersonderend Theewaters IUA with pome fruit, grains and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R1 959 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 32 000 people and over 7 000 households of which 3.8% are dependent upon river water.

Water resources

Two major dams are present in this IUA, namely Theewaterskloof (464 million m^3) at the foot of the Franschhoek Mountains and Elandskloof (11.4 million m^3) at the source of the Elands River. Theewaterskloof Dam is the source reservoir for the Riviersonderend-Berg-Eerste River Government Water Scheme. This is a 170 million m^3/a inter-basin water transfer scheme that supplies water for urban use to the Greater Cape Town Area, including Stellenbosch, as well as water for urban and agricultural use in the Berg River Catchment and the Overberg Region, and demand centres along the West Coast. The Vyeboom IB lies on the western bank of the Dam and abstracts water directly from the dam for an irrigated area of about 1850 ha. Elandskloof Dam provides water to Villiersdorp, to food-processing operations and to the Elandskloof IB for irrigation of about 1880 ha. Villiersdorp also receives water through winter abstractions from nearby mountain streams.

Water quality in the Riviersonderend Theewaters IUA was good and mostly ideal for its intended uses – Table 6-6 and Table 6-7.

Table 6-6. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Riviersonderend Theewaters IUA (B4)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H6H005Q01	B4																		
H6H012Q01	B4																		
H6H015Q01	B4																		

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Table 6-7. Present day "fitness for use" categories for selected water quality variables at key reservoirs in the Riviersonderend Theewaters IUA (B4)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H6R001Q01	B4																		
H6R002Q01	B4																		

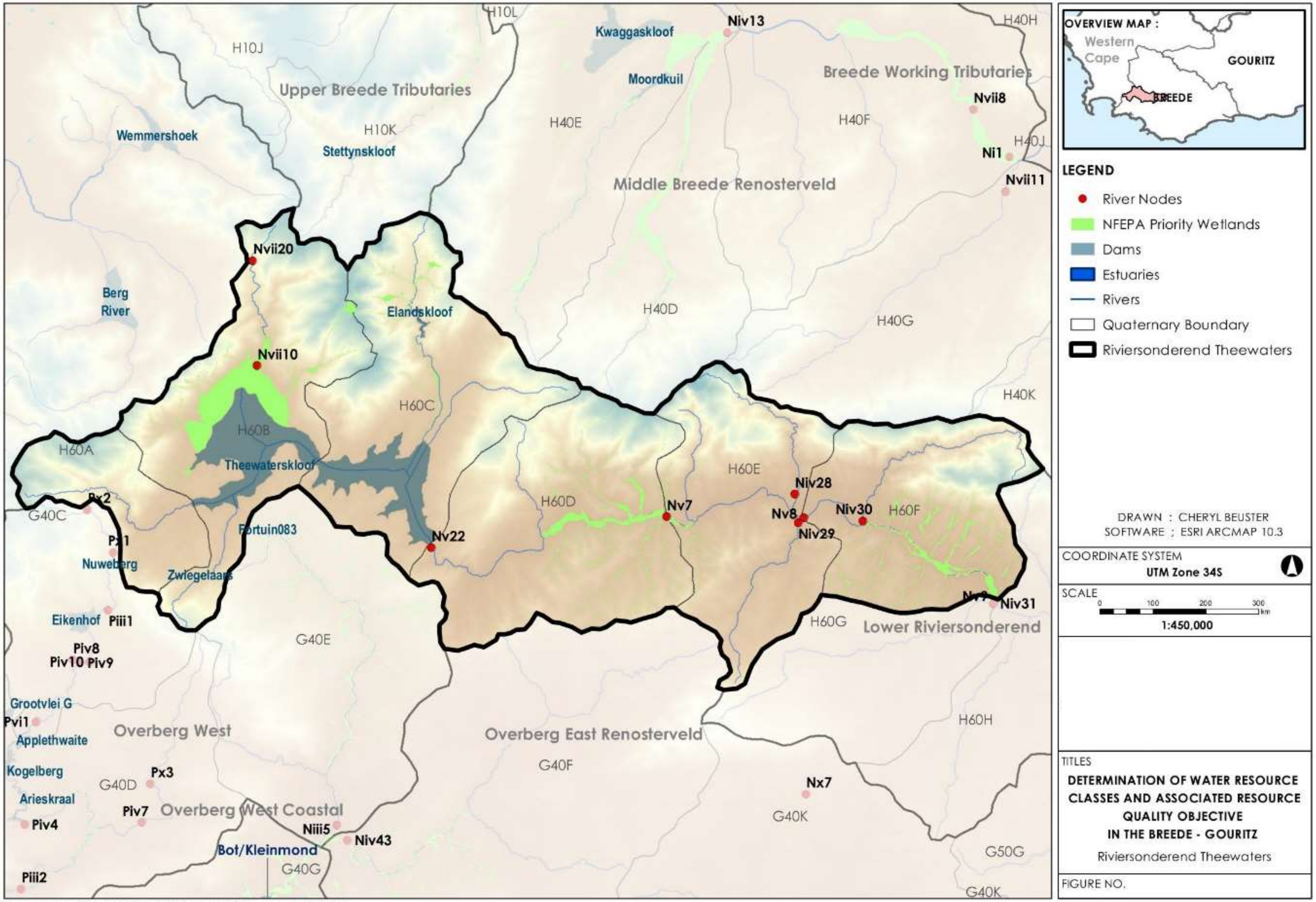
The Berg WMA boundary bounds IUS B4 to the west, which is considered to be a high, assumed to be shallow groundwater divide. The Groenlandberg Fault bounds the GRU BR-1 to the south. Groundwater flow in this unit in the Peninsula aquifer could be linked to surrounding GRUs. Botrivier relies entirely on groundwater, with all the water supply coming from boreholes and Villiersdorp receives 27% supply from groundwater. The TMG forms the Riviersonderend Mountains hence outcrops within this IUA. Shallow discharge from the TMG occurs to surface water in this area and the TMG outcrops dips to the north, hence deep groundwater flow will be to the north from Riviersonderend Mountains, linking BR-2 to BB-7 GRUs.

Ecology

The Du Toits River is located in the Southern Cape Fold Mountains and all the other rivers in the Riviersonderend Theewaters IUA are located in the Southern Coastal Belt and, apart from three non-perennial tributaries of the Riviersonderend River, flow perennially. The small tributaries are generally steep, comprising mainly Transitional and Upper Foothills while the Riviersonderend River is larger and flows through Lower Foothills, all of which are of Very High or High Ecological Importance and Sensitivity. Apart from the Du Toits River, now in a B-category 2014 up from a C-category, the ecological condition of the rivers 2014 has deteriorated since 1999 where most were moderately (C-category) or largely (D-category) modified to now being largely or severely modified (E-category). The only exception to this is the Baviaans River, a tributary of the Riviersonderend where the Breede River EWR site 6 is located. The reasons given for the condition assessment include high abstraction and numerous small farm dams with high impacts on low flows; water quality varies but is mainly good, there are some urban inputs and agricultural return flows; extensive infilling and channel manipulation in middle reaches, bed and bank stabilisation, straightening; and extensive removal of riparian vegetation, presence of exotic woody vegetation. Five of the tributaries are FEPAs and there are two Fish Support Areas and a section of the Riviersonderend has been earmarked as a Phase 2 FEPA. Examples of the kinds of rivers in the Riviersonderend Theewaters are shown in Figure 6-5.

IUA B4 starts at Theewaterskloof Dam. Wetlands within this area consist of floodplain wetlands.

Figure 6-5. Rivers typical of Riviersonderend Theewaters; Du Toits H60B-09162 (left) and Riviersonderend H60D-09239 (right)



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6.5 IUA B5: Overberg West

Socio-economics and ecosystem services

There are over 15 000 ha of irrigated and dryland crops in the Overberg West IUA with pome fruit, grains and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R1 959 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 32 000 people and over 7 000 households of which 3.8% are dependent upon river water.

Water resources

This IUA comprises the entire Palmiet River catchment as well as northern part of the Bot River catchment to the east of the Palmiet and includes the towns of Grabouw and Bot River. The source of the Palmiet River is the Hottentots Hollands Mountains and the Palmiet flows for some 4 km before it is impounded first by Nuweberg Dam (3.8 million m^3) and then by Eikenhof Dam (22.0 million m^3). Downstream of Eikenhof the river flows past Grabouw and is thereafter impounded by three sizeable in-channel dams, namely Kogelberg (19.0 million m^3), Applethwaite (5.9 million m^3), and Arieskraal (3.3 million m^3). Nuweberg, Eikenhof, Applethwaite and Arieskraal Dams supply irrigation water to about 15000 ha through the Groenland WUA. Kogelberg Dam and the high-elevation off-channel Rockview Dam are primary components of Eskom's Palmiet Pumped Storage Scheme, that also enables an inter-basin transfer of some 22 million m^3/a to Steenbras Dam for the use of Cape Town. The source of the Bot River is the Houw Hoek Mountains. There is no IB in the Bot River catchment, yet more than 1500 ha of private irrigation, as well as significant streamflow reductions due to forestry and invasive alien plants, occur across the entire Bot River catchment – about 65% of which lies in this IUA. Grabouw obtains all its water requirements from Eikenhof and Nuweberg Dams, as well as a weir on a Palmiet River tributary. Bot River obtains all its water from five production boreholes.

Water quality in the Overberg West IUA was good except in the Bot River downstream of Bot River town where elevated salts and high phosphate values were recorded (Table 6-8). This was probably due to treated wastewater effluent discharges into the Bot River from the town.

Table 6-8. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Overberg West IUA (B5)

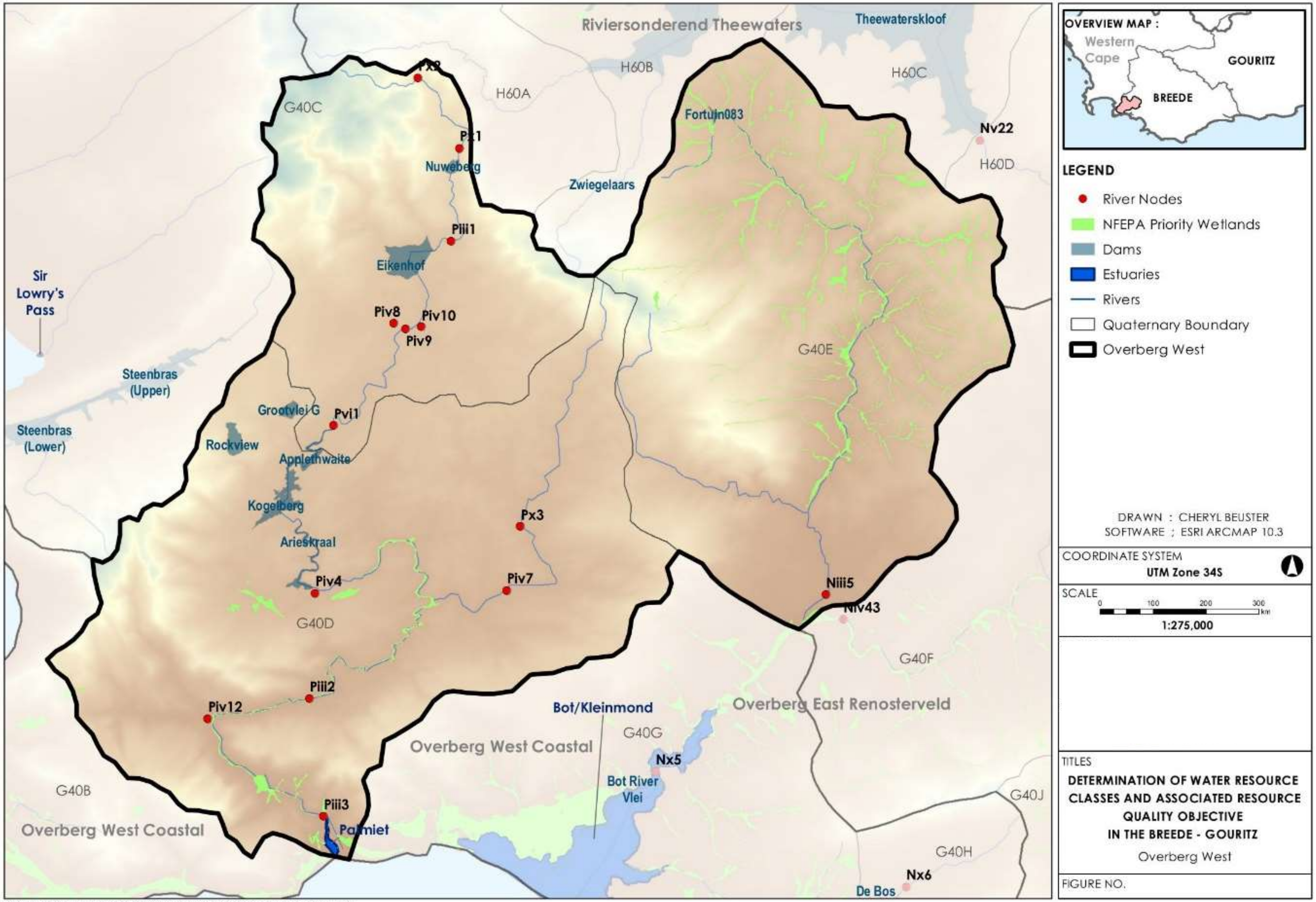
		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
G4H005Q01	B5	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue
G4H007Q01	B5	Blue	Green	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue
G4H014Q01	B5	Green	Yellow	Green	Green	Green	Yellow	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Red	Green	Green	Blue	Blue
G4H029Q01	B5	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Green	Blue	Blue	Blue	Blue

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

Overberg West IUA is underlain by the GRUs BR-1 and BO-1. The Groenlandberg Fault bounds the north eastern part of BO-1 and the eastern boundary is related to the TMG outcrop (east of Kleinmond). The Peninsula and Nardouw aquifers are significant in this GRU, and shallow groundwater will discharge to the surface water. No settlements in the IUA are reliant on groundwater as sole supply.

Ecology

All the rivers in the Overberg West IUA are located in the Southern Cape Fold Mountains Belt and all flow perennially. The small rivers are generally steep, comprising mainly Upper and Lower Foothills that are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers has not changed much since 1999 being predominantly largely modified (D-category) apart from the lower Palmiet River and tributaries that flow through Kogelberg Biosphere Reserve that are moderately modified (C-category). The reasons given for the condition assessment include high abstraction and numerous large dams with high impacts on low flows; some agricultural and urban return flows but water quality generally good; extensive infilling and channel manipulation, bed and bank stabilisation in upper reaches, lower reaches natural; and extensive removal of riparian vegetation, presence of exotic woody vegetation in upper reaches, lower reaches natural. The lower Palmiet is a FEPA supported by an upstream conservation area on the Ribbok River, while the upper reaches are earmarked as a Phase 2 FEPA.



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6.6 IUA F9: Lower Riviersonderend

Socio-economics and ecosystem services

There are over 65 000 ha of irrigated and dryland crops in the Lower Riviersonderend IUA with grains and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R260 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 14 000 people and over 3 000 households of which 4.7% are dependent upon river water.

Water resources

There are no major dams in this IUA, but releases from the upstream Theewaterskloof Dam provide irrigation water to the Zonderend IB for summer scheduling of about 6000 ha and winter scheduling of about 1400 ha. The towns of Riviersonderend, Greyton and Genadendal reside in this IUA. Riviersonderend obtains its potable supplies primarily from a tributary of the Riviersonderend River. Greyton receives its potable water from two different mountain stream diversions. Genadendal's water supplies are abstracted from the Baviaans River in the Riviersonderend Mountains. Releases from Theewaterskloof Dam also supply about 6 million m^3/a to the Rûensveld West and Rûensveld East Water Supply Schemes in IUA H17: Overberg East Fynbos and IUA F10: Overberg East Renosterveld, respectively.

Water quality in the Lower Riviersonderend IUA exhibited elevated salt concentrations (Table 6-9), probably as a result of agricultural return flows.

Table 6-9. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Lower Riviersonderend IUA (F9)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H6H009Q01	F9																		

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

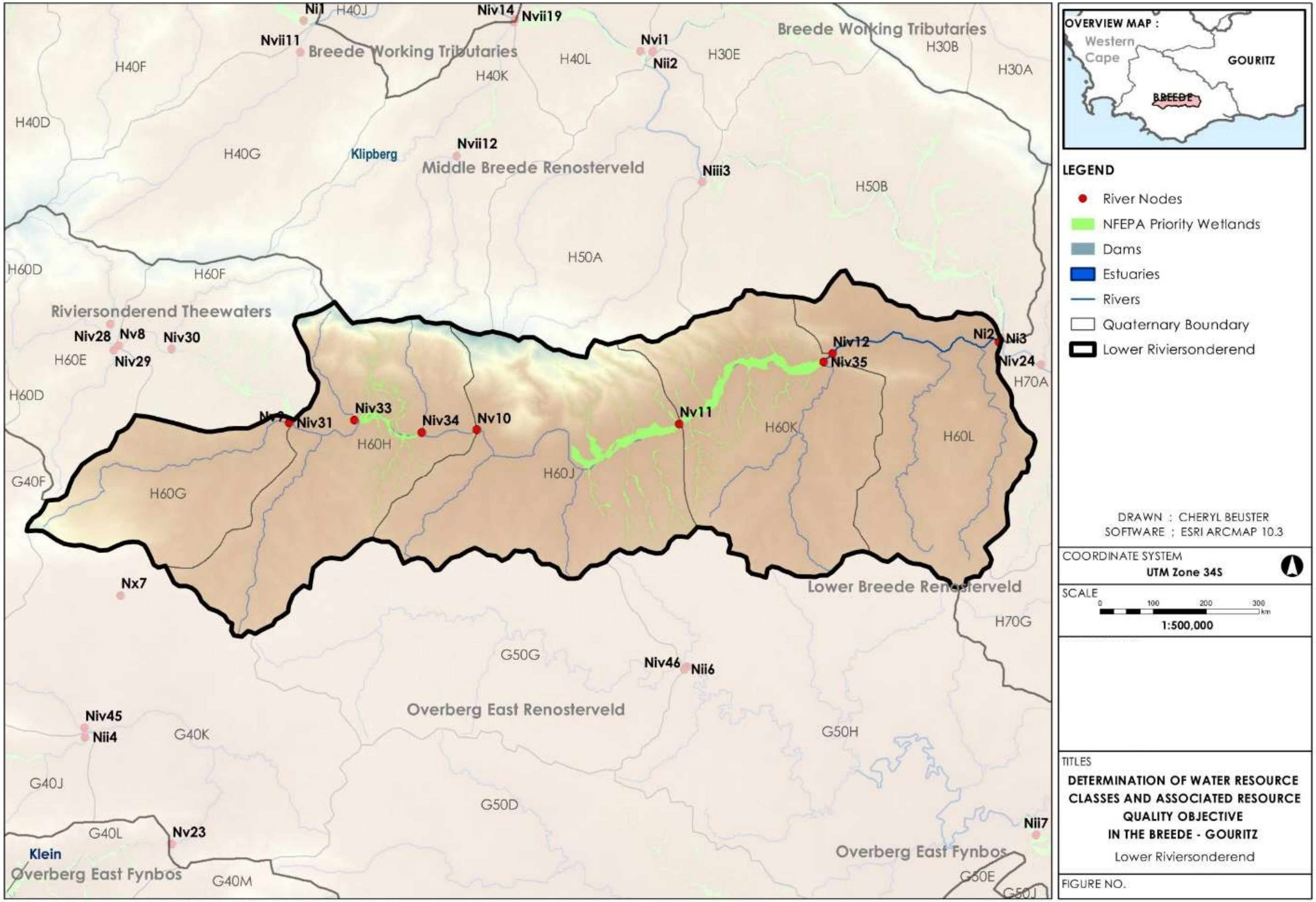
Lower Riviersonderend occurs within BR-2 GRU. This unit is associated with the TMG Group as this forms the Riviersonderend Mountains. Shallow discharge from the TMG occurs to surface water systems. As the TMG outcrop dips to the north, deep groundwater flow will be to the north from the Riviersonderend Mountains, linking BR-2 to BB-7 GRU. Towards the boundary of the IUA in the east, large low lying, rolling hills are dominated by the Bokkeveld Group outcrop, with minor Witteberg Group. None of the settlements within this are reliant on groundwater as sole supply.

Ecology

All the rivers in the Lower Riviersonderend IUA are located in the Southern Coastal Belt and, apart from two small tributaries, flow perennially. The tributaries are generally steep Upper Foothills while the Riviersonderend River is larger and flow through Lower Foothills, all of which are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers since 1999 with all rivers being largely modified (D-category) and the Kwassadie being severely modified (E-category). The reasons given for the condition assessment include low abstraction from tributaries and few farm dams with low impacts on tributary flows, high abstraction from the Riviersonderend and high impacts on flows; pollution impacts from agricultural return flows, water quality variable; tributaries are generally ploughed through, riparian vegetation generally cleared entirely, extensive infilling of Riviersonderend River, extensive and serious invasion of channel by woody exotics. There are two Phase 2 FEPAs and one Fish Support Area. Examples of the kinds of rivers in the Lower Riviersonderend are shown in Figure 6-6.

The main wetlands within the IUA are floodplain wetlands associated with the Riviersonderend River.

Figure 6-6. Rivers typical of Lower Riviersonderend; Riviersonderend H60H-09285 (left) and Kwassadie H60K-09297 (right)



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6.7 IUA F10: Overberg East Renosterveld

Socio-economics and ecosystem services

There are over 177 000 ha of irrigated and dryland crops in the Overberg East Renosterveld IUA with dryland nuts and oils seeds, grains and planted pasture representing the vast majority. Gross economic output of water affected activities was estimated to be R294 million in 2015 with tourism representing most of this. The population of the IUA is approximately 30 000 people and almost 8 000 households of which 2.9% are dependent upon river water.

Water resources

The southern boundary of this IUA straddles the upstream portions of a number of smaller coastal rivers, including the Bot, Sout, Heuningnes, Nuwejaars, Kars and De Hoop Rivers. Only small dams are present in this IUA as the Overberg's undulating topography does not lend itself to the siting of large dams. The water supply for domestic purposes in this IUA is therefore mainly obtained from groundwater sources, sometimes supplemented with water from small dams as well as water provided by the Overberg Water Board as part of the Rûensveld East Water Supply Scheme, taking water from the Lower Riviersonderend, or as part of the Rûensveld West Water Supply Scheme, taking water from immediately downstream of Theewaterskloof Dam. Towns in this IUA forming part of this Scheme include Caledon, Klipdale and Protem, but these towns also obtain some water from boreholes and/or springs. The water supply to Napier is solely from boreholes.

Water quality in the Overberg East Renosterveld IUA exhibited high salt concentrations Table 6-10) in the Klein River (G4H006) and in the Sout River (G5H008) which could largely be ascribed to the geology of the area.

Table 6-10. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Overberg East Renosterveld (F10)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	IUA	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
G4H006Q01	F10	Red	Red	Yellow	Red	Red	Red	Blue	Blue	Blue	Green	Blue	Green	Blue	Yellow	Green	Yellow	Blue	Blue
G5H008Q01	F10	Red	Red	Red	Red	Red	Red	Blue	Yellow	Blue	Blue	Green	Yellow	Green	Red	Red	Red	Red	Red

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

The northern boundary of the IUA corresponds to the northern contact between the TMG and Bokkeveld Group. The fault related Caledon (deep seated) hot spring is evidence of deep TMG groundwater flow within the BO-2 GRU. Other than discharge to surface water systems, deep groundwater flow from this area is most likely northwards where the TMG continues beneath the Bokkeveld Group. Within BO-2 Claredon has 14% groundwater supply. The rest of the IUA is underlain by BO-3 GRU. This unit has TMG outcropping at the south –western boundary, with the rest of the TMG being buried. This could be potentially recharged by the numerous ranges and inselbergs adjacent to the area. Towards the east of the GRU the area opens up to the Bontehoek fault. Napier is solely dependent on groundwater within this GRU.

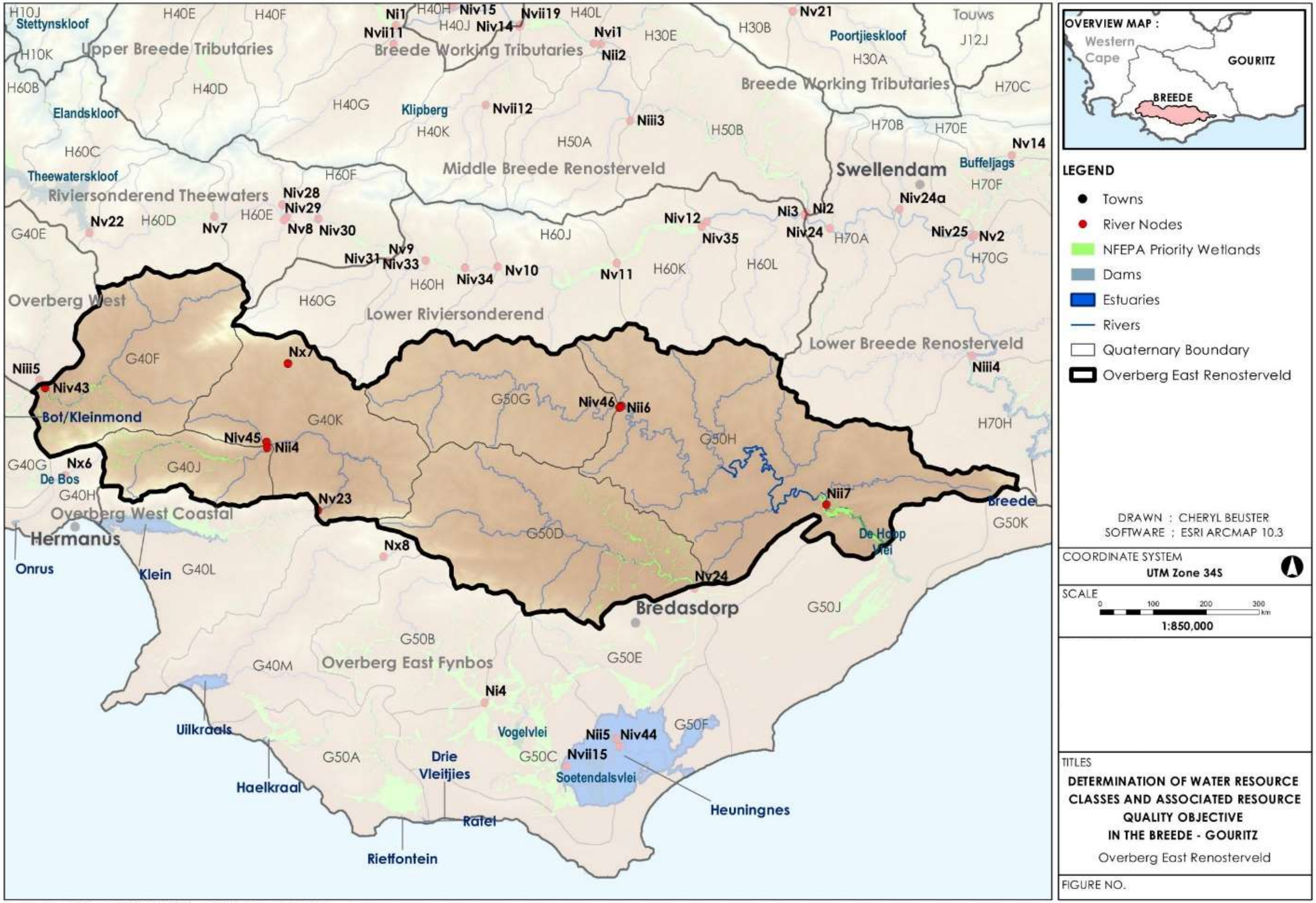
Ecology

Apart from the Swart River in the Southern Cape Fold Mountains, all the rivers in the Overberg East Renosterveld IUA are located in the Southern Coastal Belt and flow perennially. The small rivers are all low lying Lower Foothills that are of Very High or High Ecological Importance and Sensitivity. Apart from De Hoop Vlei, the ecological condition of the rivers has either remained the same since 1999 or deteriorated and generally they are in a largely modified condition (D-category). The reasons given for the condition assessment include moderate abstraction and few small farm dams with low to moderate impacts on low flows; pollution impacts from agricultural return flows; and channels are ploughed through in places, riparian vegetation generally cleared. Much of the IUA is allocated as Upstream conservation areas to support De Hoop Vlei and much is also allocated as Phase 2 FEPAs, when restoration efforts may be prioritised. The Heuningnes River and De Hoop Vlei are allocated FEPAs. Examples of the kinds of rivers in the Overberg East Renosterveld are shown in Figure 6-7.

IUA F10 occurs within the Coastal Southern Fold Mountain WRU, and is associated with the valley bottom wetlands and seeps of the Hartbees River tributaries. Diepte Gatt wetland is fed by subsurface seepage and overland flow, although encroachment by agricultural land means that regulation of the hydrological regime is limited (Malan et al., 2015). It has a moderate EIS, as it is a large seep containing rare plant types, and has a PES score of B - largely natural with few modifications. Elias Gat is a channelled valley bottom wetland. The EIS is relatively low, although the wetland does regulate water supply downstream. The upper reaches are mainly natural, whilst lower reaches have a PES score of C – moderately to largely modified due to vegetation removal, channel modification, abstraction and road crossings (Malan et al., 2015).

The Salmonsdam Wetland is a valley bottom wetland, located in the upper reaches of the Paardenberg River. The wetland scores highly in terms of its EIS due to its location within a protected area and its support of the endangered vegetation community Elim Ferricrete Fynbos (Mucina & Rutherford, 2006); it is also important in maintenance of fresh water supply to downstream users and aquatic ecosystems, and provision of tourism and recreation opportunities (Malan et al., 2015). It has a PES score of A, however the wetland is vulnerable to erosion.

Figure 6-7. Rivers typical of Overberg East Renosterveld; Swart G40F-09365 (left) and Hartbees G40J-09365 (right)



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6.8 IUA F11: Lower Breede Renosterveld

Socio-economics and ecosystem services

There are over 136 000 ha of irrigated and dryland crops in the Lower Breede Renosterveld IUA with dryland nuts and oils seeds, grains and planted pasture representing the vast majority. Gross economic output of water affected activities was estimated to be R652 million in 2015 with irrigated fruit representing most of this. The population of the IUA is approximately 31 000 people and almost 9 000 households of which 3% are dependent upon river water.

Water resources

This IUA comprises the Breede River and its tributaries from just downstream of the confluence of the Breede and Riviersonderend rivers to the Breede River mouth. The Buffeljags River is one of the larger tributaries. The Buffeljags Dam (5.7 million m^3) on the Buffeljags River is the only major dam in the IUA and supplies the Buffeljags River IB with irrigation water for a scheduled area of 1 450 ha. The incremental present-day flow generated within this sub-zone is 155 million m^3/a with an expected present-day inflow from the upstream catchments in the order of 1 000 million m^3/a. There are four towns in this IUA that use surface water, namely Swellendam, Suurbraak, Barrydale and Witsand. Swellendam lies at the foot of the Langeberg Mountains from where it sources its water (from the Klip River). Suurbraak lies on the southern side of the Buffeljags Valley and obtains its water from a minor dam in the Buffeljags River. Barrydale is situated at the northern foot of the Langeberg Mountains, in the Tradouw Valley, and obtains all of its water from a diversion in the Huis River. Witsand receives purified water from the Overberg Water Board which is treated water from the Duivenhoks River and during the summer holiday season borehole water is used to augment the supply.

Water quality in the Lower Breede Renosterveld IUA was good in the tributaries but poor in the Breede River at Swellendam (H7H006) where elevated salinities were observed (Table 6-11).

Table 6-11. Present day "fitness for use" categories for selected water quality variables at selected river water quality sampling points in the Lower Breede Renosterveld IUA (F11)

		Chloride		TDS		EC		NH_3-N		NO_3+NO_2-N		pH		PO_4-P		SAR		SO_4	
Station	**IUA**	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95	50	95
H7H005Q01	F11																		
H7H006Q01	F11																		
H7H007Q01	F11																		
H7H013Q01	F11																		

Note: 50 = median or 50th percentile, 95 = 95th percentile. Categories: Blue = Ideal, Green = Acceptable, Yellow = Tolerable, and Red = Unacceptable

The northern boundary of the IUA follows the contact between the Peninsula Formation outcrop and the remaining rocks of the TMG and overlying Bokkeveld Group. The west boundary of the IUA is bounded by the Bontehoek fault. Within the GRU BB-8 most settlements are supplied by surface water, with Witsand using groundwater to support supply during peak season only.

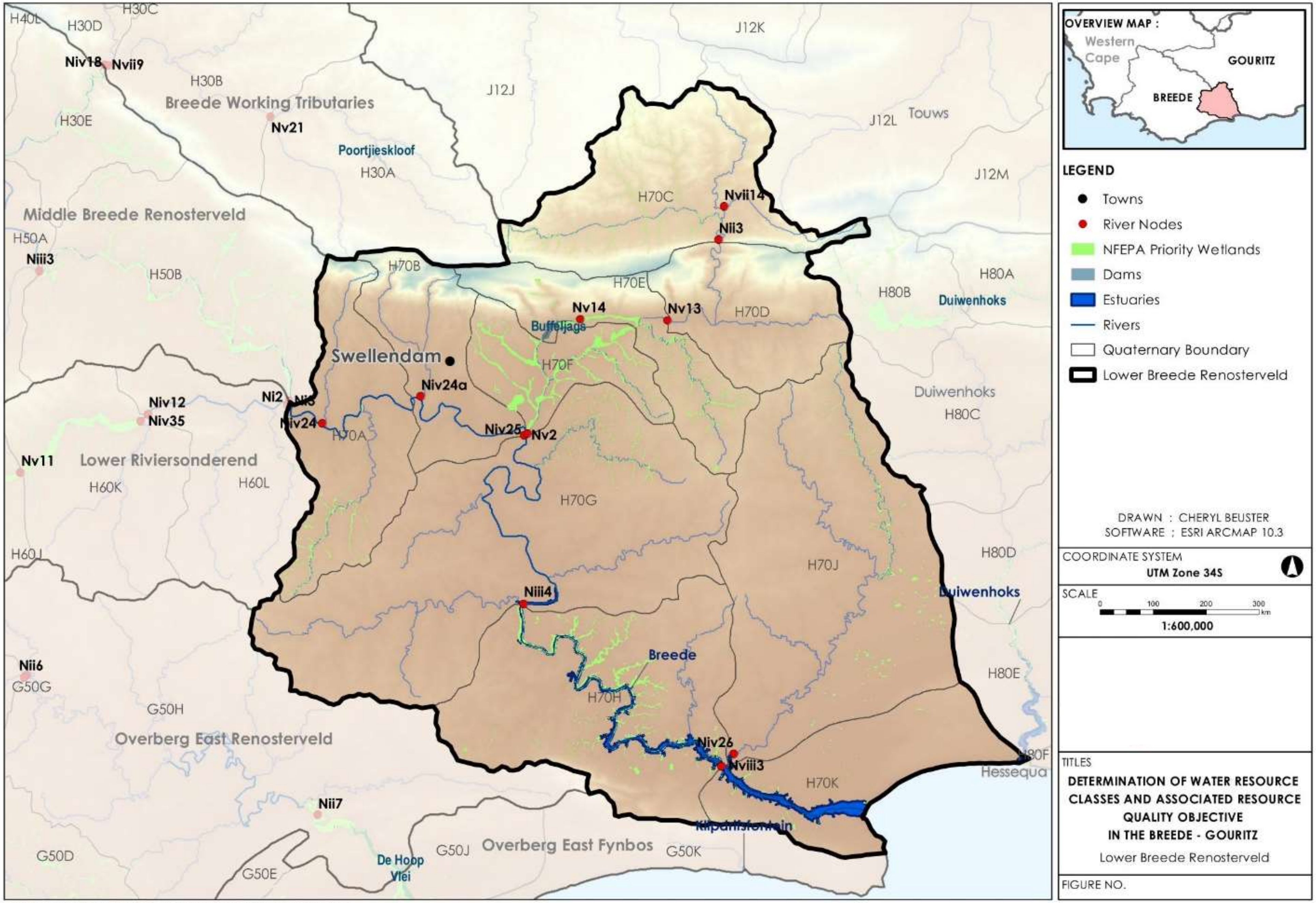
Ecology

All the rivers in the Lower Breede Renosterveld IUA are located in the Southern Coastal Belt and flow perennially. Apart from the Leeu River, an Upper Foothill tributary, the Breede River flows as a Lowland and the Slang is also a low lying Lower Foothill, all of which are of Very High or High Ecological Importance and Sensitivity. The ecological condition of the Leeu and Slang River tributaries has worsened since 1999 from moderately to severely modified (C to an E-category) while the Breede River has improved from being moderately to slightly modified (C to B-category). The reasons given for the condition assessment include low abstraction and few small farm dams with low to moderate impacts on low flows; water pollution impacts from agricultural return flows; and channels are ploughed through in places, riparian vegetation has been cleared.

The Lower Breede River is allocated as a FEPA and all inflowing tributaries as Upstream conservation areas to support this, while the Leeu River is a Fish Support Area. Examples of the kinds of rivers in the Lower Breede Renosterveld are shown in Figure 6-8.

The permanently open Breede estuary has the largest catchment and MAR of all the estuaries within the WMA. The Breede is assessed as being in a good state of estuary health. The Breede has no formal protection but the Breede River conservancy is active in environmental monitoring and compliance.

Figure 6-8. Rivers typical of Breede Working Tributaries; Napkei H70G-09337 (left) and Slang H70J-09358 (right)



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6.9 IUA H16: Overberg West Coastal

Socio-economics and ecosystem services

There are over 3 000 ha of irrigated and dryland crops in the Overberg West Coastal IUA with dryland planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R471 million in 2015 with tourism and recreation representing most of this. The population of the IUA is approximately 4 000 people and almost 1 400 households of which 1.9% are dependent upon river water.

Water resources

The primary surface water resources in this IUA are the Onrus River, the Lower Bot River and the Buffels River. The two notable dams in this IUA are De Bos Dam (6.3 million m^3) on the Onrus River and Buffels River Dam (0.8 million m^3) on the Buffels River. Hermanus, Onrus-Vermont, Zwelihle, Hawston and Fisherhaven are currently supplied from De Bos Dam. In the immediate future the water supplies to the above greater Hermanus area are planned to be augmented from three new wellfields, because the greater Hermanus area has been experiencing deficits in water supply. Water supplies to Rooi-Els, Pringle Bay and Betty's Bay are sourced from the Buffels River Dam, while Kleinmond's water supply is primarily from Lower Palmiet River abstractions.

Water quality in the Overberg West Coastal was probably similar to the Bot River downstream of Bot River town where elevated salts and high phosphate values were recorded (Table 6-8). This was probably due to treated wastewater effluent discharges into the Bot River from the town.

BO-1 and BO-2 coastal portions of the GRUs occur within Overberg West Coastal IUA. Hermanus relies on groundwater for half water supply, and Gansbaai relies on 23% groundwater supply.

Ecology

Three of the rivers in the Overberg West Coastal IUA are located in the Southern Coastal Belt and the other is in the Southern Cape Fold Mountains; all flow perennially. The small rivers are various gradients and are all of Very High or High Ecological Importance and Sensitivity. The ecological condition of the rivers has fluctuated since 1999 with an improvement being reported for the Bot River 2014, from largely to moderately modified (C to D-category), while the Onrus and the Kars River have deteriorated, from moderately to severely modified (C to an E-category). The reasons given for the condition assessment include high abstraction and numerous small farm dams with high impacts on low flows, zero flow in summer; pollution impacts from agricultural and urban return flows; significant infilling and channel manipulation, bed and bank stabilisation, straightening; and significant removal of riparian vegetation, presence of exotic woody vegetation. The Buffels River is a FEPA and the Onrus is a Fish Support Area. Examples of the kinds of rivers in the Overberg West Coastal are shown in Figure 6-9.

IUA H16 has a small portion of Coastal Sedimentary Deposits WRU, in particular where Vermont pan wetland occurs. Vermont Pan is an endorheic depression wetland, located at the foot of the Onrus Mountains. It has a high EIS due to its support of rare flora and fauna, and has a PES score of between B and C due to the altered hydrological regime caused by housing developments.

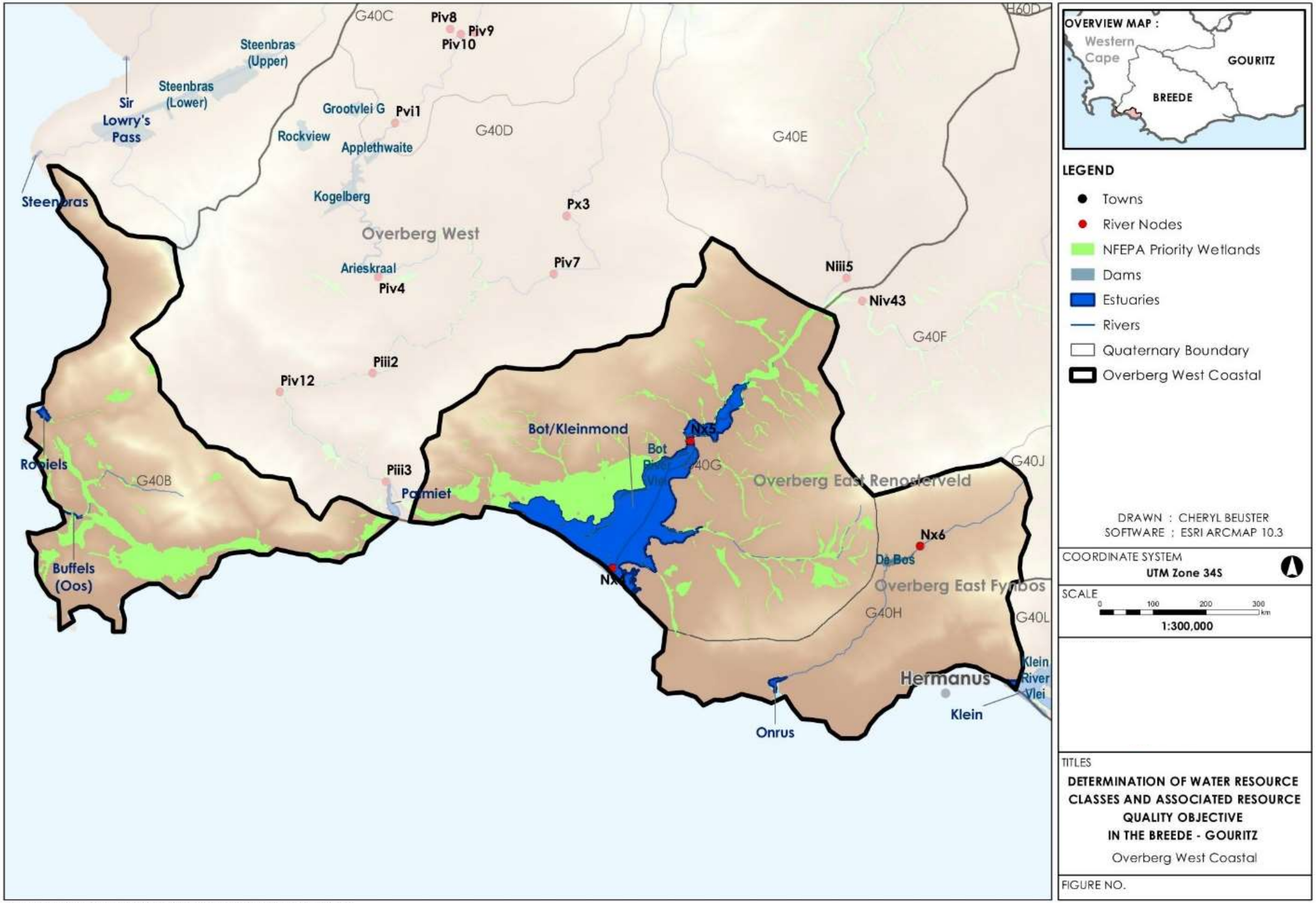
The Hemel-en-Aarde and Belsvlei wetlands are channelled valley bottom wetlands associated with the Onrus River, within the Coastal Southern Folded Mountains WRU. The Hemel-en-Aarde wetland has a high EIS due to its support of endangered vegetation type, and its contribution of water to downstream users during winter (Malan et al., 2015). It has a PES score between B and C, due to flow reduction as a result of the upstream dam, increased nutrient input from agricultural cultivation, infilling due to the construction of the R321, and invasive plants (Malan et al., 2015). Belsvlei is a channelled valley bottom wetland situated in the headwaters of the Onrus River, which drains into De Bos Dam and discharges to the sea at Onrus. It has a moderate EIS due to its support of endangered vegetation, but downstream of the wetland modifications have resulted in a PES assessment of E (Malan et al., 2015).

Along the coastal plain in the Betty's Bay area are the permanently inundated depression wetlands Groot Witvlei. The wetlands are connected by an underground pipe (Malan et al., 2015) which has altered the natural hydrological regime. The wetlands scored highly in terms of EIS due to their classification under NFEPA, location in proximity to the Kogelberg Bioreserve, the conservation importance of the regional fynbos vegetation type, and their support of several frog species of conservation concern (Malan et al., 2015). The PES was categorised as B Largely natural with few modifications as the wetlands remain in relatively good condition despite the changes in the hydrological regime as a result of the interconnecting pipeline, surrounding holiday and residential developments and alien plant encroachment (Malan et al., 2015). The wetlands contribute to ecosystem services including assimilation of waste from septic tanks in their immediate vicinity and agricultural activity higher in the catchment, as well as flood attenuation (Malan et al., 2015).

Malkopsvlei is a depression wetland on the coastal plain in Betty's Bay. The wetland is primarily supplied by surface and groundwater flow from the mountains to the north that run parallel to the coast, as well as the dunes to the south to a lesser extent (Malan et al., 2015). Malkopsvlei received a high EIS score in the most recent assessment (Malan et al., 2015) due to its support of frog species of conservation importance (being a frog biodiversity hotspot), being located within a transitional zone of the Kogelberg Biosphere Reserve, and the wetland being included in the NFEPA wetland mapping dataset. The PES was categorised as B Largely natural with few modifications as the wetland remains in a relatively good condition, despite the increased presence of housing and associated increased nutrient loading to the wetland as a result of sewerage input to its catchment. However, sewerage management will be a key focus area for maintenance and improvement of habitat integrity due to the increase in construction of dwellings in this scenic area.

There are two temporarily open estuaries (Palmiet, Onrus) and two estuarine lakes (Bot/Kleinmond, Klein) within the H16 IUA representing 14 % of the Estuary functional zone habitat and 29% of the estuary channel area within the WMA. The ecological condition of three of these estuaries is fair, whilst the Onrus is considered to be in a poor ecological state. None of these estuaries currently have any formal protection.

Figure 6-9. Rivers typical of Breede Working Tributaries; Afdaks G40H-09403 (left) and Onrus G40G-09398 (right)



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6.10 IUA H17: Overberg East Fynbos

Socio-economics and ecosystem services

There are over 47 000 ha of irrigated and dryland crops in the Overberg East Fynbos IUA with dryland grains and planted pasture representing the majority. Gross economic output of water affected activities was estimated to be R745 million in 2015 with tourism and recreation representing over half of this. The population of the IUA is approximately 48 000 people and about 15 000 households of which only 0.8% are dependent upon river water.

Water resources

This IUA includes the central and/or southern part of the catchments of a number of smaller coastal rivers, including the Klein, Sout, Heuningnes, Nuwejaars, Kars and De Hoop Rivers. The water supply for domestic purposes in this IUA is mainly obtained from groundwater sources, sometimes supplemented with water from small dams, as well as water provided by the Overberg Water Board as part of the Rûensveld East Water Supply Scheme, taking water from the Lower Riviersonderend. Bredasdorp and Waenhuiskrans/Arniston are part of this Scheme, but obtain some water from boreholes and/or springs. Gansbaai's water supply is partly from Kraaibosch Dam (0.8 million m^3) on the Uilenkraals River and partly from springs and a borehole. The water supplies to Stanford, Pearly Beach, Elim, Struisbaai and Suiderstrand are solely from springs and/or boreholes.

Water quality monitoring in the Overberg East Fynbos IUA was poor and insufficient to assess the present water quality status in the IUA.

The southern portion of BO-3 GRU occurs within the Overberg East Fynbos IUA. Within this area the Bokkeveld Group rocks underlie Cenozioc cover. Groundwater will discharge to the ocean, low lying wetlands and river systems. Wolvengat, Struisbaai, L'Alghulas, Elim, Buffeljachtbaai and Suiderstrand rely solely on groundwater supply. With Bredasdorp and Pearly Beach relying on about two thirds groundwater supply.

Ecology

All the rivers in the Overberg East Fynbos IUA are located in the Southern Coastal Belt, apart from the Bot and the Uilkraal Rivers that are in the Southern Cape Fold Mountains; all flow perennially. Apart from the headwaters of the Uilkraal River, being Transitional and steep, the others are low lying Lower Foothills or Lowlands that are of Very High or High Ecological Importance and Sensitivity. The ecological conditions of the Heuningnes and Kars Rivers have deteriorated since 1999 from being moderately to largely modified (C to a D-category); that of the Uilkraal and Nuwejaar Rivers have remained stable; and that of the Bot River have improved from largely to moderately modified (D to a C-category). The reasons given for the condition assessments include moderate abstraction and numerous small farm dams with high impacts on low flows; pollution impacts from agricultural return flows; some infilling and channel manipulation, bed and bank stabilisation, straightening in places; some removal of riparian vegetation and presence of exotic woody vegetation. The Heuningnes and De Hoop Vlei Rivers are allocated as FEPAs and there are a number of Fish Support Areas and Phase 2 FEPAs. Examples of the kinds of rivers in the Overberg East Fynbos are shown in Figure 6-10.

The two temporarily open (Uilkraals, Haelkraal) and one permanently open estuary (Heuningnes) in the H 17 IUA. This IUA includes the Heuningnes that has the largest Estuarine Functional Zone within the WMA (46% of the total). The Uilkraal has a poor health status, whilst the Haelkraal and Heuningnes are in fair ecological health. The lower Heuningnes estuary is formally protected within a Cape Nature reserve.

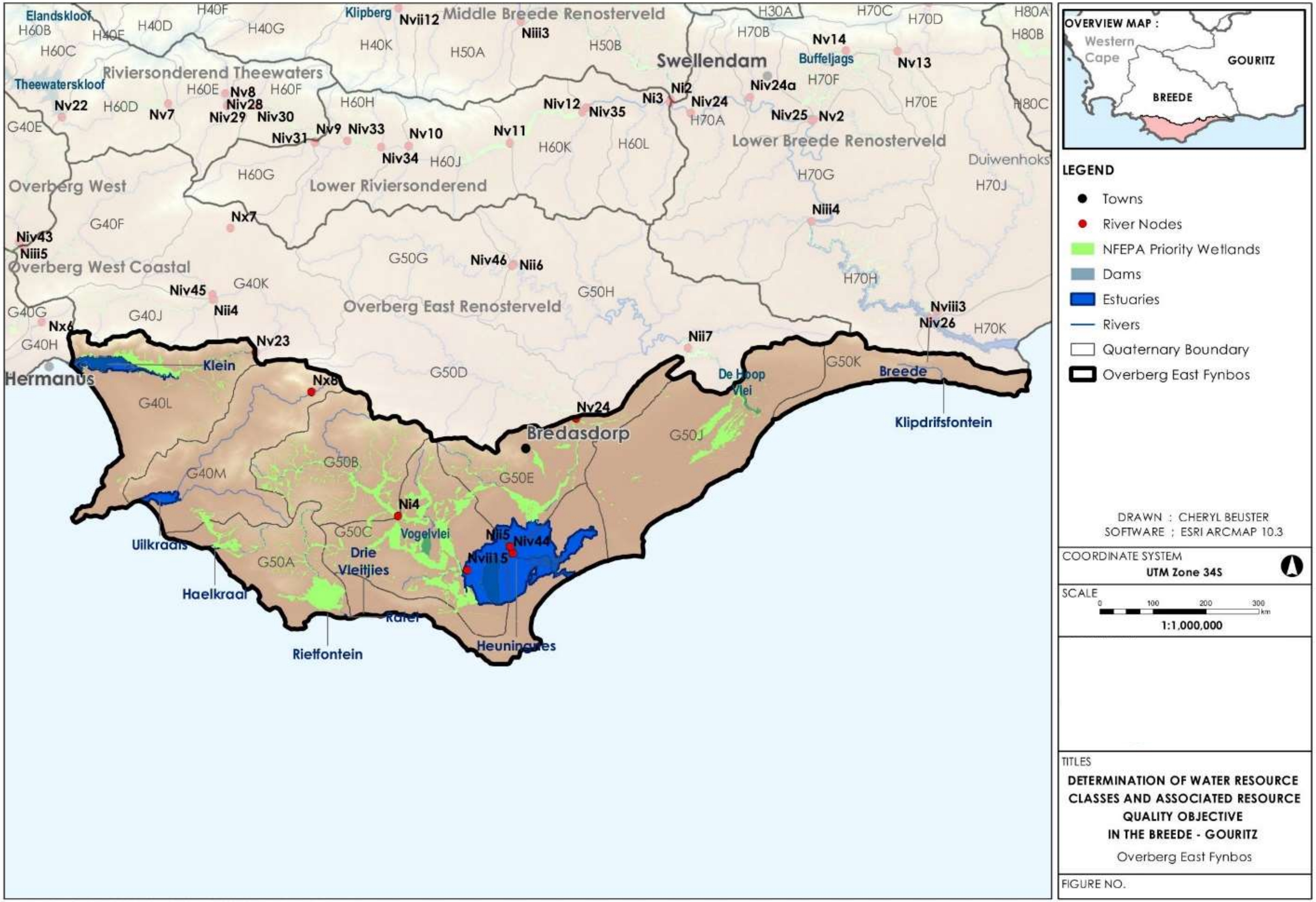
The important wetlands within IUA H17 are associated with both the Coastal Sedimentary Deposits WRU and the Coastal Southern Folded Mountains WRU. The Algulhas Salt Pan forms part of the Soutpan/Springfield wetland system and occurs on coastal sedimentary deposits. The Pan is surrounded by vulnerable and endangered vegetation types (i.e. Cape Inland Saline Salt Pans and Elim Ferricrete Fynbos (Mucina and Rutherford, 2006)). This support of rare plant types and importance for wading birds gives the wetland a high EIS. It also has a PES score of B, although it is isolated from the general hydrological system and no longer provides the service of salt harvesting for anthropogenic use.

The Nuwejaars Wetland Special Management Area has about half of its area as conservation land, with the remaining as cultivation. This area includes wetlands associated with the Nuwejaars River, and two coastal lakes (Soetendalsvlei and Voëlvlei).

The Groot Hagelkraal River is associated with three wetland systems: a floodplain wetland in the upper reaches, an un-channelled valley bottom in the lower reaches and the Pearly Beach coastal lake. The whole wetland system scores highly in terms of EIS due to its location within a biodiversity hotspot, and its support of species of conservation concern. The PES of the system was scored A or pristine for the floodplain wetland in the upper reaches, and B or largely natural with few modifications, but with some loss of natural habitat for the unchannelled valley bottom in the lower reaches (Malan et al., 2015).

The Gans Bay endorheic depression wetland occurs within the Sedimentary Deposits WRU at the foot of the Franskraal Mountains within the Coastal Southern Folded Mountains WRU. The PES score is D, as it is considered to be seriously modified due to invasive plant species and anthropogenic pressures (Malan et al., 2015).

Figure 6-10. Rivers typical of Overberg East Fynbos; Uilkraal G40M-09414 (left) and Nuwejaar G50B-09418 (right)



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Appendix A: Groundwater

Appendix B: Water Quality

Appendix C: Estuaries

Appendix D: Rivers

Appendix E: Socio-economics