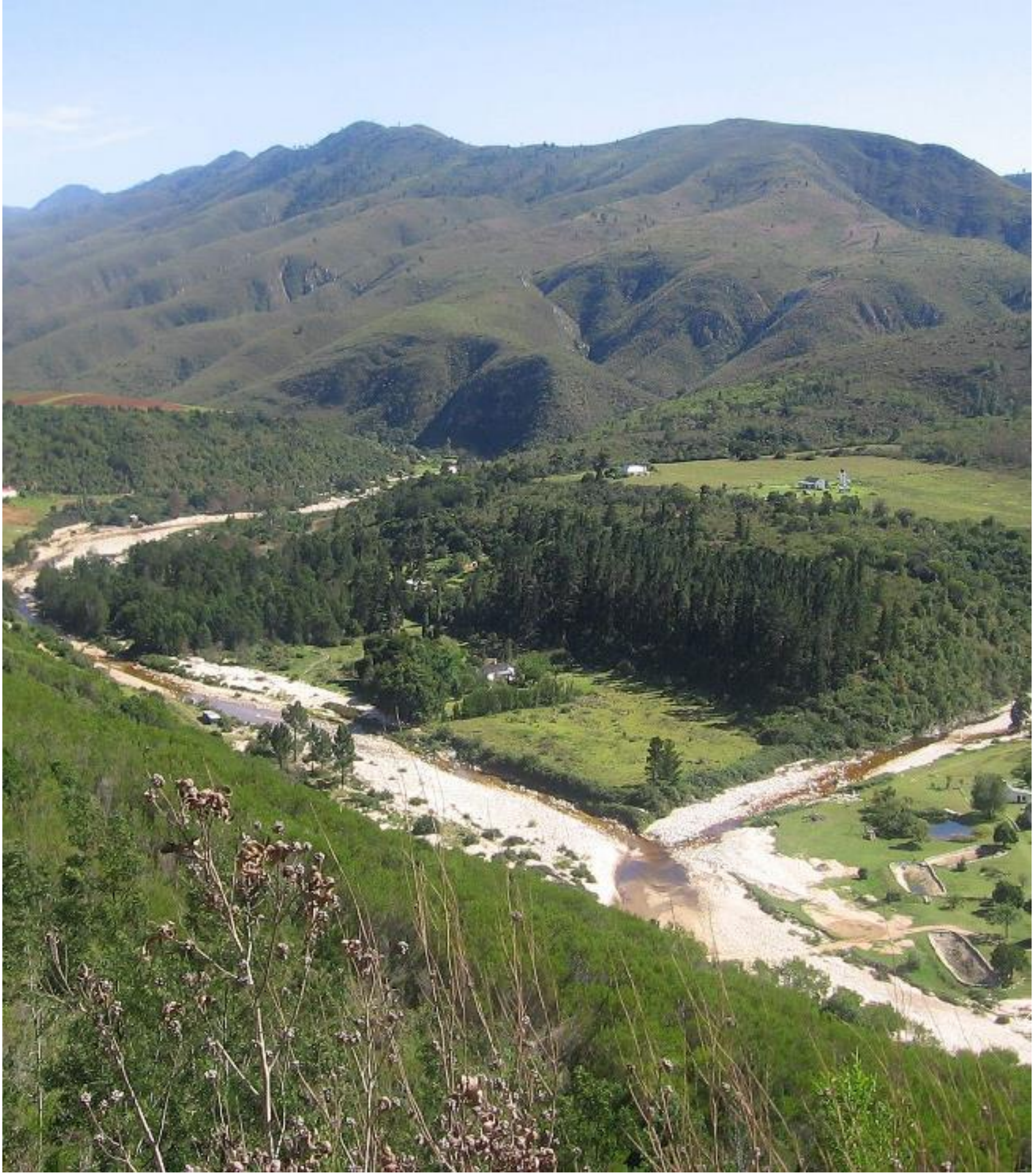

Determination of Water Resources Classes and Resource Quality Objectives in the Breede-Gouritz WMA

May 2018

Revision: Final

Evaluation of Scenarios Report

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Prepared by:

Aurecon South Africa (Pty) Ltd in sub-consultancy association with Southern Waters Ecological Research and Consulting, Anchor Environmental and Delta-h Water Systems Modelling

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Chief Director: Water Ecosystems

Document Index

Reports that will be produced as part of this Study are indicated below.

Bold type indicates this Report.

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3	RDM/WMA8/00/CON/CLA/0316	Water Resources Information and Gap Analysis
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15	RDM/WMA8/00/CON/CLA/1017	Water Resource Classes and RQOs Gazette Template
16	RDM/WMA8/00/CON/CLA/0118	Draft Project Report
17	RDM/WMA8/00/CON/CLA/0218	Final Project Report

List of Abbreviations

BGCMA	Breede-Gouritz Catchment Management Agency
BGCMS	Breede-Gouritz Catchment Management Strategy
CBA	Critical Biodiversity Area
CCT	City of Cape Town
CD: WE	Chief Directorate: Water Ecosystems
CMS	Catchment management strategy
Co	Coastal
DAFF	Department of Agriculture, Forestry and Fisheries
DWA	(Previous) Department of Water Affairs
DWAF	(Previous) Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category (A to E based on Kleynhans et al, 1996)
EGSA	Ecological Goods, Services and Attributes
EHI	Estuary Health Index
EIS	Ecological Importance and Sensitivity
ER	Ecoregion
ES	Ecological Sensitivity
ESA	Ecological Support Area
ESBC	Ecologically Sustainable Base Configuration
EWR	Ecological Water Requirements
FBC	Flow-based category
FEPA	Freshwater Ecosystem Priority Area
GK	Great Karoo
GRU	Groundwater Resource Unit
GW	Groundwater
GWBF	Groundwater Contribution to Baseflow
GZ	Geozone
ha	hectare
HGM	Hydrogeomorphic Unit
HI	Hydrological Index
IUA	Integrated Unit of Analysis
Lati	Latitude
Long	Longitude
MAR	Mean Annual Runoff
MCM	Million Cubic Meters
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas
nMAR	natural Mean Annual Runoff
NWA	National Water Act
NWRCS	National Water Resources Classification System
OER	Overberg East Renosterveld

PES	Present Ecological Status
PSC	Project Steering Committee
RDM	Resource Directed Measures
REC	Recommended Ecological Condition
RI	Recurrence Interval
Rm/Yr.	Millions of Rand per Year
RQOs	Resource Quality Objectives
SANBI	South African National Biodiversity Institute
SCB	Southern Coastal Belt
SCW	Southern Cape Wet
SECB	South-eastern Coastal Belt
SFM	Southern Fold Mountains
SK	Southern Karoo
SQ	Sub-quat
SW	Surface Water
TMGA	Table Mountain Group Aquifer
WARMS	Water Authorisation Registration and Management System
WC/WDM	Water conservation and water demand management
WCBSP	Western Cape Biodiversity Spatial Plan
WCWSS	Western Cape Water Supply System
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WRC	Water Research Commission
WRCS	Water Resources Classification System
WRU	Wetland resource unit
WRYM	Water Resources Yield Models
WRCS	Water Resource Classification System

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 (WRCs) and associated Resource Quality Objectives (RQOs) for all significant water resources in the Breede-Gouritz Water Management Area.

A 7-step procedure is described for determining the recommended class for each water resource (DWAF, 2007a). This report focuses on Step 4-7: Determining and evaluating the classification scenarios. Steps 5 and 6 represent an iterative process, whereby the determined scenarios are evaluated with stakeholders and feedback is integrated into the process to result in the recommended scenario and Water Resource Classes. The final class will then be recommended to DWS for consideration and to provide the context in which to determine the Resource Quality Objectives (RQOs).

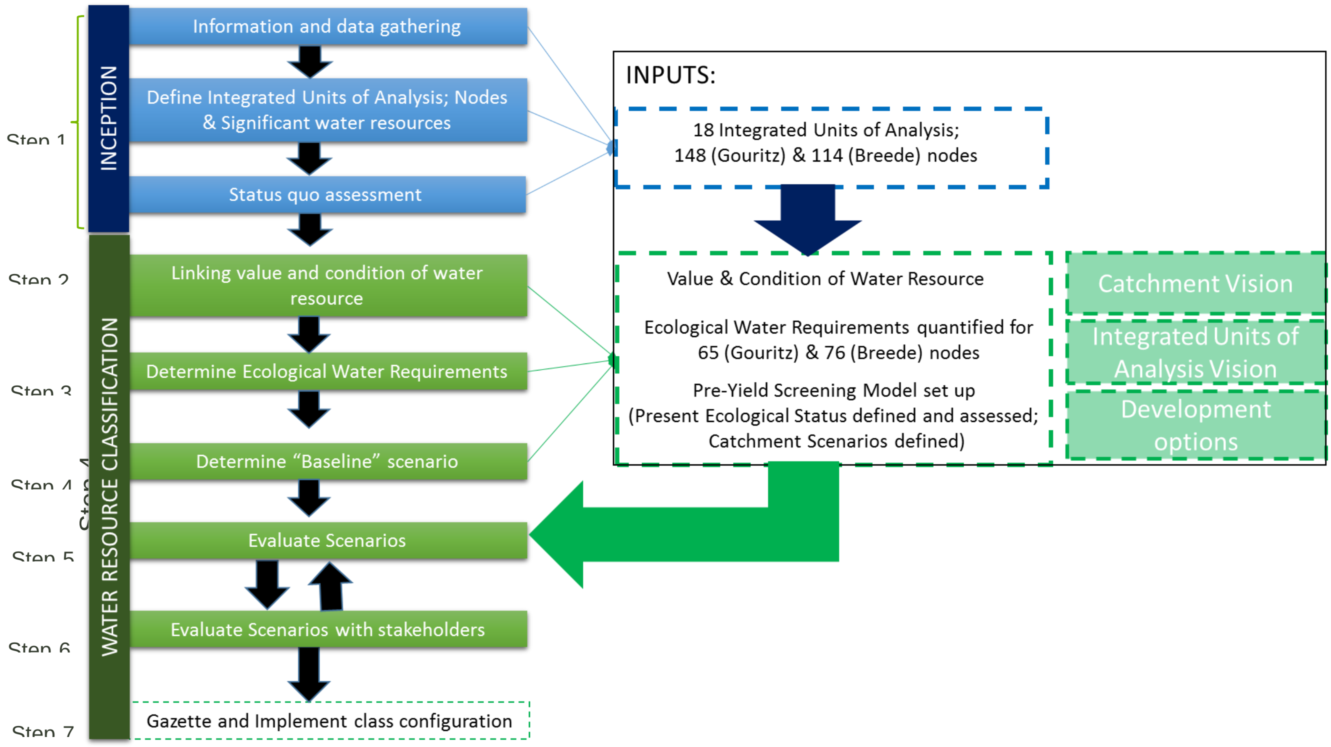

Figure E1 7-step procedure for determining the recommended class for each water resource

Delineation of Integrated Units of Analysis

Previous reports have determined a number of critical water resources in the Water Management Area including rivers, dams, wetlands, estuaries and groundwater resource units. Eighteen Integrated Units of Analysis (IUAs) have been determined as combination of both socio-economic factors and natural resources boundaries. These IUAs represent the primary focus for the analysis of classification scenarios described and evaluated in this report. Each scenario is evaluated using a multi-criteria analysis (MCA) framework including social, economic and ecological parameters.

Biophysical river nodes, estuaries, wetlands and groundwater resource units

In order to determine the required surface water requirements a total of 148 biophysical river nodes have been identified in the Gouritz catchment and 114 nodes in the Breede catchment. In addition, there are 26 estuaries identified in the WMA which are dependent on flow from the contributing catchments.

The ecological condition (EC) at each of these river and estuary nodes is the primary determinant for each of the classification scenarios considered and includes the minimum ecological sustainable based case (ESBC) scenario, the present ecological condition (PEC) and the recommended ecological condition (REC) which is determined as a function of the ecological significance (ES) of the resource.

The sustainability of each groundwater resource unit (GRU) is also determined by comparison of the recharge rate and the estimated sustainable yield from each GRU. The importance of groundwater in contributing to the maintenance of the required river and estuary ecological condition is also considered as is the ability for groundwater to meet any current and future demands not met from surface water.

A number of priority wetlands and wetland systems have been identified in each IUA and the potential impact of the classification scenario on these wetlands and wetland systems is also considered.

Catchment Vision and Future Developments

A visioning exercise for the Breede-Gouritz WMA was undertaken during the first meeting of the Project Steering Committee (PSC). The visions expressed by the PSC were summarized into themes per IUA. The main themes identified in the visioning exercise were Protection, Management, Future Use, and Water Quality. In particular the vision indicated that there needed to be a scenario that balanced the development needs with protection of ecologically important areas.

Classification Scenarios

The rationale for the scenario analysis was to explore the potential water supply, biodiversity and socio-economic outcomes of a range of potential classification options (ranging from high to low levels of ecosystem protection) against a range of demand contexts (current to high future water demands as projected for 2040) and climate contexts (current to future climate as projected for 2040). It is important to test classification options against future demands and rainfall, since the classification choices made in this process should be robust (i.e. should remain the best choice) for the foreseeable future. A total of six different scenarios were considered and are summarised in Table E1. These included:

- Three scenarios based on specified EWR requirements for all nodes (PES, ESBC, and REC) which are then tested against both current day and future demands water demands (Scenarios 1 to 3).
- A scenario in which water demands are met first, with no EC constraints (Scenario 4)
- A future climate change scenario resulting in lower flows, i.e. dry scenario. (Scenario 5)
- A spatially-targeted recommended classification scenario (RCS) combining ecological and economic priorities (Scenario 6)

Table E1 Scenarios Considered

#	Scenario	Abbreviation	Description
1	Maintain Present Ecological Status (“Baseline”)	PES	River and estuary systems are maintained in their present condition, or where currently in an E or F, improved to a D as far as possible.
2	Ecologically Sustainable Base Configuration (ESBC) Scenario (Bottom-line”)	ESBC	The maximum volume of water is made available for abstraction from the system for economic activities, with the proviso that all water resources are just maintained in a D category (i.e. the “bottom line”) where possible.
3	Recommended Ecological Categories (RECs)	REC	The RECs determined for rivers, and estuaries based on present health and conservation importance are applied in this scenario.
4	Demands prioritised without EC constraints (no EC)	NoEC	This development-focussed scenario presents the situation where the water demand for the future level of development (assuming high growth

#	Scenario	Abbreviation	Description
			in future water demands) are met. The resulting ecological conditions are not constrained and may result in worse than a D.
5	As for Sc4, but under climate change (driest 10%) conditions	CC(10)	The shifts that climate change might cause to the ecological conditions of nodes across the study area was assessed by modelling catchment flow changes relative to current day for "drying" climate scenario.
6	Spatially-targeted Classification Scenario	STS	Based on spatial considerations of priority objectives resulting in a blend of targeted ECs for all nodes ranging between REC and ESBC. The impacts of this scenario are tested against future water demands only.

In the first four scenarios, the implications for the costs of water supply are tested under both: (a) the current level of economic development and (b) projected demands under a high growth scenario. In Scenario 5 and 6, they are only tested against the projected future demands.

Methodology for Scenario Evaluation

The process of model configuration and evaluation of the different scenarios is described in this report and is outlined in terms of the following steps used in the analysis:

- Determine the natural and current day surface water flows at all river nodes and estuary nodes.
- Determine the groundwater recharge potential and availability under current demands.
- Determine target ecological category (EC) at priority EWR and river nodes and estuary nodes based on the specific scenario under consideration: (1) ecological base, (2) PES, (3) REC and (4) High Demand.
- Use the "balancing tool" to determine flow requirements at all nodes needed to meet the "target" EC or to determine the ECs for the high demand flows
- Determine the "shortfalls" in surface water availability necessary to meet the target EC.
- Determine how much of these "shortfalls" can be met from groundwater availability.
- Determine a provisional cost for supplying shortfalls from other sources (e.g. re-use).
- Evaluate the likely impact on water quality and wetlands for the different scenarios.
- Evaluate the overall socio-economic and well-being impacts for each scenario.
- Evaluate the potential impact of climate change on ecological category and water availability.

Summary of Overall Impacts of Scenarios

The results for the ecology-driven, demand-driven unconstrained (no-EC) and demand-driven unconstrained (No-EC) with climate change scenarios were assessed according to the consequences each scenario had for rivers, wetlands, estuaries, water quality, groundwater and ecosystem, goods, services and attributes. The results indicate that the risks of welfare losses under the ESBC scenario would be very high. A scenario in which demands are met without any environmental constraints would also result in a net welfare loss, and this would be exacerbated under a climate change scenario. In fact, it should be borne in mind that the results of any classification scenario are likely to be negatively affected by climate change.

Maintaining PES leads to the second-best outcome, but the best outcome from an economic perspective appears to be the allocation of the ecological REC. The results were not sensitive to discount rate.

Table E2 Estimated changes in value of EGSA and in the costs of water supply infrastructure over the period 2017 to 2040 under the different scenarios.

Scenario	Change in EGSA value (R millions, NPV)	Change in water supply infrastructure costs (R millions, PVA)	Overall gain/loss (R millions, NPV)
Maintain PES	0	0	0
ESBC	-7232.1	545.6	-7778
REC	662.7	-494.2	1157
NoEC	-377.0	545.6	-923
No EC (CC)	-674.1	545.6	-1220

Changes in EGSA and water supply values take economic and population growth into account using high-growth assumptions. All values expressed as NPV @ 6% discount rate in 2016 Rand.

Recommended Water Resource Classes

A pilot spatially targeted classification scenario was presented to stakeholders that tries to balance the protection of critical ecological areas with reducing the costs for additional water supply infrastructure to meet the shortfalls in terms of the requirements for EWRs under the proposed classification scenario. The inputs from stakeholders were then used to finalise the Targeted Ecological Category (TEC) for all nodes and to determine the final proposed recommended water resource class for each IUA.

In addition to this it was noted that there is variation within an IUA, in terms of ecological conditions, which may not be represented effectively given the large spatial scale of the IUA. In certain cases where important conservation areas (i.e. Strategic Water Source Areas or protected areas) "split" an IUA these were considered to be important to represent as separate areas in the classification summary. These areas may be considered to be the more "pristine" tributaries which should be maintained at a higher class than "working rivers" which are more degraded. The IUAs considered for this "split are indicated in Table E3.

Table E3 The IUAs considered which have important conservation areas in the study area

IUA Name	IUA	Conservation priority
Upper Breede Tributaries	A1	SWSA, Protected area
Breede Working Tributaries	A2	SWSA, Protected area
Middle Breede Renosterveld	A3	SWSA, Protected area
Riviersonderend Theewaters	B4	SWSA, Protected area
Overberg West	B5	SWSA, Protected area
Lower Breede Renosterveld	F11	SWSA, Protected area
Duiwenhoks	F12	SWSA, Protected area
Touws	E8	Protected area
Gouritz Olifants	D7	SWSA, Protected area
Gamka-Buffels	C6	Groundwater use

The final recommended target ECs for all river and estuary nodes are presented in Table E4 and Figure E2 for the Breede-Overberg region and Table E5 and Figure E3 for the Gouritz-Coastal region.

Table E4 **Annual flow as % nMAR, and river condition (A to F) at each node for the Breede-Overberg IUAs for the Present Ecological Status (PES) and Spatially Targeted Scenario (STS)**

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
B5-OverbergWest	**Piii1**	**G40C**	**Palmiet**	B	C	95.19	C	95.19	Not met	Not met		
	Piv10	G40C	Witklippieskloof		D	58.93	D	58.93				
	Piv9	G40C	Palmiet		D	42.96	D	42.96				
	Pvi1	G40C	Palmiet		D	60.68	D	60.68				
	Piv8	G40C	Klipdrif		D	93.39	D	93.39				
	Piv4	G40D	Klein-Palmiet		D	80.71	D	80.71				
	Piv7	G40D	Krom/Ribbok		D	34.85	D	34.85				
	Piii2	**G40D**	**Palmiet**	**B/C**	B/C	63.71	B/C	63.71	Met	Met		
	Piv12	G40D	Dwars/Louws		C	98.81	C	98.81				
	Piii3	**G40D**	**Palmiet**	B	B	69.83	B	69.83	Met	Met		
	Pxi1	**G40D**	**Palmiet estuary**	B	C	70.13	C	70.13	Not met	Not met		
H16- Overberg West Coastal	**Bxi1**	**G40B**	**Buffels**	B	B	81.86	B	81.86	Met	Met		
	Bxi2	**G40B**	**Rooiels**	B	B	98.63	B	98.63	Met	Met		
	Niv43	G40F	Swart		E	88.83	E	88.83				
	Niii5	G40E	Bot		C	84.20	C	84.20				
	Nxi6	**G40G**	**Bot**	B	C	81.78	C	81.78	Not met	Not met		
	Nxi8	**G40H**	**Onrus**	**D**	D	51.77	D	51.77	Met	Met		
F10-Overberg East Renosterveld	Nii4	G40J	Hartbees		D	87.08	D	55.69				Down
	Niv45	G40K	Steenbok		E	93.40	E	93.40				
	Nv23	**G40K**	**Klein**	**C**	C/D	89.23	C/D	79.11	Not met	Not met		Down
H17-Overberg East Fynbos	**Nxi7**	**G40L**	**Klein**	B	C	80.33	C	85.58	Not met	Not met		Up
	Nx8	G40M	Uilkraal		C	62.95	C	92.00				Up
	Nxi5	G40M	Uilkraal	C	E	43.93	C/D	58.79	Not met	Not met	Up	Up
	Nxi3	G50A	Ratel	C	C	90.02	C	90.02	Met	Met		
	Ni4	G50B	Nuwejaar	D	D	49.65	C/D	71.67	Met	Exceeds	Up	Up
	Nvii15	G50C	Heuningnes		D	50.14	C/D	71.67			Up	Up
	Niv44	G50C	Heuningnes		D	50.20	C/D	71.67			Up	Up
F10-Overberg East Renosterveld	Nv24	G50D	Kars	B	B/C	89.99	B/C	89.99	Not met	Not met		
H17-Overberg East Fynbos	Nii5	G50E	Kars		E	85.84	E	85.84				
	Nxi1	G50F	Heuningnes	A	C	68.78	A/B	78.17	Not met	Not met	Up	Up
F10-Overberg East Renosterveld	Nii6	G50G	Sout		D	73.69	D	73.69				
	Nii7	G50H	DeHoopVlei		B	91.96	B	91.96				
H17-Overberg East Fynbos	Bxi3	G50K	Klipdrifsfontein	A	A	64.77	A	64.77	Met	Met		
A1-UppBreedeTribs	Niv3	H10B	Titus		C	82.03	C	82.03				
	Niv1	H10C	Koekedou		D	96.32	D	96.32				
	Niv2	H10C	Dwars		C	62.47	C	52.94				Down
	nvi4	H10C	Breede		C	70.43	C	64.81				Down
	Niv4	H10D	Witels		A	100.00	A	100.00				
	Nvi3	H10D	Breede		C	75.09	C	72.88				Down
	Nvii16	H10E	Witte		A	92.04	A	92.04				
	Niv5	H10F	Witte		A	88.40	A	88.40				
	Niv6	H10F	Waboomş		D	64.05	D	37.75				Down
	Nviii1	H10F	Breede	D	D/E	77.18	D	75.82	Not met	Met	Up	Down
	Niv40	H10J	Elands		B	92.20	B	92.20				
	Niv41	H10J	Krom		B	92.21	B	92.21				
	Nvii2	H10J	Molenaars	B	B	92.20	B	92.20	Met	Met		

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
A2-BreedeWorkTribs	Niv7	H10G	Slanghoek		D	70.95	D	47.73				Down
	Niii1	H10G	Breede		D	77.70	D	74.99				Down
	Niv42	H10J	Smalblaar		E	92.20	E	92.20				
	Niv8	H10H	Jan du Toit		D	81.32	D	47.53				Down
	Nvii6	H10H	Hartbees		D	77.96	D	77.96				
	Niv9	H10H	Hartbees		D	80.09	D	58.41				Down
	Niv12	H10K	Holsloot		C	81.68	C	81.68				
	Nv3	H10H	Breede		C	62.39	C	59.83				Down
	Nv18	H20F	Hex		D	50.77	D	50.77				
	Nvii7	H20G	Hex	C	C	80.73	C	80.73	Met	Met		
	Niv10	H20H	Hex		D	58.69	D	58.69				
	Nii1	H40C	Breede		C	61.98	C	59.70				Down
	Nvii5	H40B	Koo		D	69.20	D	41.86				Down
	Niv11	H40C	Nuy		E	29.69	D/E	38.24			Up	Up
	Niv18	H30B	Kingna		D	58.05	D	42.98				Down
	Niv20	H30C	Pietersfontein		D	83.82	D	83.82				
	Nvii9	H30D	Keisie		D	84.80	D	73.21				Down
A3-MidBreede-Renoster	Niv13	H40D	Doring		E	77.78	E	77.78				
	Nvii8	H40F	Breede	C/D	C/D	61.10	C/D	59.76	Met	Met		Down
	Ni1	H40F	Breede		B	60.78	A/B	59.45			Up	Down
	Nvii11	H40G	Poesjenels		D	50.90	D	43.90				Down
	Niv15	H40H	Vink		D	83.93	D/E	45.45			Down	Down
	Nviii2	H40J	Willem Nels		D	84.78	D/E	44.77			Down	Down
	Nvii19	H40J	Breede		B	61.12	A/B	58.97			Up	Down
	Nvii12	H40K	Keisers		D	56.39	D	56.39				
	Niv14	H40K	Keisers		D	53.97	D	53.97				
	Nvi1	H40L	Breede		D	61.04	D	58.82				Down
	Nii2	H30E	Kogmanskloof		D	69.40	D	53.92				Down
	Niii3	H50A	Breede		D	61.08	D	58.26				Down
	Ni2	H50B	Breede		D	61.01	D	58.23				Down
B4-UpperRiviersonderend	Nvii10	H60B	Du Toits		B	90.87	B	90.87				
	Nv7	H60D	Riviersonderend		C	49.49	C	52.12				Up
	Niv28	H60E	Baviaans	B	B	88.72	B	88.72	Met	Met		
	Niv29	H60E	Sersants		D	88.72	D	54.44				Down
	Niv30	H60F	Gobos		C	87.77	C	62.36				Down
	Nv9	H60F	Riviersonderend	D	D	53.57	D	52.44	Met	Met		Down
F9-LowerRiviersonderend	Niv31	H60G	Kwartel		D	90.70	D	53.38				Down
	Niv33	H60H	Soetmelksvlei		D	67.84	D	47.90				Down
	Niv34	H60H	Slang		D	67.89	D	47.90				Down
	Nv10	H60H	Riviersonderend		D	55.01	D	51.95				Down
	Nv11	H60J	Riviersonderend		D	56.34	D	53.42				Down
	Niv35	H60K	Kwassadie		E	84.68	E	84.68				
	Nv12	H60K	Riviersonderend		D	56.82	D	53.96				Down
	Ni3	H60L	Riviersonderend		D	56.12	D	53.31				Down
F11-LowBreede-Renoster	Niv24	H70A	Leeu		E	85.44	E	85.44				
	Niv24a	H70B	Klip		E	92.40	E	92.40				
	Nv2	H70B	Breede		C	60.15	C	57.48				Down
	Nvii14	H70C	Huis		C	75.01	C	75.01				
	Nii3	H70C	Tradouw		B	75.21	B	75.21				
	Niv25	H70F	Buffeljags		E	73.18	E	73.18				
	Niii4	H70G	Breede	B/C	C	60.99	C	58.52	Not met	Not met		Down
	Nviii3	H70H	Breede		B	61.13	B	58.41				Down
	Niv26	H70J	Slang		E	89.07	E	51.86				Down
	Nxi2	H70K	Bree	B	B	49.53	B	47.19	Met	Met		Down

EWR sites are shown in red with preliminary RECs in column 4.

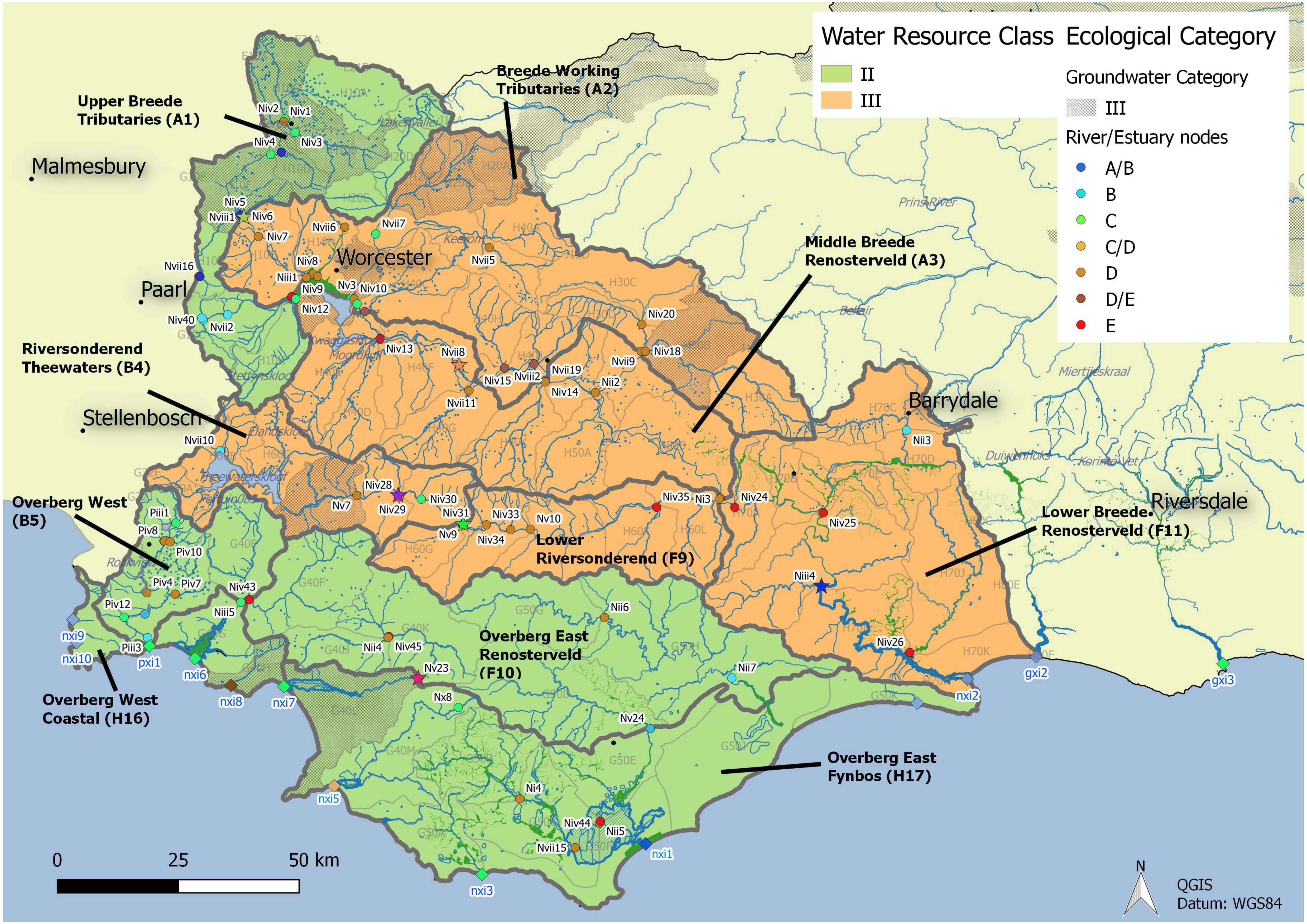

Figure E2 The water resource class and ecological category for the IUAs under the Spatially Targeted Scenario in the Breede-Overberg region of the study area

Table E5 Average monthly flows as % nMAR, and river condition (A to F) for the Gouritz-Coastal IUAs at each node for the Present Ecological Status and Spatially Targeted Scenario

IUA	Node	Quat	River	ER-REC	PES EC	PES %nMAR	STS EC	STS %nMAR	PES Meets REC?	STS Meets REC?	STS EC Ch from PES	STS %nMAR Ch from PES
E8-Touws	giv30	J12C	Ysterdams		D	50.87	D	50.87				
	giv31	J12B	Donkies		D	55.52	D	55.52				
	giv28	J12D	Touws		D	54.57	D	54.57				
	giv27	J12H	Touws		B	50.24	B	50.24				
	giv26	J12K	Brak		C	14.46	C	14.46				
	gviii1	**J12L**	**Doring**	**C/D**	C/D	43.39	C/D	43.39	Met	Met		
	gv5	**J12L**	**Touws**	**B/C**	B/C	46.37	B/C	46.37	Met	Met		
	gv4	**J11H**	**Buffels**	**C**	C	60.32	C	60.32	Met	Met		
	gv6	J11J	Groot		D	42.70	D	42.70				
	giv32	J11K	Groot		D	38.59	D	38.59				
	gv7	J13A	Groot		C	41.06	C	41.06				
	gii3	J13C	Groot		B	42.79	B	42.79				
C6-Gamka-Buffels	giv34	J11C	Buffels		A	97.25	A	97.25				
	gv25	J11F	Buffels		C	93.27	C	93.27				
	gv18	J21A	Gamka		B	77.34	B	77.34				
	giv3	J21D	Gamka		B	77.81	B	77.81				
	giv1	J22F	Koekemoers		C	87.87	C	87.87				
	giv2	J22K	Leeu		C	44.14	C	44.14				
	gv17	J23C	Gamka		B	68.99	B	68.99				
	giv21	J23F	Gamka		B	62.35	B	62.35				
	gv27	J23J	Gamka		C	61.87	C	61.87				
	gv14	J24D	Dwyka		A	85.15	A	85.15				
D7-Gouritz-Olifants; Lower Gouritz	**giv20**	**J25A**	**Gamka**	**C**	C/D	55.79	C	66.02	Not met	Met	Up	Up
	giv18	J25D	Nels		D	55.82	E	42.22			Down	Down
	gii2	J25E	Gamka		C	48.82	C	59.98				Up
	giii2	**J31C**	**Olifants**	**C**	C	85.27	C	54.74	Met	Met		Down
	giv15	J32E	Traka		C	81.11	C/D	47.89			Down	Down
	gv33	J33B	Olifants		D	79.46	D	57.22				Down
	gv21	J33D	Meirings		C	90.58	C	90.58				
	giv11	J33F	Olifants		E	47.00	E	40.04				Down
	gv36	**J34C**	**Kammanassie**	**C/D**	C/D	75.67	C/D	75.67	Met	Met		
	giv10	J34F	Kammanassie		E	41.26	D	60.46			Up	Up
	gvii2	J35A	Grobbelaars		C	82.76	C	82.76				
	giv9	J35A	Grobbelaars		E	65.75	E	65.75				
	gv19	J35D	Olifants		E	51.60	E	50.63				Down
	giv17	J35F	Olifants		D	53.21	D	50.15				Down
	giv16	J40A	Gouritz		C	55.30	C	51.97				Down
	gi4	**J40B**	**Gouritz**	**C**	C	54.34	C	51.65	Met	Met		Down
	gv28	J40C	Gouritz		D	56.22	D	53.69				Down
	gv9	J40D	Gouritz		C	59.81	C	57.51				Down
	Gxi1	**J40E**	**Gouritz estuary**	**B**	C	61.88	C	59.73	Not met	Not met		Down
F12-Duiwenhoks-Hessequa	giii5	H80B	Duiwenhoks		E	94.05	E	94.05				
	gv11	H80C	Duiwenhoks		D	94.05	D	94.05				
	giii8	**H80D**	**Duiwenhoks**	**D**	D	94.35	D	94.35	Met	Met		
	Gxi2	**H80E**	**Duiwenhoks estuary**	**A**	B	91.89	B	91.89	Not met	Not met		
I18-Duiwenhoks-Hessequa	giii6	H90B	Korinte		D	89.02	D	89.02				
	giii7	**H90A**	**Goukou**	**C/D**	C/D	87.67	C/D	87.67	Met	Met		
	gv10	H90C	Goukou		D	84.73	D	84.73				
	gv41	H90D	Goukou		C	83.50	C	83.50				
	Gxi3	**H90E**	**Goukou estuary**	**B**	C	81.41	C	81.41	Not met	Not met		

	giv25	K10D	Brandwag		D	73.80	D	73.80				
	gv39	**K10E**	**Moordkuil**	**D**	D	41.78	D	41.78	Met	Met		
	Gxi4	**K10F**	**Klein-Brak estuary**	**C**	C	77.05	C	77.05	Met	Met		
	gviii2	**K20A**	**Groot-Brak**	**B/C**	B/C	93.79	B/C	93.79	Met	Met		
	gviii12	**K20A**	**Varing**	**C/D**	C/D	97.27	C/D	97.27	Met	Met		
G14-Groot Brak	**gviii3**	**K20A**	**Varing**	**C/D**	D	74.73	D	74.73	Not met	Not met		
	gvii7	K20A	Groot-Brak		B/C	45.89	B/C	45.89				
	Gxi5	**K20A**	**Groot-Brak estuary**	**C**	E	56.20	E	56.20	Not met	Not met		
	Gxi19	**K10A**	**Blinde estuary**	**B**	B	69.23	B	69.23	Met	Met		
	Gxi20	**K10A**	**Tweekuilen estuary**	**D**	D	96.73	D	72.31	Met	Met		Down
	Gxi21	**K10A**	**Gericke estuary**	**D**	D	96.80	D	72.31	Met	Met		Down
	Gxi22	**K10B**	**Hartenbos estuary**	**C**	D	65.01	D	65.01	Not met	Not met		
	gviii4	K30A	Maalgate		D	75.80	D	75.80				
	gvii8	**K30A**	**Maalgate**	**D**	D	75.80	D	75.80	Met	Met		
	Gxi6	**K30A**	**Maalgate estuary**	**B**	B	79.32	B	79.32	Met	Met		
	gvii9	**K30B**	**Malgas**	**C**	C	95.00	C	95.00	Met	Met		
	gviii6	**K30B**	**Gwaing**	**D**	E	82.30	E	82.30	Not met	Not met		
	Gxi7	**K30B**	**Gwaing estuary**	**B**	B	85.00	B	85.00	Met	Met		
	gviii7	K30C	Swart		D	25.28	D	25.28				
	gvii11	**K30C**	**Kaaimans**	**B**	B	94.07	B	94.07	Met	Met		
	gviii8	K30C	Silver		B	94.07	B	94.07				
	Gxi8	**K30C**	**Kaaimans estuary**	**B**	B	72.45	B	72.45	Met	Met		
	gvii12	K30D	Touws		B	93.75	B	93.75				
	gx8	K30D	Klein		D	93.75	D	93.75				
	Gxi9	**K30D**	**Wilderness estuary**	**A**	B	88.59	B	88.59	Not met	Not met		
	giii10	**K40A**	**Diep**	**B**	B	96.53	B	96.53	Met	Met		
	giii13	K40B	Hoekraal		B	92.49	B	92.49				
	gvii13	**K40C**	**Karatara**	**A/B**	B	92.99	B	92.99	Not met	Not met		
	giii11	K40C	Karatara		B	92.99	B	92.99				
	Gxi10	**K40D**	**Swartvlei estuary**	**B**	B	86.61	B	86.61	Met	Met		
	gviii9	**K40E**	**Goukamma**	**B/C**	B/C	87.46	B/C	87.46	Met	Met		
G15-Coastal	**Gxi11**	**K40E**	**Goukamma estuary**	**A**	B	87.46	B	87.46	Not met	Not met		
	gvii14	**K50A**	**Knysna**	**B**	B	95.63	B	95.63	Met	Met		
	giii12	K50A	Knysna		B	94.74	B	87.20				Down
	gviii11	**K50B**	**Gouna**	**A/B**	A/B	92.21	A/B	92.21	Met	Met		
	Gxi12	**K50B**	**Knysna estuary**	**B**	B	90.63	B	86.75	Met	Met		Down
	gviii10	**K60G**	**Noetzie**	**A/B**	B	92.46	B	92.46	Not met	Not met		
	Gxi13	**K60G**	**Noetsie estuary**	**A**	B	92.45	B	92.45	Not met	Not met		
	gx3	K60G	Piesang		E	92.45	E	64.25				Down
	Gxi14	**K60G**	**Piesang estuary**	**B**	C	73.04	C	73.84	Not met	Not met		Up
	giv6	**K60C**	**Keurbooms**	**B/C**	C	93.22	C	93.22	Not met	Not met		
	giv5	K60D	Palmiet		A	93.24	A	93.24				
	gx9	K60E	Keurbooms		B	92.25	B	92.25				
	giv4	K60F	Bitou		C	97.47	C	92.10				Down
	Gxi15	**K60G**	**Keurbooms estuary**	**A**	A	91.17	A	90.04	Met	Met		Down
	gx4	K70A	Buffels		B	83.72	B/C	57.23			Down	Down
	Gxi16	**K70A**	**Matjies estuary**	**B**	B	83.73	C	70.47	Met	Not met	Down	Down
	gx5	K70A	Sout		B	85.58	B	85.58				
	Gxi17	**K70A**	**Sout(Oos) estuary**	**A**	A	85.58	A	85.58	Met	Met		
	Gxi23	**K70A**	**Groot(Wes) estuary**	**B**	B	86.73	B	86.73	Met	Met		
	gvii15	K70B	Bloukrans		B	82.69	B	82.69				
	Gxi18	**K70B**	**Bloukrans estuary**	**A**	A	98.00	A	98.00	Met	Met		

EWR sites are shown in **bold** with preliminary RECs in column 4.

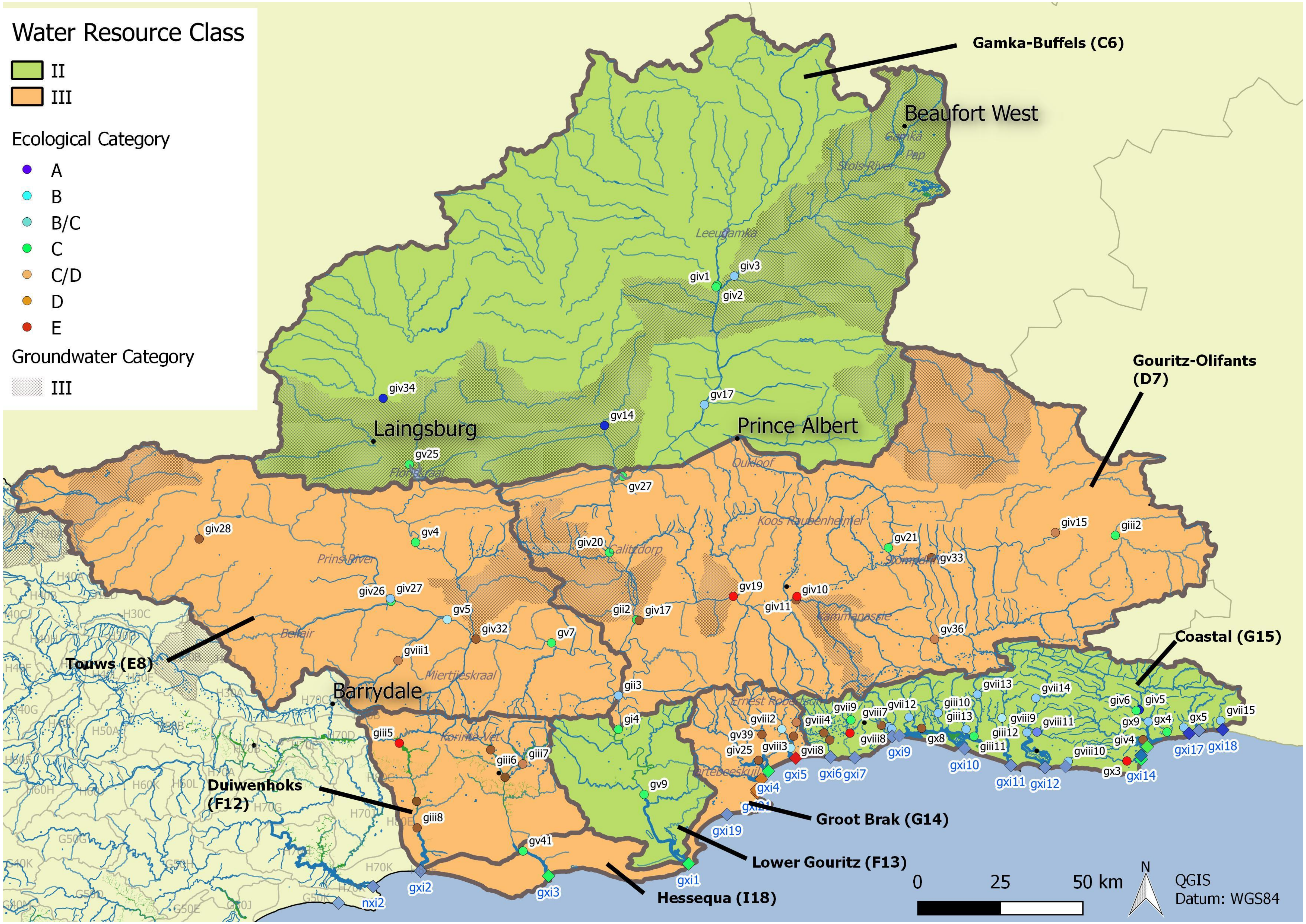

Figure E3 The final water resource class and ecological category for the IUAs under the Spatially Targeted Scenario in the Gouritz-Coastal region of the study area

The results of the final recommend classification scenario are used to determine the final proposed water resources class for each IUA based on the number of nodes of different EC in each IUA. The final proposed water resource class for each IUA in the Breede-Gouritz WMA are given in Table 6-8. In some cases, IUAs have been split to provide a clearer distinction between different water resources classes.

Table E6 Final proposed water resources classes for IUAs

Region	IUA		Spatially targeted	PES
Breede Overberg	Upper Breede Tributaries	A1	II	III
	Middle Breede Renosterveld	A2	III	III
	Breede Working Tributaries	A3	III	III
	Riviersonderend Theewaters	B4	III	III
	Lower Riviersonderend	F9	III	III
	Overberg West	B5	II	III
	Overberg West Coastal	H16	II	III
	Overberg East Renosterveld	F10	II	III
	Overberg East Fynbos	H17	II	III
	Lower Breede Renosterveld	F11	II	III
Gouritz Coastal	Gamka Buffels	C6	II	II
	Touws	E8	III	III
	Gouritz-Olifants	D7	III	III
	Lower Gouritz	F13	II	III
	Duiwenhoks	F12	III	III
	Hessequa	I18	III	III
	Groot Brak	G14	III	III
	Coastal	G15	II	II

Management considerations

A summary of the overall consequences of implementation of the proposed classification scenario for each IUA are given in Table E7 and Table E8.

Table E7 Summary of implications of the spatially targeted classification scenario for each IUA in the Breede-Overberg region of the WMA

IUA	Class	Description	Consequences of Implementation	Groundwater
A1	II	Upper Breede Tributaries (a)	• Upper Breede tributaries within the strategic water source area and Ceres Mountain Fynbos Nature Reserve/Hawequas Nature Reserve need to be maintained in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in four quaternary catchments (i.e. increases from category I to II or I to III). These four catchments are all in the H10 catchments of the Upper Breede Tributaries IUA. The increase in groundwater stress in two of the four is moderate, and the increase is fairly significant in the remaining two. This increase in stress relates to a change in groundwater category from I to II
		Upper Breede Tributaries (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Upper Breede tributaries outside of important conservation areas will be in a less natural state.	
A2	III	Breede Working Tributaries (a)	• Tributaries within Matroosberg MCA/Fonteintjiesberg Nature Reserve/Langeberg-Wes MCA/Dassieshoek Local NR need to be maintained in a good condition.	

IUA	Class	Description	Consequences of Implementation	Groundwater
		Breede Working Tributaries (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Although some river nodes are within strategic water source areas, these are not in a natural state and most will have a fair to poor condition. • Nuy River improves to a better condition, but is still in a poor condition.	in two catchments; I to III in one catchment, and II to III in one catchment. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
A3	III	Middle Breede Renosterveld (a)	• Tributaries within Brandvlei NR/Riviersonderend MCA/Vrolijkheid NR/Langberg Wes MCA/Marloth NR need to be maintained in a good condition.	
		Middle Breede Renosterveld (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Rivers are not in a natural state and most will have a poor condition.	
B4	III	Riviersonderend Theewaters (a)	• Upper tributaries within the strategic water source area and Hottentots-Holland NR/Theewaters NR//Hawequas NR/Riviersonderend NR need to be maintained in a good condition.	To achieve REC into the future, the groundwater status increases compared to PES in three quaternary catchments (i.e. increases from category I to II or I to III). These three catchments are all in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these three catchments is moderate at two catchments, and significant at one catchment with an increase in the use/ recharge ratio ('stress') is from 0 to 66% at the H60D quaternary catchment. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Riviersonderend Theewaters (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Most river nodes will be in a poor condition.	
F9	III	Lower Riviersonderend (a)	• Upper tributaries in the Riviersonderend NR should be maintained in a good condition.	
		Lower Riviersonderend (b)	• Most river nodes will be in a poor condition.	
F11	II	Lower Breede Renosterveld (a)	• River nodes in the upper tributaries will be in a good condition (i.e. A to B Ecological Category).	Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.
		Lower Breede Renosterveld (b)	• Certain river nodes (Leeu, Klip, Buffeljags and Slang) will be in an unacceptable condition.	
H16	II	Overberg West Coastal	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Swart river node will be in an unacceptable condition, and Onrus river node improved from baseline but will still be in a poor condition (i.e. C to below D Ecological Category). • Buffels and Rooiels will be in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in four (of six) quaternary catchments. These four catchments include all those of the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III). One of the quaternary catchments impacted by a
B5	II	Overberg West (a)	• The nodes at the bottom of the catchment should be maintained in a good condition (i.e. B to C Ecological Category).	

IUA	Class	Description	Consequences of Implementation	Groundwater
		Overberg West (b)	• Although there are regions within the Overberg West IUA that are of conservation importance, the surrounding land use in most cases has led to degraded systems.	change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.
F10	II	Overberg East Renosterveld	• Hartbees and Steenbok will be in a poor condition.	To achieve this scenario, the groundwater status increases compared to PES in one quaternary catchment (G40L, located in Overberg East Fynbos IUA). The increase in groundwater stress in this catchment is fairly significant, with the catchment increasing its use/ recharge ratio ('stress') from 19 to 88%. The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.
H17	II	Overberg East Fynbos (a)	• Kleinmond/Heuningnes/De Hoopvlei Ramsar wetlands need to be maintained in a good condition. • Upper tributaries in Walker Bay NR/Salmonsdam NR/Uitkraalsmond NR/Pearly beach NR/Algulhas NP/Quion Point NR/Algulhas NP/Soetendalsvlei NR/Heuningberg NR/Waenhuiskrans NR/De Hoop NR are to be maintained in a good condition.	
		Overberg East Fynbos (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Limited change from baseline condition. Conditions of river nodes are fair to poor. • De Hoop Vlei and Klipdrifsfontein will be maintained in a good condition.	

Table E8 **Summary of implications of the spatially targeted classification scenario for each IUA in the Gouritz-Coastal region of the WMA**

IUA	Class	Description	Consequences of Implementation	Groundwater
F12	III	Duiwenhoks (a)	• Upper tributaries in the Langeberg-Oos MCA/Boosmansbos/Garcia NR should be maintained in a good condition.	Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.
		Duiwenhoks (b)	• This flow regime meets the REC of D for giii8 (Duiwenhoks River). • The river node associated with Duiwenhoks wetland remains in an unacceptable condition. • Despite flowing relatively naturally, a range of agricultural impacts such as clearing of riparian vegetation for cultivation and infilling in cultivated areas have meant that the rivers of the Duiwenhoks and Hessequa are in moderate to poor condition. • Flow requirements are met for the REC of C/D at giii7 (Goukou River) with 80% of natural flows.	
I18	III	Hessequa	• The ecological condition of the Duiwenhoks and the Goukou estuaries will be B and C, respectively, which is lower than the Recommended Ecological Condition of A and B, respectively.	

IUA	Class	Description	Consequences of Implementation	Groundwater
E8	III	Touws (a)	• Tributaries within Bokkeriviere NR/Touw Local Authority NR/Anysberg NR/Warmwaterberg NR/Klein Swartberg MCA/Towerkop NR/Ladismith Klein Karoo/Rooiberg MCA/Wolwekop NR/Langeberg East MCA are to be maintained in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in two quaternary catchments. These two catchments are J12B and J13C; located at the northwest (upstream) and southeast (downstream) extremities of the catchment respectively. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio ('stress') from 2 to 100%, corresponding for a change in status category from I to III. The change at J13C is moderate. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Touws (b)	• Ysterdams, Donkies and upper Touws rivers at the upper reaches of this region and the upper Groot River will remain in poorer condition.	
C6	II	Gamka-Buffels (a)	• Most river nodes will be in a good condition.	No increase in groundwater use.
		Gamka-Buffels (b)		There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.
D7	III	Gouritz-Olifants (a)	• Tributaries within Klein Swartberg MCA/Grootswartberg MCA/Swartberg East NR/Kammanassie MCA/Rooiberg MCA/Gamkaberg NR/Doringrivier Wilderness area are to be maintained in a good condition.	To maintain PES into the future, the groundwater status increases compared to PES in seven quaternary catchments. These catchments are in the J25 (west of the IUA, west of Gamka River) and J33 and J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate to significant, and the increase in the use/ recharge ratio ('stress') ranges from 0 to 20% under current PES, to 26 to 97% at the quaternary catchments. Four of the seven change from a groundwater status of I to III. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Gouritz-Olifants (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Olifants, Grobbelaars and Kammanassie river nodes will be in a very poor condition. Other nodes are in a fair to poor condition.	
F13	II	Lower Gouritz	• The river and estuary nodes will remain in a baseline condition.	

IUA	Class	Description	Consequences of Implementation	Groundwater
G14	III	Groot Brak	• Groot Brak estuary will remain in an unacceptable condition.	To achieve this scenario, the groundwater status increases compared to PES in one quaternary catchment (K20A in the east of the IUA). The increase in groundwater stress in these catchments is low, with the catchment increasing in use/recharge ratio ('stress') from 1% to 24%, corresponding to a change in category from I to II. The catchment K20A has a high GWBF/EWR ratio, and abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.
G15	II	Coastal (a)	• Rivers and estuaries need to be maintained in a good condition.	To maintain PES into the future, the groundwater status increases compared to PES in two quaternary catchments. These catchments are K30C and K30B around George. The increase in groundwater stress is moderate, with an increase in its use/ recharge ratio ('stress') from between 2 and 5% under current PES, to between 39 and 40% in future respectively, corresponding for a change in status category from I to II. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Coastal (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Most river and estuary nodes will be maintained in a good condition.	

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Appendix A: Detailed model results for Spatially Targeted Scenarios

Appendix B: Groundwater tables

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1 Introduction

1.1 Background

Chapter 3 of the National Water Act 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 National Water Act (NWA), established a Water Resources Classification System that is formally prescribed by Regulations 810 dated 17 September 2010.

The Water Resources Classification System (WRCS) provides guidelines and procedures for determining Water Resource Classes, Ecological Reserves and Resource Quality Objectives (RQOs).

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 and associated Resource Quality Objectives for all significant water resources in the Breede-Gouritz Water Management Area (WMA).

The 7-step WRCS procedure is described in the WRCS Overview Report (Department of Water Affairs and Forestry, DWAF, 2007a) and leads to the recommendation of the Class of a water resource (the outcome of the Classification Process).

The three Water Resource Classes are defined as:

- Class I: Minimally used: The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is minimally altered from its pre-development condition.
- Class II: Moderately used: The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is moderately altered from its pre-development condition.
- Class III: Heavily used: The configuration of ecological categories of the water resources within a catchment results in an overall water resource condition that is significantly altered from its pre-development condition.

Seven steps are required to determine the Water Resource Classes. Steps 1-3 have been completed. This report focuses on *Step 4-7: Determining and evaluating the scenarios*. Steps 5 and 6 represent an iterative process, whereby the determined scenarios are evaluated with stakeholders and feedback is integrated into the process to result in the recommended scenario and water resource classes. Each of these steps are listed in section 1.3, below.

Along with the prescribed methodology, previous classification studies were reviewed to determine an appropriate strategy for scenario planning. Reports of relevant previous studies that are referred to are the scenario evaluation reports for the Crocodile (West), Marico, Mokolo and Matlabas catchments (DWS, 2015) and the reports of the Inkomati Water Management Area (DWS, 2014).

1.2 Study area

The study area covers all significant water resources of the Breede-Gouritz WMA. The Breede River and Gouritz River catchments and their primary tributaries, Riviersonderend, Groot, Gamka and Olifants rivers, dominate the study area, but it also includes numerous smaller coastal catchments.

1.2.1 Breede River Basin and Overberg Area

Ten integrated units of analysis (IUAs) have been delineated in the Breede River basin and Overberg area (Figure 1-1). The flow direction of the main rivers in each IUA are indicated by white arrows in the figure. The IUAs were grouped together, as shown in Table 1-1, according to their connectedness with regards to flow.

Table 1-1 IUAs grouped for presentation of results

IUA Code	IUA Name	Group
A1	Upper Breede Tributaries	1
A2	Breede Working Tributaries	
A3	Middle Breede Renosterveld	
B4	Riviersonderend Theewaters	2
F9	Lower Riviersonderend	
F11	Lower Breede Renosterveld	3
H16	Overberg West Coastal	4
B5	Overberg West	
F10	Overberg East Renosterveld	5
H17	Overberg East Fynbos	

1.2.2 Gouritz River Basin and Outeniqua Area

Eight IUAs have been delineated in the Gouritz River basin and the Outeniqua area (Figure 1-2). The flow direction of the main rivers in each IUA are indicated by white arrows in the figure. The IUAs were grouped together, as shown in

Table 1-2 IUAs grouped for presentation of results, according to their connectedness with regards to flow.

Table 1-2 IUAs grouped for presentation of results

IUA Code	IUA Name	Group
F12	Duiwenhoks	6
I18	Hessequa	
E8	Touws	7
C6	Gamka-Buffels	8
D7	Gouritz-Olifants	9
F13	Lower Gouritz	
G14	Groot Brak	10
G15	Coastal	11

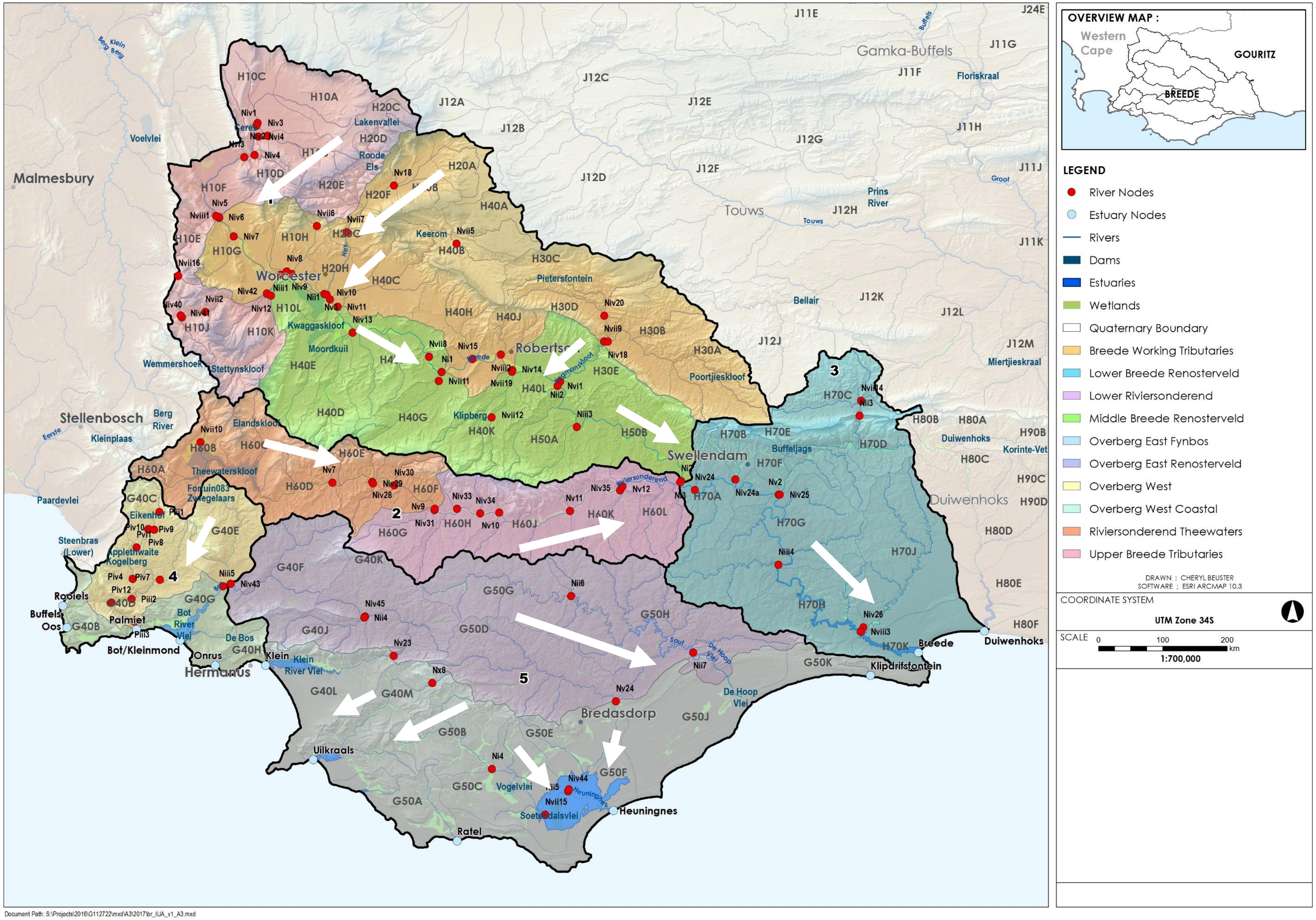

Figure 1-1 Direction of flow through the IUAs of the Breede River basin and Overberg area

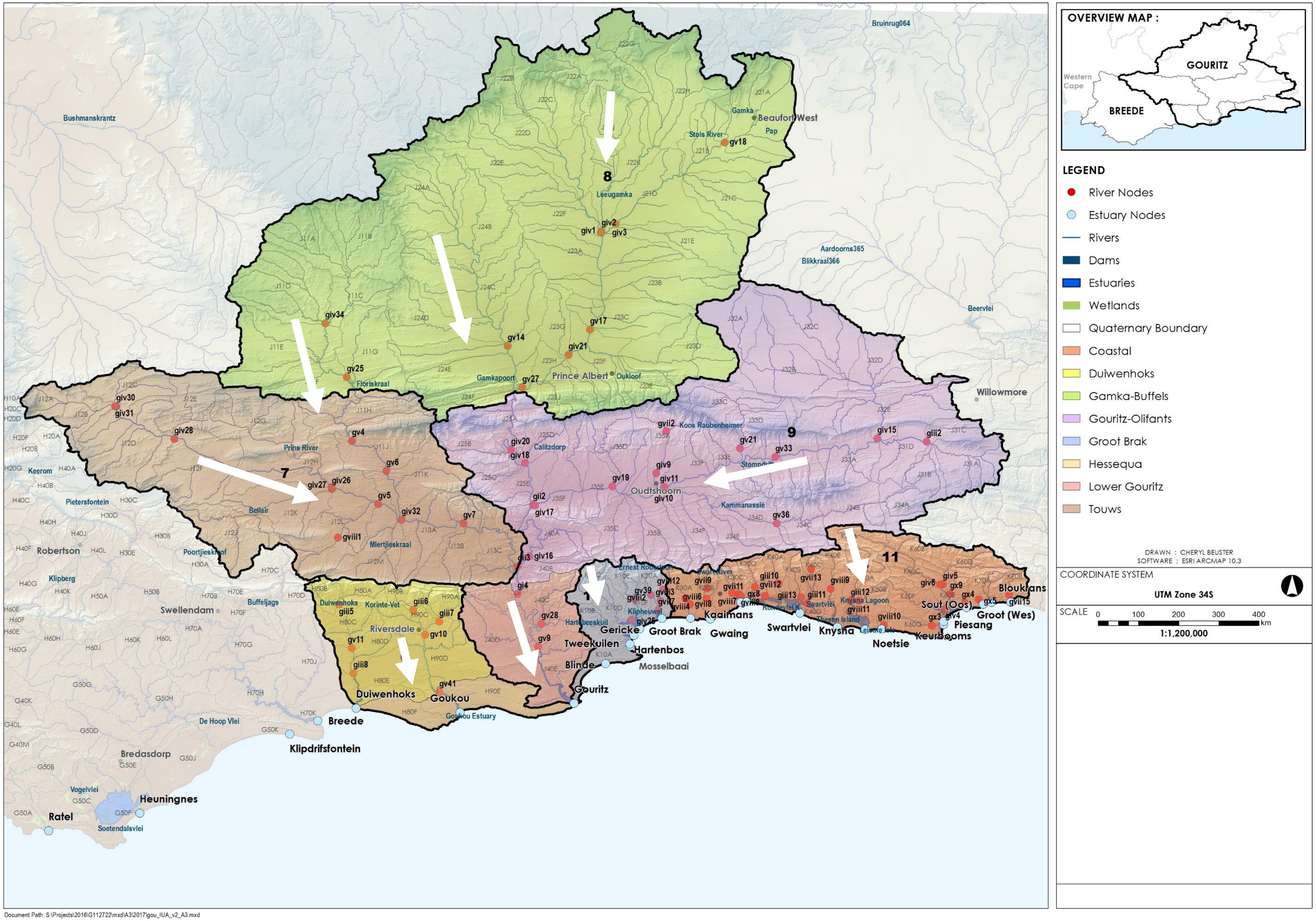

Figure 1-2 Direction of flow through the IUAs of the Gouritz catchment and Coastal areas

1.3 Steps in the Water Resources Classification System

The evaluation of scenarios is the penultimate step in determining the water resources class and is dependent on the integration of the inputs from the previous steps in the Water Resource Classification System (WRCS) process (Figure 1-3). The relevant outputs from previous steps are summarised below:

1. **Water resources information and gap analysis (DWS, 2016a)**

   The data gathering process and review of existing water resource information was initiated on the initial stage of the project. This allowed an assessment of whether there were any information shortfalls or gaps to successfully undertake the project. The information gathered, including an inventory of current water resource models available, and the results of the analysis were synthesised and presented in the Water Resources Information and Gap Analysis Report.

   In terms of the information analysis undertaken there were no significant limitations in terms of modelling, or information and data availability for the study area. Although the information gathering process was the first step of the project, information gathering and synthesis will continue throughout the project to update and improve the project when new information and data becomes available.

2. **Resource Unit and Integrated Units of Analysis (IUA) delineation, including nodes (DWS, 2016b)**

   The delineation of Resource Unit (RUs), allocation nodes, and integrated units of analysis (IUAs) is the first component of the first step of the Classification procedure. The IUAs represent an integration of spatial units that defined the significant water resources units and socio-economic zones. Each IUA represents a relatively homogeneous area in terms of resource units and socio-economic characteristics that requires its own specification of Water Resources Class. The objective of defining IUAs is to establish broader-scale units for assessing the socio-economic implications of scenarios and to report on ecological conditions at a sub-catchment scale. The process of delineating and determining the IUAs for the water resources in the Breede-Gouritz WMA was outlined in the Resource Unit and Integrated Units of Analysis Delineation Report (DWS, 2016b).

   The study followed the delineation approach as defined in the WRCS Guidelines, Volumes 1 and 2 (DWAF, 2007f), and considered the following elements to delineation river resource units: ecoregion; geomorphic zone; hydrological characteristics; present ecological status; vegetation bioregion; and catchment boundaries. The study area was divided into homogenous socio-economic zones and these zones were overlaid on the River Resource Units that had earlier been delineated. This process had to be refined and rationalised with stakeholder inputs in order to get the final delineation of IUAs. At the end of this process 18 IUAs were determined for the study area (10 IUAs for the Breede-Overberg and 8 IUAs for the Gouritz) with 148 nodes in the Gouritz area and 114 nodes in the Breede-Overberg area.

3. **Status Quo assessment of significant water resources (DWS, 2016c)**

   The description of the status quo of the identified significant water resources in the WMA is the second component of the first step 1of the WRCS procedure. The Status Quo Report described the current status of the water resources in the study area in terms their physical and ecological characteristics and the socio-economic environment of the surrounding areas through which they flow, or are located.

4. **Linking the value and condition of the water resource (DWS, 2017a)**

   Step 2 of the WRCS consists of the Linking the Value and Condition of the Resource. The objective of this step is to identify the classification scenarios and outline the method statement to determine the consequences of the classification scenarios on and integrate these into preliminary Water Resource Classes for stakeholder evaluation.

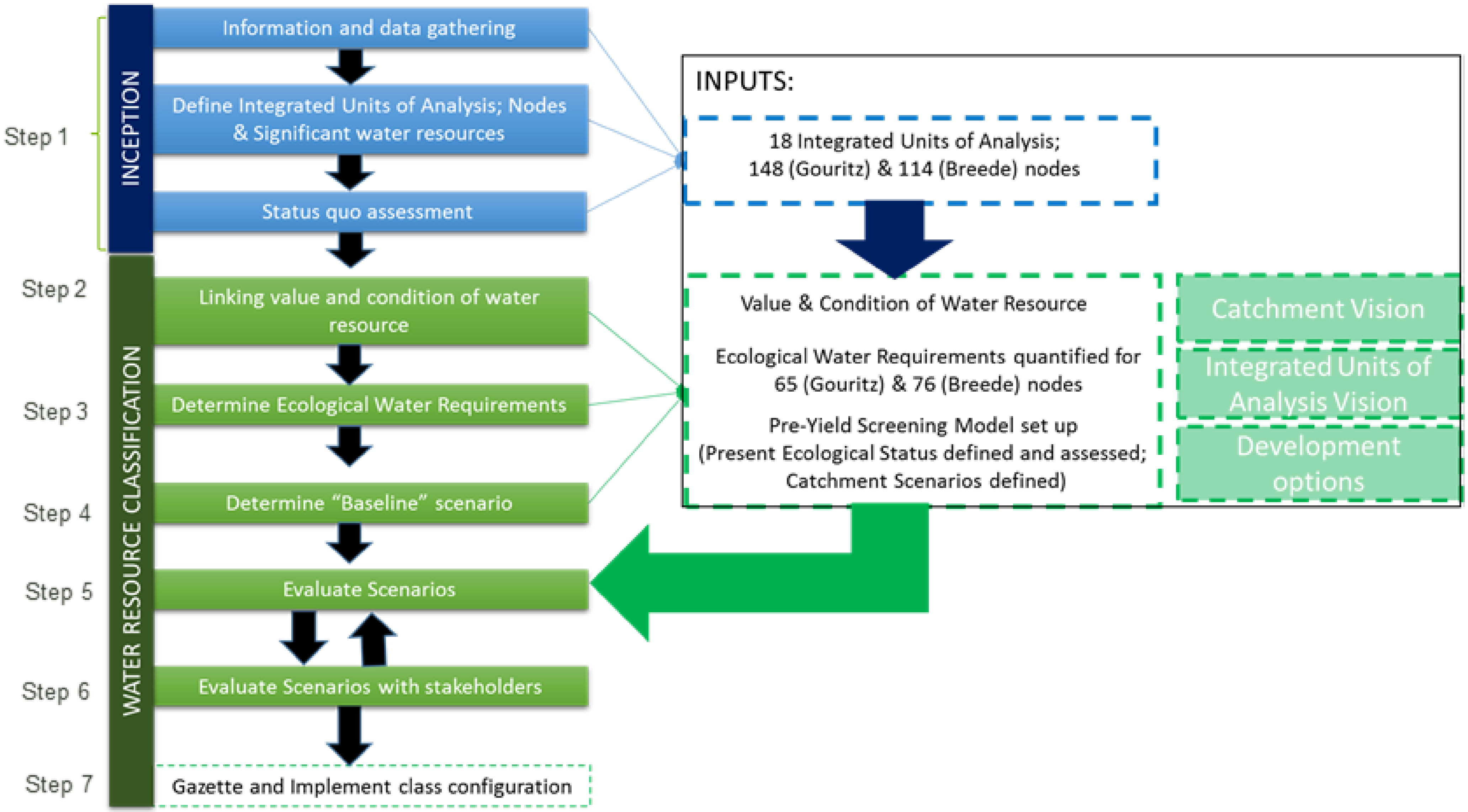

Figure 1-3 Scenario evaluation inputs to determine the recommended scenarios

5. **Quantification of the Ecological Water Requirements (EWR) and changes in Ecosystem Goods, Services and Attributes (EGSA) (DWS, 2017b)**

The quantification of the Ecological Water Requirements and changes in Ecosystem Goods, Services and Attributes comprises Step 3 of the WRCS procedure. The purpose of this step is to report on the ecological water requirements (EWRs) at each node and to describe the approach to evaluate the changes in ecosystems goods, services and attributes (EGSAs). These data were incorporated into the analysis of classification scenarios.

The provisional nodes identified in the IUA delineation Report were reviewed based on comments received from the stakeholders and adjusted accordingly. From these, for the pragmatic purpose of calculating ecological water requirements and going forward into the scenario analyses, a sub-set of nodes were selected, based on their necessity and suitability for routing flows through the basin in a downstream direction and their respective importance to capture flows required at estuaries. To facilitate routing of flows through the river basins and to meet estuarine requirements and for other critical environmental areas, 65 nodes were selected in the Gouritz River basin and Coastal region and 76 nodes in the Breede River basin and Overberg region. EWRs were calculated at these nodes and summarised into summary tables, rule curves and hydrological time series following the standard Ecological Reserve template formats.

Determining the changes in EGSA is required as the sectors dependent on aquatic ecosystem services could either shrink or expand as a result of moving to a lower or higher ecological class. In this report, the main impacts considered were tourism, property and inshore fisheries. These sectors and their linkages to the aquatic ecosystem services in the study area were explained in more detail in the Status Quo Report (DWS, 2016b). Estuaries are the main freshwater-dependent ecosystems that impact on all three of these sectors, but rivers and wetlands can also influence tourism values. Additionally, the impact of changes in ecosystem condition on the wellbeing of inhabitants of and visitors to these catchments were also taking into consideration. This required estimating the relationships between ecosystem condition and the capacity to supply natural resources, as well as amenity values such as recreation and spiritual fulfilment. The changes in EGSAs, in response to changes in water quantity, quality and ecological condition of water resources will be incorporated into the analysis of scenarios.

6. **Ecological Sustainable Base Configuration (ESBC) Scenario (DWS, 2017c)**

The Ecologically Sustainable Base Configuration (ESBC) scenario comprises the first component of Step 4 of the WRCS procedure. The objective of this component was to set up the ESBC scenario and the tool (pre-yield model, called the basin configuration tool in this report) used to analyse the scenarios. The ESBC is the minimum environmental flow scenario that sustains the lowest acceptable ecological condition for water resources basin-wide (a D category). The establishment of the ESBC scenario aimed to route flows through the network of nodes such that the flows required for this minimum ecological condition are met in the rivers basin-wide and at the estuaries.

In order to set up the ESBC and other scenarios, and perform a pre-yield assessment of these, a “basin configuration tool” was developed. This tool makes allowance to report volumes resulting from the ESBC as “surpluses” and “deficits” of flow relative to current day at each node (results summarised per IUA). The tool calculates changes in ecological condition at each river and estuary node in response to changes in flow, increases and decreases, and also allows the user to change the ecological conditions at each node and report whether this results in a surplus or deficit of flow, relative to current day. An explanation of the tool is provided in 3.3.1.

7. **Evaluation of Scenarios (This Report)**

The final step in the WRCS is the analysis and evaluation of alternative scenarios. The results of the evaluation of scenarios is then discussed with Stakeholders and results in a final recommended water resource class for the water resources of each IUA in the Study Area that will then be taken forward to the next phase of the study which is to determine associated Resource Quality Objectives.

2 Stakeholder Visions for IUAs

A visioning exercise for the Breede-Gouritz WMA was undertaken with key stakeholders, during and after the first Project Steering Committee (PSC) meeting held on the 1st of February 2017. The purpose of the visioning exercise was to articulate the aspirations of various stakeholders for the future of the WMA. The visions expressed by the PSC were summarised into themes per IUA and are shown in Table 2-1. The main themes identified in the visioning exercise were Protection, Management, Future Use, and Water Quality.

These comments were incorporated into the report in the following way:

- **Protection**
    - FEPAs are mentioned in the Recommended Scenario. IUAs where there are FEPAs, SWSAs or Nature Reserves receive flow for the REC in the Recommended Scenario
    - It was mentioned that in the Groot Brak IUA there must be support for the removal of alien vegetation. The goal must be for the continual improvement and maintenance of the catchment. This may be incorporated into non-flow related components of the Recommended Scenario.
- **Future use and development**
    - IUAs where there are no important conservation areas, but where development needs to be maximised receive the ESBC flows in the Recommended Scenario
    - The following was also noted:
        - Water should be used sustainably to ensure the long-term availability of good quality surface water and groundwater sources in the Overberg West Coastal IUA.
        - The Riviersonderend and Overberg West Coastal IUAa have over-abstraction issues. There is also a concern about the City of Cape Town and farmers increasing their water demand. These water demands should be managed to prevent water shortages. Education focussed on saving water should be promoted throughout the IUAs.
        - The Bitou River is currently being over-used by farmers.
- **Water Quality (to be assessed under the RQO determination process)**
    - The following was noted:
        - For the Overberg West Coastal and Coastal IUAs, existing water quality in rivers and estuaries should be maintained in the good state that it is currently in and balanced against the need to develop tourism potential.
        - In the Gouritz-Olifants IUA there were some water quality issues, as water in De Rust and Dysselsdorp was not consumable from December 2016. Due to a veld fire, residents needed to get drinking water from Oudtshoorn, in the form of donations. There was also a concern that there should be maintenance in riverbeds where a dam is built. The riverbed should be kept clear of obstructions, in case of dam overflow.
        - In the Groot Brak IUA the quality of runoff must be improved, thus ensuring that there is additional water available for the Reserve and for ecological well-being.

Table 2-1 The vision themes for the Breede-Gouritz WMA by IUA

Theme		A1	A2	A3	B4	B5	C6	D7	E8	F11	F12	G14	G15	H16	H17	I18
Protection	River FEPAs and fish FEPAs should be mentioned separately in order to compile a good reflection of how much of the good water quality is from the protected areas. Conservation of water provision and biodiversity is key. PES of the entire catchment or IUA should be improved, particularly for the FEPA rehabilitation rivers/catchments.															
	Support for the removal of alien vegetation.															
Management	Over-abstraction of water is an issue. No evident improvement on water pricing strategies, resources and increasing demands and capacities.															
	Water allocation to agriculture should be maximized in order to sustain growth in the regional economy and increase job opportunities.															
	Water demands from the City of Cape Town and farmers should be managed accordingly to prevent water shortages.															
	Maintenance in riverbeds where the dam is built. Riverbed should be kept clear of obstructions in case of dam overflow.															
Future Use	Water allocation to agriculture must be maximised to sustain growth in regional economy and increase job opportunities.															
	Allowance should be made for building more off-stream dams.															
	Water use should be more sustainable to ensure long-term availability of surface water and groundwater sources.															
	Water quality and PES information should be updated. Ecological status of rivers should be improved if possible.															
	Quality of runoff must be improved to ensure ecological well-being and availability of additional water.															
	Water quality in rivers and estuaries should be maintained in the current good state.															

3 Approach

The approach used to analyse the alternative ecological and development scenarios is as follows:

1. Define the scenarios
2. Determine surface flows and ecological condition (EC) categories
3. Quantify impacts on ecosystems health and biodiversity
4. Determine impacts on available yield and water supply
5. Estimate impacts on groundwater condition
6. Quantify impacts on ecosystem goods, services and attributes
7. Determine overall socio-economic impacts

The results of the analysis (surface water; ecosystem health and biodiversity; groundwater condition; and socio economics) are then presented to Stakeholders and used to develop a final recommended classification scenario and recommended Water Resource Class for each IUA.

3.1 Scenarios Considered

The rationale for the scenario analysis was to explore the potential water supply, biodiversity and socio-economic outcomes of a range of potential classification options (ranging from high to low levels of ecosystem protection) against a range of demand contexts (current to high future water demands as projected for 2040) and climate contexts (current to future climate as projected for 2040). It is important to test classification against future demands and rainfall, since the classification choices made in this process should be robust (i.e. should remain the best choice) for the foreseeable future.

There are a large number of potential combinations of the level of protection and contexts, thus a useful and straightforward subset had to be chosen. Four levels of protection were chosen: maintaining present ecological status, the baseline (PES); reducing protection to the minimum allowable (ESBC), improving protection to the level recommended from an ecological perspective (REC), and an unconstrained option (where ecosystem health was determined by the level of water use i.e. no EC constraints). The impact of the scenarios on the costs of water infrastructure and supply of shortfalls, was evaluated against current and future demands, with the latter being the demands estimated under a high growth scenario. It is recognised that the unconstrained scenario may result in the health of some nodes dropping below the minimum acceptable level (D), but the scenario provides important insight. From these simple options, a more complex scenario approach (e.g. with varying levels of protection in different areas) was formulated together with stakeholders for inclusion in the final round of analysis.

Scenarios are developed based on the ecological condition targeted at each node under the specific scenario (e.g. improving to the REC) and its associated EWR flows at all river and estuary nodes, the flow regime (i.e. current day or impacted by climate change), the estimated water demands for the catchment (i.e. current or future), and the current or proposed future water supply infrastructure. A total of six different scenarios were considered and are summarised in Table 3-1. These included:

- Three scenarios based on specified EWR requirements for all nodes (PES, ESBC, and REC) which are then tested against both current day and future demands water demands (Scenarios 1 to 3).
- A scenario in which water demands are met first, with no EC constraints (Scenario 4)
- A future climate change scenario resulting in lower flows, i.e. dry scenario. (Scenario 5)
- A spatially-targeted recommended classification scenario (RCS) combining ecological and economic priorities (Scenario 6)

Table 3-1 Scenarios Considered

#	Scenario	Abbreviation	Description
1	Maintain Present Ecological Status ("Baseline")	PES	River and estuary systems are maintained in their present condition, or where currently in an E or F, improved to a D as far as possible.
2	Ecologically Sustainable Base Configuration (ESBC) Scenario (Bottom-line")	ESBC	The maximum volume of water is made available for abstraction from the system for economic activities, with the proviso that all water resources are just maintained in a D category (i.e. the "bottom line") where possible.
3	Recommended Ecological Categories (RECs)	REC	The RECs determined for rivers, and estuaries based on present health and conservation importance are applied in this scenario.
4	Demands prioritised without EC constraints (no EC)	NoEC	This development-focussed scenario presents the situation where the water demand for the future level of development (assuming high growth in future water demands) are met. The resulting ecological conditions are not constrained and may result in worse than a D.
5	As for Sc4, but under climate change (driest 10%) conditions	CC(10)	The shifts that climate change might cause to the ecological conditions of nodes across the study area was assessed by modelling catchment flow changes relative to current day for "drying" climate scenario.
6	Spatially-targeted Scenario	STS	Based on spatial considerations of priority objectives resulting in a blend of targeted ECs for all nodes ranging between REC and ESBC. The impacts of this scenario are tested against future water demands only.

In the first four scenarios, the implications for the costs of water supply are tested under both: (a) the current level of economic development and (b) projected future demands (2040) under a high growth scenario. In Scenario 5 and 6, they are only tested against the projected future high growth demands.

3.1.1 Ecology-driven Scenarios (1, 2 and 3)

The primary consideration in determining the recommended classification scenario for the WMA is the impact of alternative ecological water requirements (EWRs) across all nodes as a function of the ecological category (EC) targeted under that specific scenario. In order to evaluate these impacts, three EWR driven scenarios were considered. Under each scenario the implications for ecosystem health and ecosystems goods, services and attributes (EGSAs) were evaluated as well as the impact on the costs of water supply. The impact on water supply takes into account two alternative demand scenarios: (a) the current level of economic development and (b) projected demands under a high growth scenario.

3.1.2 Demand-driven, Unconstrained (No EC) Scenario (4)

This scenario considers the impact of future development on the resulting ecological condition at all nodes with no constraints applied in terms of making water specifically available for environmental flows. The future unconstrained scenario takes into account all current planned future development options.

3.1.3 Demand-driven, Unconstrained, Climate Change Scenario (5)

The shifts that climate change might cause to the ecological conditions of nodes across the study area was assessed by modelling catchment streamflow changes relative to current day for the 90th percentile case selected from the "drying" side of the spectrum of outcomes from a wide range of climate change impact models for different emission scenarios (Cullis et al, 2015) covering the whole of South Africa. For every node the proportional mean monthly streamflow changes under the CC (10%) scenario was superimposed on the current day mean monthly streamflow values at that node. These changed nodal mean monthly streamflow values were then input to the basin configuration tool and used to evaluate the impact of climate change ecological condition.

3.1.4 Spatially-targeted Scenario (6)

The five scenarios described above are all based on a catchment-wide WMA wide approach to setting the EWRs for all nodes across the catchment. For some of them, for example the REC scenario, consideration was given to ecologically important areas and some consideration given to the present ecological conditions and current and future development concerns, this will not necessarily be the preferred future scenario for all stakeholders. In order to achieve this, it is important to consider a spatially distributed solution, where different priorities can be recognised in different parts of the WMA. For example, some areas will be considered to be more ecologically or socially important and should be given a high ecological condition, e.g. the REC scenario, while in other areas it is recognised the future development is important and the ecological condition (EC) should be closer to the ESBC scenario to allow for future growth in water demands.

Determining the final balance of targeted ecological conditions across the WMA, requires consultation with the Stakeholders. To achieve this, the results of the analyses of the initial six scenarios were considered and compared with the specific development objectives and vision scenarios for each IUA as provided by members of the Project Steering Committee (PSC). A proposed classification configuration (the "Spatially-targeted Classification Scenario") was then developed by the project team in consultation with key stakeholders at workshops on 29th November 2017, 12th-16th March 2018 and 19th April 2018. These workshops, and feedback therein, was used to fine-tune the final classification scenario, which was termed the Spatially Targeted Scenario (STS).

The assessment of this scenario is covered in Chapter 6.

3.2 Determining the surface water flows for scenarios

3.2.1 Natural and present-day conditions

The Water Resources of South Africa, 2012 (WR2012) Pitman rainfall-runoff catchment model configurations (Water Research Commission, WRC, 2016) were used to support the various specialist tasks and the scenario analyses in this study. In summary, the WR2012 Pitman configurations for natural and current-day catchment conditions (with rainfall inputs covering the period 1920/21 – 2009/2010) were obtained and scrutinised for correctness.

A number of anomalies or inadequacies were evident; therefore, at a number of locations there were refined or corrected in terms of the bulk infrastructure details, farm dam details, return flows from treated effluent and current day water requirement details. Some components and links of some of the model networks were also modified and improved. These improved configurations were then further sub-divided to reflect the river and estuary nodes identified in this study.

Natural and present-day monthly flow sequences (each 90 year in length) were then generated at all the river and estuary nodes by means of the above modified WR2012 Pitman model configurations. This is described in detail in the "*Linking the Value and Condition of the Water Resource*" Report (DWS, 2017a).

3.2.2 High future (2040) demands with and without EC constraints

The projected 2040 "high-growth" water demands were super-imposed on the present-day model configurations and monthly flow sequences (each 90 year in length). The 2040 urban/industrial surface water requirements for all towns throughout the WMA were sourced from the "*Situation Assessment Report"* produced as part of the Breede-Gouritz Catchment Management Strategy Study (Golder, 2016), which is the most-updated information readily available except for larger municipalities (i.e. Bitou, Knysna, Greater George, Greater Mossel Bay, Oudtshoorn and Worcester) where the projections were based on recent planning and/or feasibility studies of individual water supply schemes, which accounts for about 50% of the total water requirements projected for the WMA. Municipalities representing 90% of the projected water volumes being used for the range of urban centres or communities that resort under them, were invited to confirm the projections, or alternatively to comment or to provide alternate water projections.

Table 3-2 presents both low-growth and high-growth water requirements for all towns for which increased surface water abstraction is indicated in the BGCMA (2016) report. In the unconstrained scenario, the model was then used to simulate the monthly flow volumes at each node used to determine the ecological category for each scenario. In the constrained scenario, it was used to determine the shortfall in supply, if any. In addition to those developments listed in Table 3.2, a small number of towns were identified from All Towns data and other relevant sources, for which future demand is to be met by groundwater (alone). This includes the future planned groundwater development for the City of Cape Town, planned for catchments within the Breede area. These groundwater requirements were in the high future (2040) demands, when assessing their impact on groundwater (section 3.5). Many of the developments listed in BGCMA (2016) report to be supplied by surface water, are listed in the All Towns data as being recommended to use groundwater. Given the BGCMA (2016) report was used to inform the surface water developments applied in the surface water model, the scenarios reflect maximised surface water use and therefore maximised direct impact on ecosystem health and biodiversity.

The increase in treated effluent due to increased urban/industrial water use was also included in the 2040 simulations as this was specifically relevant to some estuary nodes. This resulted in increased flows downstream of these towns, which then supported any unmet water abstractions further downstream.

NB: It should be noted that the impact of a low-growth scenario on the ecological condition was assessed for nodes in the Gouritz region. For the vast majority of nodes there was no change in ecological condition from the present day. Hence, it was decided that only the high-growth scenario would be taken further.

It was assumed that future increases in irrigation water allocations will be allowed by DWS for increased allocations from Brandvlei Dam, through increased capacity for the Smalblaar-Holsloot diversions as well as for the Papenkuils pump station in the Breede River and additional irrigation allocations from a raised Gamkapoort Dam in the Gouritz system. This is consistent with DWS policy on future allocations to agriculture as defined in the National Water Resource Strategy (NWRS). In addition, it is possible that small-scale agricultural development may take place in small chunks throughout the WMA. Such dispersed irrigation development could have an influence on rural populations, although much of the labour would be seasonal, and difficult to plan for. The influence that such potential small-scale development can have on the growth rates of rural populations are currently not known, although the influence would likely be within the level of uncertainty associated with the forecasted growth rates.

Table 3-2 Projected urban/industrial water requirements by 2040 for all towns for which increased surface water abstraction is indicated in Golder (2016)

IUA	Location	Current Water Requirements (million m^3/a)	Low Growth Water Requirements (million m^3/a)	High Growth Water Requirements (million m^3/a)
G15	Knysna	4.0	6.4	8.8
G15	Bitou	3.8	5.4	8.1
G15	Greater George	12.3	18.9	27.8
G14	Mossel Bay	6.8	9.1	14.9
F12	Heidelberg	0.4	0.6	1.0
F11	Riversdale	1.6	1.9	3.7
D7	Oudtshoorn	6.0	7.2	11.6
D7	Uniondale	0.2	0.4	0.6
E8	Ladismith	1.1	1.1	2.1

IUA	Location	Current Water Requirements (million m^3/a)	Low Growth Water Requirements (million m^3/a)	High Growth Water Requirements (million m^3/a)
E8	Touws River	0.9	0.9	1.4
C6	Calitzdorp	0.5	0.6	0.9
C6	Beaufort West	2.6	2.6	3.8
D7	Prince Albert	0.3	0.3	0.5
B5	Grabouw	1.3	1.4	2.6
H16	Rooi Els/Pringle Bay/ Betty's Bay	1.4	2.1	12.5
F10	Caledon	1.6	1.8	3.1
F10	Bredasdorp	1.0	1.1	2.0
H16	Kleinmond	1.1	1.6	4.1
H16+H17	Greater Hermanus	4.3	6.7	12.9
H17	Gansbaai	1.8	3.4	12.3
A2	Barrydale	0.3	0.3	0.7
F11	Swellendam	1.4	1.5	2.4
B4	Villiersdorp	0.4	0.4	0.8
F10	Genadendal, Greyton, etc.	0.3	0.3	0.6
F9	Riviersonderend	0.4	0.4	0.8
A3	Ashton	2.4	2.5	4.8
A2	Montagu	1.0	1.1	2.0
A3	Robertson	2.2	2.4	3.9
A3	McGregor	0.2	0.2	0.4
A3	Bonnievale	1.2	1.3	2.5
A2	De Doorns	0.7	0.7	1.4
A2	Worcester	13.6	17.0	23.0
A1	Wolseley	1.3	1.4	1.7
A1	Rawsonville	0.3	0.3	0.5
A1	Ceres	4.2	4.6	8.8
A1	Prince Alfred Hamlet	0.4	0.5	1.0

To cater for the increased urban/industrial and the aforementioned irrigation water requirements under the high-growth scenario, we included a number of planned new bulk surface water supply augmentation schemes, as fully implemented by 2040. These are outlined in Table 3-3. These details were gleaned from recent planning reports regarding these schemes (Aurecon, 2009; 2012; 2014; 2017; Golder, 2016).

Table 3-3 Planned bulk surface water supply infrastructure augmentation schemes in place by 2040

IUA	Recipient	Details
G15	Bitou	Off-channel Wadrif Balancing Dam receiving 3.0 million m^3/a through increased pumping from the Keurbooms River. New groundwater scheme supplying 1.8 million m^3/a.
G15	Knysna	Augmented Charlesford pump station on the Knysna River delivering 3.3 million m^3/a to the planned Concordia Balancing Dam.
G15	George	Raised Garden Route Dam - additional 2.5 million m^3/a supply. New Malgas River Dam – additional 7.0 million m^3/a supply. Re-use of treated effluent Phase 2 – additional 2.3 million m^3/a.

IUA	Recipient	Details
D7	Oudtshoorn	New Kombuis Dam with FSC of 15 million m^3 on the Grobbelaars River.
C6	Gamka Irrigation Board	Raised Gamkapoort Dam FSC from 37 to 98 million m^3.
H17	Hermanus	Raised De Bos Dam or new dam to provide 1.7 million m^3 additional capacity.
H16	Rooi Els, Pringle Bay, Betty's Bay	Raised Buffels River Dam or new dam to provide 2.8 million m^3 additional capacity.
A1	Voëlvlei Dam inter-basin transfer	Maximum capacity of the planned Michell's Pass diversion on the Breede River to Voëlvlei Dam in the Berg River catchment set at 36 million m^3/a.
A2	Breede River irrigators	Increased allocations from Brandvlei Dam through increased capacity for the Smalblaar-Holsloot diversions as well as for the Papenkuils pump station, totalling 51 million m^3/a.

3.2.3 Climate change Scenario

Potential changes to surface water availability due to climate change over the whole of South Africa were examined by Cullis *et al* (2015) by application of more than 300 climate change impact models for different carbon emission scenarios. For this study, the quaternary catchment flow changes relative to current day for a relatively severe "dry" scenario - the 10th percentile case - were selected from the "drying" side of the spectrum of outcomes for the Study area from Cullis (2015). For every node the proportional mean monthly flow changes ("deltas") under the CC (10) scenario were then super-imposed on the current day mean monthly flow values at that node. These changed nodal mean monthly flow values were then input to the basin configuration tool and used to determine the impact on ecological condition.

3.3 Ecosystem Health and Biodiversity

3.3.1 Rivers

The basin configuration or balancing tool was used to construct the three ecological category scenarios, maintain PES (baseline), ESBC and REC by loading the required ecological conditions into the tool and reporting, as outputs, the changes in flow required to sustain the ecological conditions at each node relative to present-day flows. The "balancing tool" calculates changes in ecological condition at a specific node, relative to the baseline (i.e. PES), in response to changes in the average annual, monthly and seasonal flow. An overview of the construction of the tool and how it works is provided below.

Changes in ecological condition and water quantity were translated into consequences for water quality, goods and services, wetlands linked to rivers and economic costs. The basin configuration tool was also used to understand the outcome of the high-growth future water requirements and the climate change scenarios by loading the corresponding monthly flow time series into the balancing tool and reporting the changes in ecological condition at each river and estuary node.

Overview of the *basin configuration tool*

The basin configuration tool (hereafter called the **tool**) is an Excel-based model that was programmed to route flows through the river nodes to the estuaries; nodes represent various points of interest in the study area. As such, the tool is a hydrological model that was created to model how changes in flow affect the ecological condition of rivers and estuaries, the two primary water resources where data from past Ecological Reserve studies are readily available. To achieve this, the tool calculates the ecological condition of rivers (at the nodes) and estuaries as the flows are increased or decreased, relative to flows of the current day.

It is important to note that the Ecological Reserves for rivers and estuaries were calculated based on percentage change from natural flows, *viz.* NOT relative to present-day flows.

There are various inputs into the tool, some of which are related to the programming that runs in the background. Technical programming is not discussed here. The following description deals with the main inputs used to construct the ecological scenarios (at each node):

- The location of each node geographically in the study area relative to the other nodes, up- and downstream respectively;
- The ecological condition of each river and estuary node;
- Naturalized hydrological monthly time series data (cumulative and incremental flows), calculated as volumes in Million Cubic Meters (MCM);
- Present-day hydrological monthly time series data (cumulative and incremental flows), calculated as volumes in MCM; and
- Hydrological monthly Ecological Reserve time series data (cumulative and incremental flows), calculated as volumes in MCM for a range of ecological conditions.

The location of each node, relative to the others, is important in the tool as flows are linked together in a downstream direction toward their receiving estuary. In some cases, there are a large number of nodes that are linked together in a network of tributaries and river channels of various orders, such as in the Breede and Gouritz River systems. In other cases, there are few, sometimes one, river node upstream of the estuary on one river channel, for example the Onrus and Bot Rivers in the Overberg; there are variations in between these two extremes. Whatever the case, for each receiving estuary, the different flows (listed above) associated with each node, the location of the node in the river network and its ecological condition are loaded into the tool (Excel spreadsheet).

The nodes are listed in a downstream direction with the distal nodes listed first. The tool calculates the cumulative flows in a downstream direction for each node by taking into account which nodes deliver flow from upstream. In short, for each node, the tool calculates and reports what the cumulative present-day flows are. This is the primary data source against which all other flow calculations are made. The next main source of data for the flow calculations are the Ecological Reserve flows; provided for a range of ecological conditions where rivers and estuaries in better condition maintain higher levels of flow.

The Ecological Reserve flows were calculated using naturalized hydrological time series data for each node in the Desktop Model that calibrates Ecological Reserve flows based on flow sequences from Ecological Reserve studies, or the use of region-specific settings. The model only calculates intra-annual flows, *viz.* flows that include the small intra-annual floods (that occur every year) and excludes the larger inter-annual floods (1:2, 1:5, 1:10 etc.). Therefore, in order to compare various Ecological Reserve flows to the naturalized and current hydrological time series, which are TOTAL flows (inclusive of all floods), it was necessary to first put back the inter-annual floods into the Ecological Reserve hydrological time series' prior to any comparative calculations.

The starting point for calculations that compare the hydrological outcome of setting Ecological Reserve flows at a location or interest (node) therefore are naturalized, present-day and Reserve TOTAL flow time series.

The other data source of importance to the tool, and the necessary scenario calculations, is the present ecological status of each node. This is the baseline ecological condition of each (river and estuary) node, taken from the 2014 PES EIS data base (DWS 2014a). The data gathered for the study area, in this case, were derived from field studies. Thereafter, all the PES/EIS data of the Gouritz River and Coastal region were reviewed and updated by the Gouritz River Ecological Reserve team (DWS 2014b).

The links between flow and ecological condition were programmed into the tool based on a number of standard assumptions common to environmental flow studies in general, including:

- Ecological conditions were ranked into groups designated different ecological categories (Kleynhans and Louw 2007)

- Present-day and Ecological Reserve flows were ranked into groups designated different flow categories, based on their % differences to naturalized flow
- Changes in flow were linked to changes in ecological condition in a non-linear manner such that rivers/estuaries in good ecological condition were more responsive to changes in flow, whereas rivers/estuaries in poor ecological condition were less responsive to changes in flow
    - the premise being that poor ecological conditions often result from a combination of impacts, not just flow alone, and where this is the case an improved ecological condition requires multiple interventions, not flow manipulation alone

The interface of the tool is:

- a list of nodes, associated with
    - incremental nodes that contribute flow at that point
    - river names
    - their location per quaternary and integrated unit of analysis (IUA)
    - the present ecological status (baseline ecological condition)
    - the recommended ecological category at river and estuary Ecological Reserve study sites
- a program button per node that allows the user to change flow routed at each node:
    - present-day
    - Ecological Reserve flows for different ecological categories

The user works from the various estuaries in an upstream direction, loading different flow volumes at each node and while doing so, the tool calculates how the cumulative flows at each node downstream changes, relative to current day flow, and calculates whether this relative change is sufficient, when compared to the flow sustaining the baseline ecological condition (current day), to improve the ecological condition of the water resource at that node, if flows are increased relative to present-day, or degrade in response to decreases in flow. As flow, and resulting ecological conditions change, the results calculated to aid interpretation per node were:

- Present ecological condition;
- Scenario ecological condition;
- Present-day annual flow volume as a percentage of MAR;
- Scenario annual flow volume as a percentage of MAR;
- Cumulative current day annual flow volume in MCM;
- Scenario cumulative annual flow volume in MCM;
- Surplus/deficit annual flow volume relative to present-day;
- Present-day wet season average monthly flow volume as a percentage of MAR;
- Present-day dry season average monthly flow volume as a percentage of MAR;
- Seasonal scenario ecological condition (rivers only);
- Scenario wet season average monthly flow volume as a percentage of MAR; and
- Scenario dry season average monthly flow volume as a percentage of MAR.

3.3.2 Wetlands

There is little quantitative information relating ecosystem response to changes in flow in wetland systems. Although the Ecological Reserve Determination method is being used for floodplains and lakes, there is still no formal template available for other wetland types (Rountree et al., 2006). The management of wetland Ecological Reserves is also difficult as the hydrological dynamics of a wetland are not easily identified or controlled (Rountree *et al*., 2006). While some wetland systems such as floodplains and channel wetlands tend to rely primarily on surface and sub-surface water flows, others, such as seeps and some marginal wetlands around floodplains, rely primarily on groundwater inputs. The management of a groundwater Reserve is far more difficult than that of a surface water Ecological Reserve. Linkages between (close) groundwater abstraction and water level in the wetland are more difficult to determine than is the case for river systems.

The Status Quo report (DWS, 2016c) defined the Wetland Regions within the study area according to the spatial framework of Ecoregions. Nested within Wetland Regions are the Wetland Resource Units, defined by vegetation type and Hydrogeomorphic (HGM) unit and prioritised according to Ecological Importance and Ecosystem Services. As the HGM unit is defined by landform it is important to understand the location of a wetland in the landscape and the underlying geological controls.

Defining the Wetland Regions provides a foundational understanding of the controls of wetland formation in the study area. Typical wetland types found in each Wetland Region are as follows:

- Western Folded Wetland Region (WR1)
  - Typically valley bottom and floodplain wetlands
- Coastal Southern Folded Wetland Region (WR2)
  - Typically seeps and depression wetlands as well as valley bottom and floodplain wetlands
- Southern Coastal Wetland Region (WR3)
  - Typically valley-bottom wetlands and seepage wetlands
- Coastal Sediment Wetland Region (WR4)
  - Wetlands are infrequent, possibly due to deep infiltrating soils and a lack of shallow/perched water tables. Inter-dune depressional wetlands and present suggesting groundwater contributions
- Nama Karoo Wetland Region (WR5)
  - Typically small seeps and river-linked wetlands
- Great Karoo Wetland Region (WR6)
  - Typically seeps with a likely high degree of groundwater dependence
- Cape Fold Wetland Region (WR7)
  - Typically small seeps associated with groundwater-fed springs
- Southern Folded Wetland Region (WR8)
  - Typically small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence
- Southern Cape Folded Wetland Region (WR9)
  - Typically seeps and depressions as well as river-linked wetlands
- South East Coastal Wetland Region (WR10)
  - Typically valley bottom wetlands
- Sedimentary Lakes Wetland Region (WR11).
  - Typically lakes and wetland flats

From an RDM perspective, important wetlands include those that have both ecological importance for the maintenance of biodiversity ecosystem integrity, as well as those that provide ecosystem services. In terms of ecosystem services, wetland prioritisation needs to consider both the ability of a wetland to provide services as well as the demand for such services within the catchment. These two aspects define the importance of wetlands in terms of ecosystem services.

The prioritisation of Wetland Resource Units occurs within each Wetland Region, and is based on those wetlands that have been defined as important in terms of ecological importance and for provision of ecosystem services (Figure **3-1**).

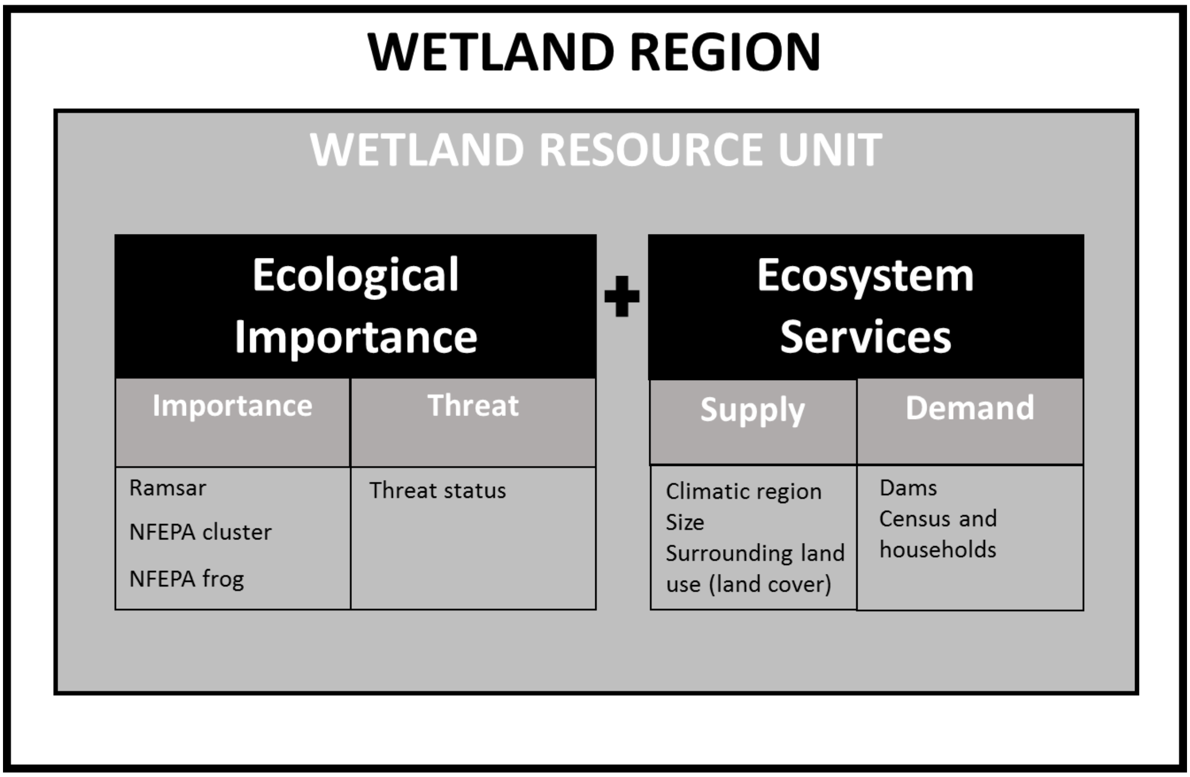

Figure 3-1 Conceptualisation of how Wetland Resource Units are nested within Wetland Regions

The methodology proposed for assessment is therefore as follows:

- Wetland Resource Units will be assessed qualitatively at individual river/estuary nodes in terms of impacts from surface and groundwater usage
- Wetland Resource Units will be assessed qualitatively at the catchment scale for all scenarios in terms of indirect impacts

3.3.2.1 Surface and groundwater usage impacts to wetlands

According to MacFarlane *et al.* (2009) hydrology, in terms of the movement of surface and subsurface water into, through and out of a wetland, is a key component of assessment of wetland health. The hydrological condition of a wetland impacts many important processes, including anaerobic conditions in the soil, availability of nutrients and other solutes and sediment fluxes; which in turn influence which fauna and flora inhabit a wetland. Hydrology of a wetland may be altered through human modifications (in terms of quantity and timing of water inputs) to the wetland catchment; as well as through direct modifications to the wetland which alter the distribution and retention patterns of water within the wetland.

Sensitivity to changes in hydrology is different depending on the wetland type, in general the characteristics of wetland types in terms of hydrology are as follows:

- **Floodplains**

  Floodplains generally receive most water during high flow events when waters overtop the streambank. They are considered important for flood attenuation because of the nature of vegetation and topographic setting. Flood attenuation is likely to be high early in the season until the floodplain soils are saturated, whilst in the late season flood attenuation is reduced. The nature of clayey soils in floodplains means that soils retain water, thus limiting contribution to streamflow and groundwater recharge. As flood waters overtop streambanks the waters drop sediments, and nutrient bound sediments, which are left behind to accumulate.

- **Channelled valley-bottom wetlands**

  Channelled valley-bottom wetlands have less active deposition than floodplains and tend to be narrower with steeper gradients. Groundwater input to the main stem channel is also generally greater.

- **Non-channelled valley-bottom wetlands**

  Stream channel inputs are spread diffusely across the wetland even at low flows, resulting in high levels of soil organic matter. This aids nitrate and toxicant removal, particularly if there is groundwater contribution.

- **Hillslope seep wetlands**

  Normally associated with groundwater discharge, although there are additional contributions from surrounding runoff. Contribute streamflow regulation early in the season, until soils are saturated. Good provision of nitrate removal, but poor at erosion control owing to location on steep slopes.

- **Depressions (pans)**

  Can receive both surface and groundwater flows, which accumulate in the depression owing to the impervious underlying layer which prevents water from draining away. Temporary pans allow for the precipitation of minerals, although these deposited minerals can be transported out of a system by wind.

- **Flats**

  A wetland flat is not fed by water from a river channel, and is typically situated on flat land (often on a coastal plain). The primary source of water is precipitation, although on coastal plains groundwater may rise to or near the ground surface. Water typically exits via evapotranspiration and infiltration.

3.3.2.2 Indirect impacts to wetlands

Indirect impacts to wetlands are linked to future development scenarios unrelated to water use. Future development is likely to include increased population density and associated infrastructure growth in urban/agricultural areas. A change or intensified land use would impact the hydrology, geomorphology and vegetation of wetlands. Increased hardened surfaces would increase the surface water contribution to wetlands due to the increased stormwater discharge. Wetland vegetation health may change completely through transformation for the development of infrastructure, substantially for croplands/plantations or moderately for abandoned lands. Increased development would also increase or decrease the input of sediment to wetlands. Reduction of sediment inputs through the development of upstream dams, or increasing sediment through increased upstream erosion would impact the geomorphological stability of wetlands.

Particular threats and sensitivity to change are as follows:

- **Floodplains**

  Upstream dams, or dams within wetlands as well as channel straightening and infilling through construction of bridges or through wetland “reclamation” are the greatest impacts in floodplains. Floodplains are generally resilient to changes in sediment inputs as the system is dominated by fluvial processes. The main impact will be when harmful erosion is occurring due to a change in the natural dynamic (i.e. dam upstream removing sediment). Floodplain size, and manner of releasing water back into the wetland is also important.

- **Channelled valley-bottom wetlands**

Channel straightening and infilling through construction of bridges or through wetland "reclamation" are the greatest impacts in channelled valley-bottom wetlands. Changes in runoff characteristics and erosional, depositional features and loss of organic material are also important. Channel straightening steepens channel slope, and thus promotes headward erosion. The effect of headward erosion will be attenuated over a longer distance. The infilling of a wetland confines flow and geomorphic activity to a localised area.

- **Non-channelled valley-bottom wetlands**

  Changes in runoff characteristics through increased stormwater inputs and increased erosional/deposition are important in non channelled wetlands.

- **Hillslope seep wetlands**

  The location on slopes means that hillslope seeps are sensitive to erosion. Habitat transformation through agricultural use is also likely.

- **Depressions (pans) and Flats**

  Depression wetlands and Wetland flats are sensitive to increased stormwater inputs as this impacts the seasonality of the wetlands. Habitat transformation is also likely.

3.3.2.3 Present Ecological Status and Environmental Importance and Sensitivity of wetlands

A preliminary Ecological Reserve has been set for the Papenkuils wetland, which is a floodplain wetland and the Duiwenhoks and Bitou Floodplain wetlands were selected as priority wetlands for the Gouritz preliminary Ecological Reserve (DWS, 2015). The Duiwenhoks and Bitou Floodplain wetlands assessments provided Ecological Importance and Sensitivity (EIS) and Present Ecological Status (PES) results, but a list of 31 other priority wetlands was also assessed in terms of characteristics, major threats and rehabilitation recommendations. A coarser, quaternary scale assessment was also provided for the Gouritz area indicating the PES, EIS and REC of wetlands per catchment.

Further detail on the PES and EIS of wetlands in the study area is available through a study by Malan et al. (2015), which also looked into the changes in water chemistry in the wetlands, and the Working for Wetlands programme. These projects looked at specific wetlands within the study area.

3.3.3 Estuaries

3.3.3.1 Determining ecological category

Ecological categories for PES, REC and ESBC were predetermined for all estuaries in the study area. In the case of ESBC this was set at a "D" for all estuaries, except where nodes upstream of the estuary required more flow than this to maintain them in a D category, while in the case of PES and REC this was determined through rules contained in the manual for determination of the Ecological Reserve for estuaries (DWA 2012, Table 3-4-Table 3-6).

Table 3-4 The Estuary Health Index used to estimate the overall Estuary Health Score, giving an example in italics. Source: DWA (2012)

Variable	Weight	Score
Abiotic (habitat) variables		
Hydrology	25	41
Hydrodynamics and mouth condition	25	80
Water quality	25	59
Physical habitat	25	80
1. **Habitat health score** = weighted mean	**50**	**65**
Biotic variables		

Variable	Weight	Score
Microalgae	20	60
Macrophytes	20	60
Invertebrates	20	70
Fish	20	60
Birds	20	90
2. Biological health score = weighted mean	**50**	**70**
ESTUARY HEALTH SCORE = weighted mean of 1 and 2		**68.5**

Table 3-5 Estuary Health Index (EHI) score and Present ecological status (category) - Present Ecological Status (PES) of an estuary based on an integrity score which indicates Present State as a percentage of pristine state. Source: DWA (2012)

Estuary Health Index (EHI) score	Present ecological status	Description
100 - 91	A	Unmodified, natural
76 – 90	B	Largely natural with few modifications
61 – 75	C	Moderately modified
41 – 60	D	Largely modified
21 – 40	E	Highly degraded
0 – 20	F	Extremely degraded

Table 3-6 Rules for to deriving Recommended Ecological Category (REC) for an estuary based on estuary importance and PES. Source: DWA (2012)

		PES			
		A	**B**	**C**	**D, E or F**
Estuary importance	**Protected or desired protected status**	A or BAS	A or BAS	A or BAS	A or BAS
	Highly important (80 – 100)	A	A	B	C
	Important (60 – 80)	A	A	B	C
	Of low to average importance (0 – 60)	A	**B**	C	D

BAS = Best Attainable State

For scenarios 4 (no EC constraints) and 5 (no EC constraints with climate change) the Ecological Category (EC) for each estuary was determined using modelled relationships between %MAR and EC that were developed for this study and have been included in the basin configuration tool (Figure 3-2). The reader is referred to Volume 7 of this report series (Report no. RDM/WMA8/00/CON/CLA/0217: Quantification of the EWR and changes in EGSAs) for more details on this.

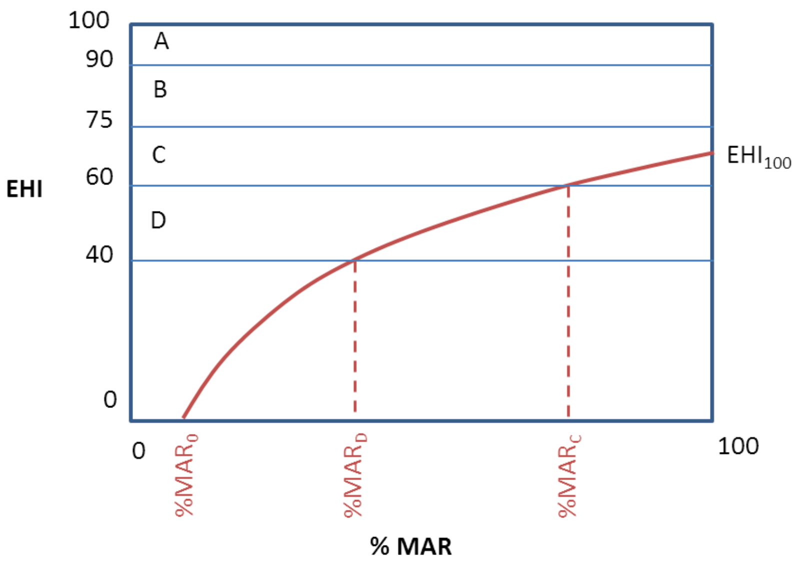

Figure 3-2 **Relationships between %MAR and estuary health (EHI) for the (typical) situation where flows are reduced compared to natural (Turpie in prep., DWS 2017)**

3.3.3.2 Biodiversity changes associated with a change in ecological category

Biodiversity changes associated with a change in ecological category were estimated using a suite of response curves for each estuary that describe the relationship between estuary health (as defined by the Estuary Health Index, EHI) and the individual biotic components of the EHI score. Positive correlations were found to exist between the EHI fish health, bird health and macrophyte health (see Quantification of the EWR and changes in EGSAs Report– DWS 2017). Using these relationships, matrices were created that allow for prediction of proportional changes in fish, bird and macrophyte abundance with changing EHI class (Table 3-7, Table 3-8 and Table 3-9).

Table 3-7 **Matrix of proportional changes between Present Ecological State and Assigned Ecological Category used to model changes in Macrophyte Habitats**

		Assigned Ecological Category					
		A	**B**	**C**	**D**	**E**	**F**
PES	**A**	1.0	0.9	0.7	0.5	0.3	0.1
	B	1.2	1.0	0.8	0.6	0.3	0.1
	C	1.4	1.2	1.0	0.7	0.4	0.1
	D	2.0	1.7	1.4	1.0	0.6	0.1
	E	3.5	3.0	2.5	1.8	1.0	0.2
	F	16.1	13.9	11.2	8.1	4.6	1.0

Table 3-8 **Matrix of proportional changes between Present Ecological State and Assigned Ecological Category used to model changes in estuarine fish populations**

		Assigned Ecological Category					
		A	**B**	**C**	**D**	**E**	**F**
PES	**A**	1.0	0.9	0.7	0.5	0.3	0.0
	B	1.2	1.0	0.8	0.6	0.3	0.1
	C	1.4	1.2	1.0	0.7	0.4	0.1
	D	2.0	1.7	1.4	1.0	0.5	0.1
	E	3.7	3.2	2.6	1.8	1.0	0.2
	F	23.0	19.8	15.9	11.3	6.2	1.0

Table 3-9 Matrix of proportional changes between Present Ecological State and Assigned Ecological Category used to model changes in estuarine waterbird populations

		Assigned Ecological Category					
		A	**B**	**C**	**D**	**E**	**F**
PES	**A**	1.0	0.9	0.7	0.5	0.3	0.1
	B	1.2	1.0	0.8	0.6	0.4	0.1
	C	1.4	1.2	1.0	0.7	0.4	0.1
	D	1.9	1.7	1.4	1.0	0.6	0.2
	E	3.2	2.8	2.3	1.7	1.0	0.3
	F	10.4	9.0	7.3	5.4	3.2	1.0

These matrices were applied to fish, bird and macrophyte abundance data for each estuary derived from the National Biodiversity Assessment (NBA) (Turpie et al, 2012). While these data are not the most recently collected data for each estuary, the dataset provides the only complete and consistently collected dataset across the country. This dataset includes areas of different estuarine macrophytes groups including inter- and supratidal saltmarsh, submerged macrophytes and reeds and sedges.

Fish data included total numbers of individuals in 84 different species as well as numbers of over-exploited or collapsed species (Table 3-10). Bird data included total bird numbers by species (n = 35 species) as well as numbers of individuals in red-data species such as Great White Pelican, Great Flamingo, Lesser Flamingo and African Black Oystercatcher.

Table 3-10 List of over-exploited or collapsed fish species occurring within the Breede and Gouritz WMAs

Species	Common Name
Argyrosomus japonicus	Dusky Kob
Lithognathus	White Steenbras
Pomadasys commersonnii	Smallspotted Grunter
Rhabdosargus holubi	Cape Stumpnose
Diplodus capensis	Cape White Seabream
Rhabdosargus globiceps	White Stumpnose
Myxus capensis	Freshwater mullet

For the NBA for South Africa, biodiversity targets were set for estuarine species and habitats (Turpie et al. 2012). Targets for estuarine macrophytes such as saltmarsh, reeds and sedges were set at 20% of their natural extent conserved for each different habitat type (Turpie et al. 2012). Population targets for fish and bird species under conservation were set at 50% for red-data species/over-exploited species, 40% for exploited species and 30% for the rest (Turpie et al. 2012). The aim was to secure protection status for target populations for each of these groups (macrophytes, fish and birds) by establishing a protected area network comprising of the minimum number of estuaries required to achieve this target.

The primary analysis undertaken for the NBA (Turpie et al. 2012) identified 133 estuaries that would need to be incorporated into a national network of protected estuaries to meet biodiversity targets defined for this study, some of these were already partially or wholly protected. In all, 61 were identified as requiring full protection (i.e. 100% of the estuarine habitat to be protected) and 72 as requiring partial protection (at least 50% of estuarine habitat to be protected). This amounted to about 46% of the total number of estuaries in the country and 79% of estuarine area.

While protecting the estuaries themselves help meet these goals, the condition of the protected estuaries was not taken into consideration, although this clearly also plays a role in determining whether or not these biodiversity conservation goals are met (note that it was simply assumed for the purposes of the NBA study that any estuary under conservation would be maintained in a good state of health – mostly “A” or “B” category). However, since the flow of water into these estuaries plays a large role in determining their health, it is also important to consider how the contribution of the Breede-Gouritz WMA estuaries might change under different flow scenarios in the absence of any changes to the protection status.

Thus, for the purposes of this study we examined how the total amount and quality of estuarine habitat would change and how populations of priority species (fish and birds) in the individual IUAs and in the Breede Gouritz WMA as a whole would change relative to present day under the different scenarios evaluated in this classification study and also how these indicators would change for the priority estuaries selected in the NBA (Turpie et al. 2012).

3.3.4 Water Quality

The current status of water quality was described in the *Status Quo Report* in terms of the level of compliance of observed key water quality parameters with various standards for water quality. In the analysis of scenarios, the potential impact of each scenario on water quality status in each IUA is evaluated based on the anticipated changes in flow and the considered impact that this will have on water quality. The terminology used to describe water quality is equivalent to the terms used in the *Status Quo Report*. Fitness for use is described using four water quality categories, namely Ideal, Acceptable, Tolerable, and Unacceptable. The terms were defined as follows (DWAF, 2006):

Category	Explanation
Ideal	The water quality is ideal for all uses and poses no health risk, aesthetic risk, no reduction in yield for agricultural crops, and no impact on aquatic ecosystems.
Acceptable	The water quality may have a slight health risk for sensitive individuals and noticeable aesthetic effect but not objectionable for domestic water users. For recreational users there may be a slight health risk for sensitive individuals. For agricultural users, only sensitive crops may be affected. For aquatic ecosystems some chronic effects may occur in sensitive species.
Tolerable	For domestic users there may be slight health risk for most individuals and objectionable aesthetic effect to sensitive persons. For recreational users, minimal health risk, and slight health risk for most individuals. For agricultural users there may be minimal health risk and some yield loss can be experienced.
Unacceptable	For domestic users there may be significant health risk with short-term exposure and the water will be aesthetically unacceptable. For recreational water users there will be severe health risk and the water will be aesthetically unacceptable. For agricultural users the economic viability of irrigation will be questionable. For aquatic ecosystems, species diversity will be significantly reduced and community as a whole will be compromised.

3.4 Water Availability and Supply

3.4.1 Definition of yield as average annual water supply

In a water resources augmentation context, surface water yield is generally expressed as the maximum annual withdrawal at a specific annual assurance (as %) of supply (also expressed as recurrence interval in years of failure of supply). No Water Resources Yield Model (WRYM) configurations were available for the Breede-Gouritz WMA (except a few local sub-system setups). Hence, the surface water modelling was undertaken with the available WR2012 Pitman rainfall-runoff catchment model configurations for the WMA.

For this study, yield is defined as the average annual water supply, expressed as 12 monthly averages. This definition meets the requirements of the basin configuration tool methodologies used for the ecological condition determinations under the different scenarios formulated for this study, as well as for the concomitant economic analyses.

3.4.2 Surface water

The modelled flows were compared with the flows required under the alternative ecological category scenarios, ESBC and REC, and the deficit/surplus relative to the required ecological flows calculated. Additional water supply sources were then identified to meet any deficits. In most cases, groundwater was the most plausible additional water resource, but in a few cases along the coast new regional schemes or seawater desalination were the next plausible interventions.

Surface water flows were also determined under projected 2040 water requirements (under a high-growth scenario) with planned additional bulk infrastructure in place to meet some of the increased demands. In cases where these increased demands could not be met, groundwater was identified and the available groundwater in that quaternary catchment correspondingly reduced. Following this, a similar exercise as that described in the previous paragraph was conducted.

3.4.3 Groundwater

The groundwater information necessary for scenario evaluation, and groundwater's role in the WRCS, has been presented in the preceding project reports, namely the delineation of Groundwater Resource Units (GRUs; DWS, 2016b), the status quo of groundwater per GRU (DWS, 2016c), which included a trend analysis for the current status of water level and water quality, description of the links between groundwater and other study components (DWS, 2017a), and the groundwater balance model and resulting present status (DWS, 2017b). The results of the groundwater balance model (the balance – or remaining groundwater availability), and the relationship between use/recharge and groundwater status, is used in the assessment of scenarios.

In any of the scenarios, groundwater use may increase due to planned groundwater developments, or due to an attempt to meet future requirements where there is a surface water deficit based on surface water flows having to meet a required ecological flow. The proposed or required increases are assessed in the groundwater balance model. Hence in the results the overall surface water shortfall for the future demand scenario is presented as well as the estimate of the amount that can be met from groundwater, which informs costing. The resulting change in use/recharge ratio (or stress) leads to a change in groundwater status (from present groundwater status), and is also reported on for each scenario (e.g. from I to II).

The groundwater balance data, present status analysis and results of scenario evaluation will be used, with other information (such as location of sole source groundwater resources, listed in the Status Quo Report), in the prioritisation of resource units for RQO development. In prioritised areas, more detailed assessments may be necessary to 'ground truth' the water balance model results, in order to more confidently set RQOs.

3.5 Groundwater Conditions and Impacts

The present status of groundwater is formally defined in relation to the alteration from the pre-development condition. It is a function of groundwater use, and the impacts of that use (Dennis et al, 2013). However, current guidelines (Dennis et al, 2013) then link the present status directly and only to groundwater use as a portion of recharge. Perhaps the reason for this is that use/recharge provides a readily applicable quantitative assessment, and the impacts of use are rarely quantifiable or represented in regional datasets.

To attribute changes in river flow to groundwater use would require long term monitoring (pre abstraction, and current) in >3 piezometers close to a river, at regular distances in river reaches where groundwater is thought to discharge to surface. Alternatively, it would require high-confidence surface water modelling in which all other factors (runoff, return flow, surface water use and interflow) are well known such that the change in Groundwater Contribution to Baseflow (GWBF) can be accurately determined.

Groundwater stress categories (Table 3-11) can also be used as spatial compliance categories for groundwater; i.e. of 20-65% of the quantified units (i.e. quaternaries) in an area (i.e. IUAs) are moderately used, then the groundwater status can be considered as Level II, i.e. moderately used (Dennis et al, 2013).

For this study the level of groundwater stress was used to determine the resulting groundwater status per water resources classification scenario. Limitations of the definition of groundwater status/condition based on aquifer stress include:

- Aquifer stress (if defined as Use/Recharge) usually does not take into account groundwater's role in meeting the EWR (i.e. GWBF). An aquifer with significant contribution to the Ecological Reserve (high GWBF/EWR) could be over-exploited with a low aquifer stress index, whilst the reverse is true for an aquifer that doesn't contribute significantly to GWBF and therefore EWR (Riemann 2013)
- As with most water balance approaches the calculation of aquifer stress uses mean annual recharge, and when used to make decisions on groundwater availability, could lead to over-abstraction for aquifers in arid climates with episodic recharge, and under development of aquifers with high storage capacity and long response time (Riemann, 2013).
- Related to the challenges of water balance approaches, there is no spatial consideration: an abstraction close to a river, in an aquifer with low stress, could significantly impact the ability to meet groundwater's contribution to EWR. Likewise, a particular wellfield may be causing negative impacts locally (reduced discharge to a nearby spring), whereas the aquifer (or quaternary) as a whole may have minimal use
- There is an implicit assumption that a heavily used aquifer (high use/recharge based Table 3-11) has negative impacts (those listed in Table 3-12), and that alteration or impact is directly proportional to use/recharge. However, the volume abstracted does not directly relate to the same reduction in discharge (this depends on flow regime, distance to river, and access to storage).
- To 'ground truth' the results from a stress index, and determine alteration from pre-development state would ideally require indicators for aquifer storage depletion, discharge depletion, and recharge enhancement (rarely available). Comparison with water level data alone will only indicate storage reduction, which is a certainty in response to pumping, hence is not necessarily an indication of "stress" or level of alteration.

Acknowledging the limitations, in line with other studies, (DWA, 2012, DWS, 2015) and current guidelines, (Dennis et al, 2013), the (current) Use/Recharge (stress) is calculated for each quaternary catchment, and the present status assigned accordingly (equivalent to the PES scenario). Results are then presented for quaternary catchment and GRU scale.

Table 3-11 Definition of groundwater Stress/Classification Status (from Dennis et al, 2013)

Present Status	Generic Description	Affected Environment
Minimally used (I)	The water resource is minimally altered from its pre-development condition	No sign of significant impacts observed
Moderately used (II)	Localised low level impacts, but no negative effects apparent	Temporal, but not long-term significant impact to: -spring flow -river flow -vegetation -land subsidence -sinkhole formation -groundwater quality
Heavily used (III)	The water resource is significantly altered from its pre-development condition	Moderate to significant impacts to: -spring flow -river flow -vegetation -land subsidence -sinkhole formation -groundwater quality

Table 3-12 Recharge/Use as an Indicator Groundwater Status (from Dennis et al, 2013)

Present Status	Description	Use/ Recharge (Stress)
I	Minimally used	≤20%
II	Moderately used	20-65%
III	Heavily used	>65%

3.6 Ecosystem Goods, Services and Attributes (EGSAs)

Impacts of changes in Ecological Condition were estimated on the basis of assumed relationships between ecosystem health and capacity to supply provisioning, regulating and cultural services, and the value of these services. The main types of ecosystem services considered are summarised in Table 3-13, along with the flow-related characteristics that are likely to be the main drivers of these values. These variables were all assessed in the scoring of estuaries using the Estuary Health Index (EHI). Additional details are given in the *Ecological Water Requirements and Ecosystem Goods, Services and Attributes* Report (DWS, 2017b).

Table 3-13 Main ecosystem services provided by rivers, wetlands and estuaries used in the analysis

Category of service	Types of values	Description of EGSA	Independent variables related to estuary condition
Goods (Provisioning services)	Subsistence fishing	Invertebrates and fish collected on a subsistence basis for consumption or bait	Invertebrate abundance Freshwater fish abundance Estuary line- and net fish abundance
Services (Regulating services)	Nursery value	Contribution to marine fish catches due to the nursery habitat provided by estuaries	Abundance of estuary-dependent marine fish
Attributes (Cultural services)	Tourism value & property value	A river, wetland or estuary's contribution to recreation/tourism appeal of a location	Overall health Line fish abundance Water quality

In order to inform this analysis, the relationships between abiotic and biotic scores and the overall health score for estuaries were explored. In general, it was found that the component scores were strongly correlated with the overall health scores, with all having a slope close to unity. Variation was highest for birds, which are influenced by non-flow disturbance factors, fish, which are influenced by fishing, and macrophytes, which are influenced by habitat loss through development. Nevertheless, it suggests that the overall relationships are generally consistent with the Ecological Health Index (EHI) score.

3.7 Socio-economic Impacts

3.7.1 Additional Water Supply Infrastructure Costs

For each of the ecology-driven scenarios, Maintain PES, ESBC and REC, the deficit/surplus of modelled flows relative to the required ecological flows were calculated at each node. Additional water supply interventions to meet any nodal deficits were based on a review of the status quo assessment for the development of a catchment management strategy for the Breede-Gouritz WMA (Golder, 2016).

Generic "unit costs" of water supply (capital + engineering) in R/m^3 were derived from inflation-escalated costs compiled in relatively recent feasibility studies for each type of intervention and on the basis of the demand met by of each of these interventions (Ninham Shand, 2007, 2009; Aurecon, 2009; 2012; 2014; Golder, 2016). These "unit costs" were then used to cost the appropriate interventions needed to cover the respective nodal deficits. The individual intervention costs were then consolidated per IUA. It should be noted that these generic costs do not include allowances for operation and maintenance.

In terms of additional infrastructure costs, consideration was given to the potential for additional groundwater use, distinguishing between local groundwater availability and potential supply from TMG aquifers, and potential surface water supply schemes, including treated wastewater plant effluent re-use.

These generic "unit costs" are as follows:

- Small local groundwater scheme: R5/m^3.
- Large groundwater scheme: R8/m^3.
- TMG ground water scheme: R12.50/m^3.
- Large surface water pump scheme: R8/m^3.
- Surface water storage scheme: R13/m^3
- Treated wastewater plant effluent re-use: R13/m^3.
- Desalination: R17.50/m^3.

In the case of the Future High-Growth scenario, these generic unit costs were also used to cost the appropriate water supply interventions needed to cover the shortfall in water supply at every demand point as well as at every node and these costs were then consolidated per IUA together with the cost of planned bulk infrastructure for each IUA.

3.7.2 Overall Economic Impacts of Scenarios

The economic impacts of the different scenarios include (a) the impacts arising from changes in ecosystem health and the delivery of ecosystem services and (b) the impacts of changes in available water for use. The latter were taken to be the additional water supply costs that would need to be incurred in order to meet current and future water demands. For the current situation, this was in addition to the existing water supply infrastructure. For the 2040 projections, this was in addition to all the planned surface water infrastructure for the WMA. The planned infrastructure was identified from various technical reports.

Costs and benefits were compared over the period 2017 to 2040, based on estimated scenario implications in 2040. The values of ecosystem services were assumed to grow over time in proportion to population and economic growth, at the same overall rate of growth as estimated for water demand under the high growth scenario. The changes in value in each time period were reduced to a net present value using a discount rate of 6% (the rate advocate by World Bank). Sensitivity analysis was performed using discount rates of 3% (social rate of discount) and 9%.

The total infrastructure investments required to meet 2040 water demands under each scenario were costed using 2016 costs. It was assumed that the infrastructure investments would be spread over a 20-year period, starting in the first year. The annual values were then discounted to present value terms as described above.

The overall economic impact of each scenario was expressed in terms of the direct gains and losses of ecosystem services and water supply costs, expressed in present value terms.

3.7.3 Social Implications for Scenarios

Implementation of the Ecological Reserve does not have major social implications in terms of meeting basic human needs for households in the form of water for domestic use or access to resources harvested for subsistence uses in the study area. This is because only a very small percentage of household in the study area fall into this category, and the number of these households is decreasing through improvements in service provision. This is a significant difference from other parts of the country with a more rural population.

The potential social implications of each scenario were assessed and described in qualitative terms.

4 Results of Scenario Analysis

In order to present the results, the IUAs have been grouped together where this makes sense, for example because of the strong flow linkages between them. For example, the three IUAs describing the upper Breede River catchment are described together rather than individually. The results of the scenario analysis are therefore presented for each group of IUAs.

The scenario descriptions for surface water focus on changes in streamflow and the resulting changes in river and estuary ecological condition for each scenario as well as river linked wetlands. Condition is scored relative to the natural condition, with **A** being closest to natural and **F** being the lowest possible score (see box below). In some instances, and for certain IUAs, other mention is made of wetlands, conservation areas of importance or certain worthy socio-economic factors, as appropriate.

Note that in the discussions below, "surpluses" refer to situations where the present-day flows at a node meet the flow requirements of the particular scenario, and "deficits" refer to situations where the present-day flows cannot supply the flow required by a particular scenario.

In the tables of results that follow, colouring is used to guide description and highlight changes. The ecological condition classes are coloured in the standard fashion, blue for better conditions, and red for poorer conditions, and green and orange in between. Other shading is used for the percentages of flow relative to natural mean annual runoff (nMAR) in the tables that follow). Here, light pink indicates a small change from natural, light orange a greater change, then darker orange and finally red to indicate a large degree of change in flow, relative to natural. Lastly, the surplus or deficit volumes per node, are also colour coded where light pink indicates a deficit and light blue indicates a surplus. Very small changes from natural or current day respectively, are not colour coded. Nodes in bold text are estuary nodes.

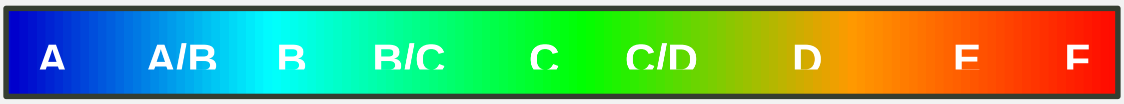

Illustration of the distribution of Ecological Categories on a continuum.

Illustration of the distribution of percentages of flow relative to mean annual runoff on a continuum.

Illustration of the distribution of deficit or surplus flows on a continuum.

In addition to the impact of each scenario on the ecological condition at the **river and estuary nodes**, the overall impact on **water quality**, **wetlands**, **water supply, groundwater** and **ecological goods, services and attributes (EGSAs)** are also described for each scenario and for each group of IUAs. A summary of impacts for the whole WMA is presented in section 5**.**

4.1 Upper Breede, Middle Breede, and Working Tributaries

There are 43 nodes in the Upper Breede, Breede Working Tributaries and Middle Breede Renosterveld IUAs (Figure 4-1). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-1).

Table 4-1 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Upper Breede, Breede Working Tributaries and Middle Breede Renosterveld IUAs

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
A1-Upper Breede Tribs	Niv3	H10B	Titus		C	82.03	D	37.91	C	82.03	C	82.03	C	69.72
	Niv1	H10C	Koekedou		D	96.32	D	96.32	D	96.32	D	83.05	D	86.41
	Niv2	H10C	Dwars		C	62.47	D	37.77	C	62.47	C	61.67	C	56.09
	nvi4	H10C	Breede		C	70.43	D	46.46	C	70.43	C	69.04	C	62.39
	Niv4	H10D	Witels		A	100.00	C/D	42.39	A	100.00	A	100.00	A/B	93.91
	Nvi3	H10D	Breede		C	75.09	D	44.45	C	75.71	C	60.39	C	68.75
	Nvii16	H10E	Witte		A	92.04	C	33.65	A	92.04	A	92.04	A	87.58
	Niv5	H10F	Witte		A	88.40	C	39.31	A	88.40	A	88.40	A	78.01
	Niv6	H10F	Wabooms		D	64.05	D	37.75	D	64.05	D	64.05	D	54.89
	Nviii1	**H10F**	**Breede**	**D**	D/E	77.18	E	42.41	D	77.01	D/E	68.64	E	69.49
	Niv40	H10J	Elands		B	92.20	C	45.82	B	92.20	B	92.20	B	83.51
	Niv41	H10J	Krom		B	92.21	C	46.15	B	92.21	B	92.21	B	83.52
	Nvii2	**H10J**	**Molenaars**	**B**	B	92.20	C	47.33	B	92.20	B	92.20	B	83.51
A2-Breede Working Tribs	Niv7	H10G	Slanghoek		D	70.95	D	47.73	D	70.95	D	70.95	D	60.84
	Niii1	H10G	Breede		D	77.70	E	42.68	D	77.56	D	65.65	D	69.53
	Niv42	H10J	Smalblaar		E	92.20	E	57.19	E	92.20	E	92.08	E	83.51
	Niv8	H10H	Jan du Toit		D	81.32	D	47.53	D	81.32	D	81.32	D	69.26
	Nvii6	H10H	Hartbees		D	77.96	D	49.34	D	77.96	D	77.96	D	66.42
	Niv9	H10H	Hartbees		D	80.09	D	47.14	D	80.09	D	80.09	D	68.22
	Niv12	H10K	Holsloot		C	81.68	D	38.64	C	81.68	C	73.47	C	74.48
	Nv3	H10H	Breede		C	62.39	D	45.49	C	62.30	C	54.16	C	52.73
	Nv18	H20F	Hex		D	50.77	D	54.65	D	54.65	D/E	44.56	D/E	37.87
	Nvii7	**H20G**	**Hex**	**C**	C	80.73	C/D	49.48	C	81.14	C	80.08	C	62.97
	Niv10	H20H	Hex		D	58.69	D	49.26	D	59.08	D	58.06	D/E	41.00
	Nii1	H40C	Breede		C	61.98	D	45.91	C	61.94	C	50.43	C	51.42
	Nvii5	H40B	Koo		D	69.20	D	41.86	D	69.20	D	69.20	D	51.23
	Niv11	H40C	Nuy		E	29.69	D	43.84	D	44.68	E	29.69	E/F	22.24
	Niv18	H30B	Kingna		D	58.05	D	46.42	D	58.05	D	58.30	D	41.43
	Niv20	H30C	Pietersfontein		D	83.82	D	83.82	D	83.82	D	83.82	D	61.37
	Nvii9	H30D	Keisie		D	84.80	D	73.21	D	84.80	D	82.76	D	62.72
A3-Midle Breede-Renosterveld	Niv13	H40D	Doring		E	77.78	E	77.78	E	77.78	E	77.78	E	60.01
	Nvii8	**H40F**	**Breede**	**C/D**	C/D	61.10	D	47.25	C/D	61.49	D	50.70	D	50.34
	Ni1	H40F	Breede		B	60.78	C	47.24	A/B	61.18	B	50.43	B	49.99
	Nvii11	H40G	Poesjenels		D	50.90	D	43.90	D	50.90	D	50.90	D/E	37.41
	Niv15	H40H	Vink		D	83.93	D/E	45.45	D	83.93	D	83.93	D	61.04
	Nviii2	H40J	Willem Nels		D	84.78	D/E	44.77	D	84.78	D	84.78	D	63.39
	Nvii19	H40J	Breede		B	61.12	B	47.13	A/B	61.50	B	50.87	B	49.88
	Nvii12	H40K	Keisers		D	56.39	D	47.25	D	56.39	D	54.50	E	40.83
	Niv14	H40K	Keisers		D	53.97	D	44.61	D	53.97	D	52.91	D/E	39.07
	Nvi1	H40L	Breede		D	61.04	D	47.15	D	61.42	D	51.87	D	49.73
	Nii2	H30E	Kogmanskloof		D	69.40	D	57.24	D	69.40	D	70.21	D	50.43
	Niii3	H50A	Breede		D	61.08	D	47.62	D	61.43	D	51.98	D	49.44
	Ni2	H50B	Breede		D	61.01	D	47.44	D	61.36	D	52.04	D	49.19

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems in these IUAs were limited to tourism values occurring along the rivers. These values were estimated to total over R200 million per year under present conditions, with the highest value in the Breede Working Tributaries (Table 4-2). The values did not change significantly between the different scenarios except in the Upper Breede IUA where the ESBC scenario was expected to reduce tourism value.

Table 4-2 Ecosystem goods, services and attributes (EGSA) values (R million/yr.) for the Upper Breede, Breede Working Tributaries and Middle Breede Renosterveld IUAs

IUA	EGSA value component	Current	Scenario			
		PES	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Upper Breede (A1)	Tourism	63	57	63	63	63
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**63**	**57**	**63**	**63**	**63**
Breede Working Tributaries (A2)	Tourism	90	90	90	90	90
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**90**	**90**	**90**	**90**	**90**
Middle Breede (A3)	Tourism	50	50	50	50	50
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**50**	**50**	**50**	**50**	**50**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

A short summary of the observed impacts under each scenario is given below.

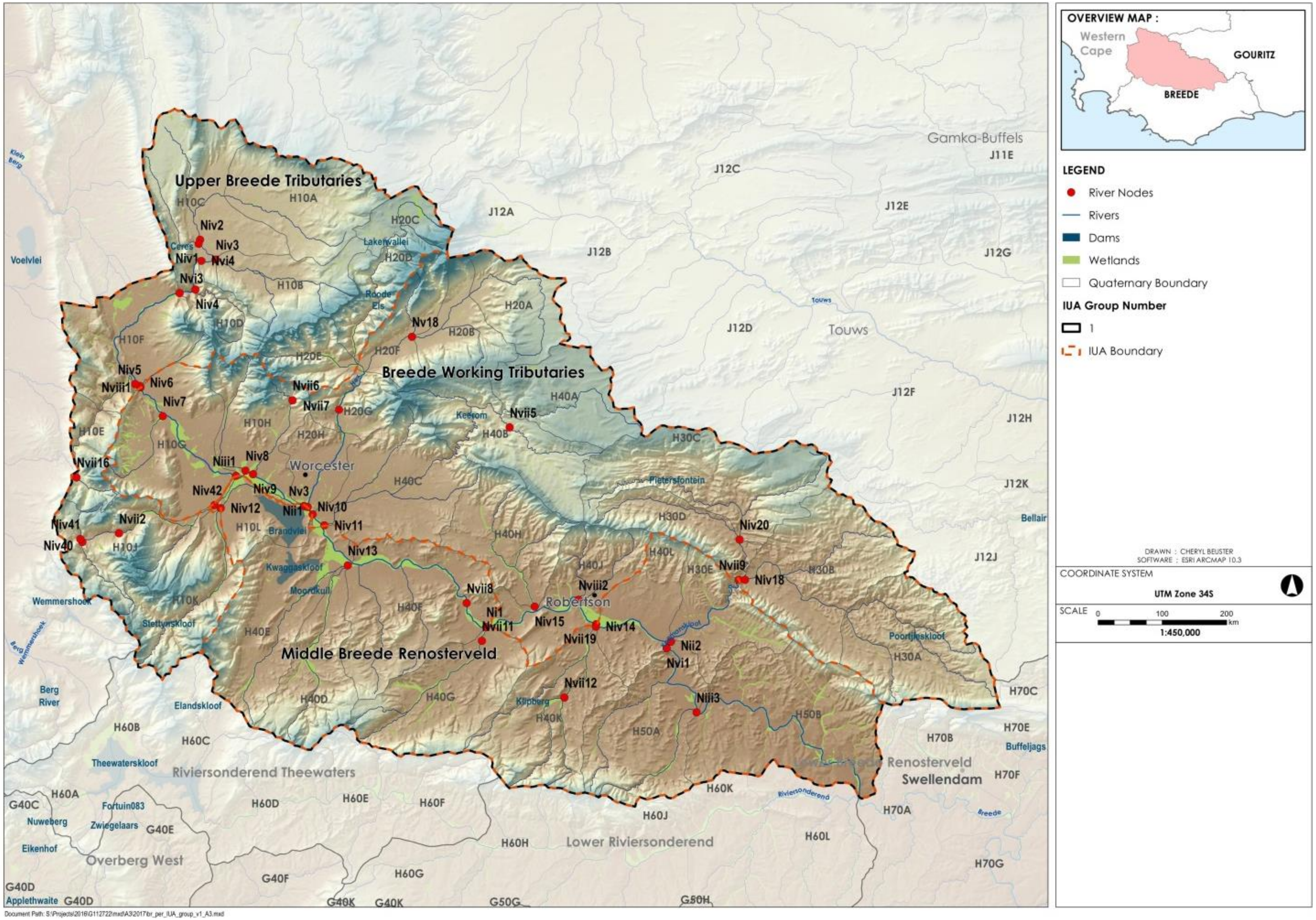

Figure 4-1 The nodes and significant water resources for the Upper Breede Tributaries, Breede Working Tributaries and Middle Breede Renosterveld IUAs

4.1.1 Maintain PES ("Baseline")

Rivers

There are a number of rivers in good ecological condition. The Witels and Witte Rivers are both in an A condition, a rare occurrence, and are both of conservation interest. The Witels is one of the few remaining rivers that flow naturally, as indicated by the 100% score relative to natural in the seasonal and annual percentage columns below. There are two nodes on the Witte River, both also flowing close to natural with the upper reach node (Nvii16) flowing closer to natural than the downstream node (Niv5), as water is abstracted from the Upper Witte River between these two nodes and delivered into the Berg River via Gawie se Water, an abstraction that takes summer low flows upstream of Eerste Tol at Bainskloof Pass. There are other rivers in good condition, the Krom, Elands and Molenaars Rivers in Du Toitskloof, and also two sections of the Breede River downstream of Le Chasseur (Nvii8), all in a B condition. The rivers in Du Toitskloof flow close to natural, while those downstream of Le Chasseur flow higher than natural in the dry season as a result of irrigation releases made from Brandvlei Dam during summer.

Unfortunately, 22 of the rivers (half in this region) are in a D condition for a number of reasons that include the fact that their flows in summer are much less than occur naturally (between 5-25% of mean annual runoff), which affects aquatic organisms such as macroinvertebrates and fish, and there are high densities of invasive woody plants present in the river basin surrounding Worcester, Robertson and Montagu, coupled with much clearing of indigenous riparian vegetation along river banks for agriculture.

It is worth noting that the Witte, Witels, Krom, Elands and Molenaars rivers are situated in nature reserves and in scenarios going forward their flow requirements could be maintained at current day, to sustain their current condition and status as water source areas.

There are three rivers in an E condition, i.e. the Smalblaar River that flows through Rawsonville, the Nuy downstream and the Doring River that flows downstream of Villiersdorp in a northerly direction toward Worcester; both are bulldozed canal-like river channels with little aquatic or riparian biota. In these instances, there is little hope of restoring rivers current in an E-condition and many of the rivers in a D-condition simply by increasing flows back to natural, if this is possible alone, as these poor conditions result from a multitude of impacts.

There are four river EWR sites in this section, Breede River Basin Study EWR site 1 (Nviii1) in a D/E condition, BRBS EWR site 2 (Nvii2) in a B condition BRBS EWR site 3 (Nvii8) in a C/D condition and the Hex River EWR site 3 (Nvii7) in a C condition.

Wetlands

Most of the wetlands in the high-lying areas are within high yield Strategic Water Source Area (Breede), and within protected areas. There are Northwest shale fynbos channelled valley bottom wetlands within Cedarberg-Koue Bokkeveld Complex IBA associated with Niv2. Wetlands within the Boland Mountains IBA and the Kluitjieskraal Working for Wetlands project are associated with Nviii1. Nvii2 is associated with Southwest granite fynbos channelled valley bottom wetland. Other Channelled valley bottom wetlands, which are associated with the surface water condition, are in particular between nodes Nvii2 (Molenaars River, with an ecological category of B) and Niv42 (Smalblaar with an ecological category of E) there are Channelled Valley Bottom wetland types with a C condition within this area. The condition of the river will be difficult to improve from an E category, therefore the surrounding wetlands may be impacted.

The Papenkuils Wetland (East Coast Shale Renosterveld Floodplain Wetland) is located next to Brandvlei Dam and downstream of the confluence of the Smalblaar and Breede Rivers (RHP, 2011), between nodes Niii1 (Breede River) and Niv42 (Smalblaar River) to node Nv3 (Breede River). Although the Smalblaar River node (Niv42) has a low ecological category (E), the Breede River nodes (Niii1 and Nv3) are in better condition (D and C, respectively), and are thus better able to support the preliminary Ecological Reserve determined for the Papenkuils (at an ecological condition of C).

Upstream agricultural activities including the diversion of Papenkuils Wetland inflow into Greater Brandvlei Dam are a threat to the integrity of the wetland (RHP, 2011). Problems include reduced water inflow, as well as invasive alien vegetation and habitat modification. An intermediate level Ecological Reserve determination was carried out for the Papenkuils Wetland. The results indicate that the present ecological status category of the wetland is fair (C), contrasting with its ecological importance rating of high. This implies that steps must be taken to rehabilitate the functioning of the wetland. The wetland has high conservation importance. Kluitjieskraal wetland, also occurring in agricultural land, has had rehabilitation work done by the Working for Wetlands programme.

Estuaries

There are no estuaries in this IUA.

Water Quality

In the baseline scenario, water quality in the Upper Breede Tributaries will remain in an Ideal category, except in the Breede River downstream of Ceres, where slightly elevated salts, as a result of return flows and treated wastewater effluents in the Ceres area, will prevail. Water quality in Brandvlei Dam and Roode Elsberg Dam will remain in an Ideal category. Water quality in the Breede Working Tributaries will remain in an Ideal category in the upper reaches of the tributaries, with high salinities in the lower reaches of the tributaries (Tolerable to Unacceptable categories) due to agricultural return flows and intensive irrigation practices in their catchments.

Water quality in the Middle Breede Renosterveld IUA tributaries will continue to exhibit high salinities (Unacceptable categories) as a result of the geology of the area, intensive irrigation practices, and saline irrigation return flows. However, the freshening releases from Brandvlei Dam during the summer months (dry season) to maintain a quality suitable for irrigation agriculture up to the Sanddrift Canal, will maintain the quality in the middle Breede River in an Acceptable category and mitigate the impacts of poor quality inflows from the Breede Working Tributaries. Water quality in Klipberg Dam and Kwaggaskloof Dam will remain in a very good state (Ideal to Acceptable category). The impacts of WWTW discharges such as elevating nutrient concentrations and elevating bacterial counts from urban runoff in the middle Breede River, will continue unless point source control measures are enforced more strictly.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in five quaternary catchments (i.e. increases from category I to II or I to III). These five catchments are all in the H10 catchments of the Upper Breede Tributaries or Breede Working Tributaries IUA. The increase in groundwater stress in these five catchments is fairly significant, and the increase in the use/ recharge ratio (‘stress’) is from between 1 and 26% under current PES, to 60 to 94%. This increase in stress relates to a change in groundwater category from I to II in two catchments; I to III in one catchment, and II to III in two catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions, the Breede Working Tributaries IUA provides an estimated R90 million/yr. in value through tourism, whereas Upper Breede and Middle Breede IUA provided R63 and R50 million/yr. respectively.

4.1.2 ESBC scenario

The Ecologically Sustainable Base Configuration scenario (“bottom line”) aims to achieve D ecological conditions for the rivers and estuaries and theoretically should require less flow than that of the current day. In the results that follow, the overall health scores are more important than the seasonal scores when considering long-term average conditions and realistic change in response to flow and other interventions.

The seasonal scores reported are more hypothetical than the former scenario but are included to illustrate the difference between present-day flows, mostly where dry season flows are supressed relative to natural, and Reserve flows that are based on natural and so have a natural distribution of flow between the wet and dry season that tends to be in stark contrast, *viz.* with higher levels of flow in the dry season than present currently. This is an important illustration to make since, in most cases, the reasons for reduced and sometimes nearly absent flow in the dry season, are high agricultural demands on flow that coincide with the growing season of the dry season. This means that many rivers barely flow in the dry season as a result of abstractions. It also means in some cases where releases can be made that flows are elevated above natural in the dry season via flow releases to support these demands.

In the results that follow, comparing the annual and seasonal percentages of flow relative to natural tends to show that on average over a year the percentage change from natural may not appear to be a reason for concern, but in a number of cases this annual average is sustained by higher flows in the wet season and little in the dry season. That being said, as is the nature of models, the assumptions upon which the basin configuration tool is based are more suited to calculating long-term changes in average condition and less suited to instantaneous change that may be reflected seasonally. This means that primary attention in interpreting the scenario results must be given to the annual average calculations of change in ecological condition. The seasonal results can guide where flow change must be addressed, if possible, to balance flow seasonally more naturally. In most cases, this will be practically unrealistic.

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the nodes, apart from at nviii1 and Niii1 on the Breede River, niv42 the Smalblaar River, Niv13 the Doring River, Niv15 the Vink River and Nviii2 the Willem Nels River, that were either in a D category to begin with that now drops to a D/E or E category in this scenario, mainly due to reduction in incremental flows from upstream, in the case of the Breede River, or due to being in an E category to begin with and there being no change due to flow manipulation up or down.

Small *annual* deficits in flow volume are indicated except at Nv18 (Hex) and Niv11 (Nuy) (i.e. the current flows will meet what is required at each node, annually apart from at these two nodes). The last node in this tier of nodes (Ni2, i.e. at the outlet of the Mid Breede Renosterveld IUA) has, on an annual basis, a surplus relative to current flows. However, on a monthly basis, there are deficits from December to March at this node (i.e. the flows under this scenario are greater that what is there currently).

Present-day flows were retained at a number of nodes, either because routing Reserve flows through these nodes deteriorated their ecological condition or that of nodes downstream, or due to the node being selected as a water source area that requires maintaining 100% of natural flow, such as that done for the Witels River.

EWR flows routed down the Witte, Elands, Krom and Molenaars River deteriorated their ecological conditions (ECs) from A's and B's to C's, respectively, despite these rivers being located in nature reserves. This reduced the average annual monthly flow percentages of the Witte River to a third of their current day flow and that of the Elands, Krom and Molenaars River to approximately half their natural flow, both annually and seasonally.

Similarly, EWR flows were routed through two lower Breede River nodes Ni1 and Nvii19, which are both currently in a B ecological condition. This sustained their B condition and did not dramatically change the average annual flow percentage, when compared to natural, but in contrast to the results of EWR flows described for the Witte, Elands, Krom and Molenaars Rivers, changes the seasonal distribution, increasing the dry season (January to March) flows from their current 24%to 33%.

Wetlands

Little change occurs with the ESBC scenario. The Papenkuils Wetland requirements to meet a C category are met at node nv3, but inflow from Smalblaar River (Niv42) is still of a poor ecological condition (in Unacceptable categories).

Estuaries

There are no estuaries in this IUA.

Water Quality

In the ESBC scenario, water quality in the Upper Breede Tributaries will remain in an Ideal category, as many of the streams are largely unimpacted by irrigation return flows or effluent discharges. Water quality in the Breede River downstream of Ceres would deteriorate by half a water quality category due to less dilution of irrigation return flows and WWTW discharges, and higher volumes of poor quality (elevated salts and agrochemicals) irrigation return flows, if the surplus water generated in this scenario is used locally to support expanded irrigation activities. Water quality in Brandvlei Dam and Roode Elsberg Dam will remain in an Ideal category. Water quality in the Breede Working Tributaries will continue to exhibit good quality (Ideal category) in the upper reaches of the tributaries. However, in the ESBC scenario wet season flows would decrease and the dry season flows would increase. The impacts on water quality is that the increase in flow during the dry season would dilute the poor quality in the lower reaches of the river impacted by large irrigation return flows and improve quality by half a water quality category. The reduction in flow during the wet season may not result in a major change in the wet season quality. However, under this scenario lower volume of freshening releases will be made from Brandvlei Dam during the summer months (dry season) which will result in elevated salinity in the river reach up to Sanddrift Canal (deteriorate by half a water quality category). This may impact negatively on the irrigation farmers as it may not adequately mitigate the impacts of poor quality inflows (in Unacceptable categories) from the Breede Working Tributaries. Water quality in Klipberg Dam and Kwaggaskloof Dam will remain in a very good state (Ideal to Acceptable category). The impacts of WWTW discharges such as elevating nutrient concentrations and elevating bacterial counts from urban runoff in the middle Breede River will reduce during the dry season due to higher dilution as a result of the elevated flows.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in two quaternary catchments. These catchments are both in the H10 area (Upper Breede Tributaries). The increase in groundwater stress in these catchments is minor, increasing the use/ recharge ratio (‘stress’) from between 1 and 4% under current PES, to 21 and 24% respectively. This increase in stress relates to a change in groundwater category from I to II in the two catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

The value of tourism under this scenario was slightly lower in the Upper Breede IUA than under PES conditions (loss of R6 million/yr.). The tourism value remained the same for the other two IUAs.

4.1.3 REC scenario

The purpose of the Recommended Ecological Category (REC) scenario is to meet the Reserve requirements required to sustain the proposed REC of the river and estuary Reserve sites in the WMA.

Rivers

Present-day flows were retained at the bulk of the nodes in this region for the REC scenario, as these result in the REC being achieved at the relevant nodes. The exceptions are at Nvi3 and Nviii1 on the Breede, Nv18 (the Hex), and Niv11 (the Nuy). The flow changes at Nvi3 and Nviii1 improved the condition at Nvii1 from a D/E to a D, while the Nuy improved from an E to a D. The improvements were due to higher dry season flows than current (although wet season flows were lower than current).

The four river EWR sites in this section are Breede River EWR site 1 (Nviii1 REC = D, achieved through flow changes), Breede River EWR site 2 (Nvii2 REC = B), Breede River EWR site 3 (Nvii8 REC = C/D) and the Hex River EWR site 3 (Nvii7 REC = C). The latter RECs were achieved with current flows.

Wetlands

Little change occurs with the REC scenario. The Papenkuils Wetland requirements to meet a C category are met at node nv3, but inflow from Smalblaar River (Niv42) is still of a poor ecological condition

Estuaries

There are no estuaries in this IUA.

Water Quality

In the REC scenario, water quality in the Upper Breede Tributaries will remain in the same state as described for the Baseline scenario, namely water quality would be in an Ideal category except in the Breede River downstream of Ceres where slightly elevated salts, as a result of return flows and treated wastewater effluents in the Ceres area, will prevail.

Water quality in Brandvlei Dam and Roode Elsberg Dam will remain in an Ideal category. Water quality in the Breede Working Tributaries will continue to exhibit good quality (Ideal category) in the upper reaches of the tributaries, but high salinities in the lower reaches of the tributaries due to agricultural return flows and intensive irrigation practices in their catchments will maintain these river reaches in an Unacceptable category.

Water quality in the Middle Breede Renosterveld IUA tributaries will continue to exhibit high salinities as a result of the geology of the area, intensive irrigation practices, and saline irrigation return flows (unacceptable category). However, the freshening releases from Brandvlei Dam during the summer months (dry season) to maintain a quality suitable for irrigation agriculture up to the Sanddrift Canal, will maintain the quality in the middle Breede River in an Acceptable category, and mitigate the impacts of inflows with high salts from the Breede Working Tributaries.

Water quality in Klipberg Dam and Kwaggaskloof Dam will remain in a very good state (Idea to Acceptable categories). The impacts of WWTW discharges such as elevating nutrient concentrations and elevating bacterial counts from urban runoff in the middle Breede River will continue unless compliance to effluent standards are enforced more strictly.

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in five quaternary catchments (i.e. increases from category I to II or I to III). These five catchments are all in the H10 catchments of the Upper Breede Tributaries or Breede Working Tributaries IUA. The increase in groundwater stress in these five catchments is fairly significant, and the increase in the use/ recharge ratio (‘stress’) is from between 1 and 26% under current PES, to 60 to 94%. This increase in stress relates to a change in groundwater category from I to II in two catchments; I to III in one catchment, and II to III in two catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

The tourism value remained the same as the PES condition for all three IUAs.

4.1.4 No EC – High Growth scenario

The purpose of the no EC future high growth scenario is to assess the shifts in ecological condition at all the nodes relative to the PES caused by elevated 2040 water use levels, as well as the implementation of planned new bulk water infrastructure.

Rivers

This flow regime reduces the flow substantially at some nodes, but results in a deterioration in EC at only one node, Nv18, on the Hex River, which drops from a D to a D/E.

Wetlands

Little change occurs with the High future demands scenario in the upper Breede IUAs. The Papenkuils Wetland requirements to meet a C category are met at node nv3, but inflow from Smalblaar River (Niv42) is still of a poor ecological condition. Flow does not reduce substantially at these nodes.

Estuaries

There are no estuaries in this IUA.

Water Quality

In the High Future Demands scenario, most of the increase in demand would come from a growth in urban/industrial demands. This would result in increased return flows of treated wastewater from municipal WWTWs, and possibly increased urban runoff from seepage from aging sewerage infrastructure, and seepage from leaking potable water infrastructure into the urban stormwater system. The impacts of treated effluent discharges and urban runoff on receiving rivers can be mitigated through compliance to discharge standards, and improved maintenance of water supply and sewerage infrastructure.

Water quality in the Upper Breede Tributaries will be impacted in the rivers where substantial reductions in flow will occur. The reduction in flow in the Koekedou River as a result of raising Koekedou Dam, will result in less dilution of agricultural runoff generated in the Dwars River catchment, upstream of Ceres. The increase in municipal wastewater discharges into the upper and middle Breede River from towns such as Ceres, Worcester, Robertson and Ashton will result in higher nutrient loads in the Breede River.

For the high-growth future development scenario it was assumed that no future increases in irrigation water allocations will be allowed by DWS across the whole WMA, except for increased allocations from Brandvlei Dam. This would result in larger flows of freshening releases in the middle Breede River downstream of Brandvlei Dam. The increase in allocation to irrigation agriculture would result in higher salt and agro-chemical loads into the Breede River, either through the working tributaries, or direct return flows into the Breede River. This could lead to a deterioration of one water quality category. However, during the dry season the freshening releases from Brandvlei Dam will mitigate the municipal and agricultural impacts in the middle Breede River. When no freshening releases are made down the Breede River, the impacts of continued urban and agricultural return flows would lead to higher salt and nutrient concentrations in the mainstem Breede River, leading to a deterioration of one water quality category.

Groundwater

Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.

EGSA

The tourism value remained the same as the PES condition for all three IUAs.

4.1.5 Climate change scenario

The purpose of a climate change scenario is to assess the shifts in ecological condition at all the nodes relative to the PES caused by a relatively severe “drying” of the climate in the Study area in the future.

Rivers

For 8 of the 43 nodes in this sub-region a deterioration in EC (relative to PES) is indicated under this particular climate change scenario.

The river reaches involved are the Witels (A to A/B), upper Hex (D to D/E), lower Hex (D to D/E), Nuy (E to E/F), Poesjenels (D to D/E), upper Keisers (D to E), lower Keisers (D to D/E) and Breede u/s Robertson (C/D to D).

Wetlands

Little change occurs with the Climate Change scenario. The Papenkuils Wetland requirements to meet a C category are met at node nv3, but inflow from Smalblaar River (Niv42) is still of a poor ecological condition

Estuaries

There are no estuaries in this IUA.

Water Quality

In the Climate Change scenario, water quality in the Upper Breede Tributaries may deteriorate by half a water quality category (Ideal to Acceptable categories) as described for the Baseline scenario, due to higher evaporation and lower dry season flows in the rivers. Downstream of Ceres moderately elevated salts, as a result of agricultural return flows and treated wastewater effluents in the Ceres area, will prevail.

Water quality in Brandvlei Dam and Roode Elsberg Dam will remain in an Ideal category. Water quality in the Breede Working Tributaries will exhibited good quality (Ideal category) in the upper reaches of the tributaries, but higher salinities in the lower reaches of the tributaries due to agricultural return flows, increased evaporation, and intensive irrigation practices in their catchments will maintain these river reaches in an Unacceptable category.

Water quality in the Middle Breede Renosterveld IUA tributaries will continue to exhibit high salinities (Unacceptable categories) as a result of the geology of the area, intensive irrigation practices, and saline irrigation return flows. However, the freshening releases from Brandvlei Dam during the summer months (dry season) to maintain a quality suitable for irrigation agriculture up to the Sanddrift Canal may not be sufficient to reduce salinities to an Acceptable category for irrigation, and the quality in the middle Breede River may deteriorate by half a water quality category.

Water quality in Klipberg Dam and Kwaggaskloof Dam will be maintained in an Ideal category. The impacts of WWTW discharges resulting in elevated nutrient concentrations and elevated bacterial counts from urban runoff in the middle Breede River will increase due to the lower flows unless point source control measures are enforced more strictly.

EGSA

The tourism value was not expected to differ from the PES condition for all three IUAs.

4.2 Riviersonderend IUAs

There are 14 nodes along the Riviersonderend River and including nodes in the Riviersonderend Theewaters and Lower Riviersonderend IUA (Figure 4-2). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-3). A short summary of the observed impacts under each scenario is given below.

Table 4-3 Annual flow as as % nMAR, and river condition (A to F) at each node for all scenarios for the Riviersonderend Theewaters and Lower Riviersonderend IUAs

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
B4-Riviersonderend Theewaterskloof	Nvii10	H60B	Du Toits		B	90.87	B/C	56.57	B	90.87	B	90.87	B	82.67
	Nv7	H60D	Riviersonderend		C	49.49	C	50.54	C	54.60	C	49.49	C	39.25
	Niv28	**H60E**	**Baviaans**	B	B	88.72	C	38.58	B	88.72	B	88.72	B	69.49
	Niv29	H60E	Sersants		D	88.72	D	56.62	D	88.72	D	88.72	D	69.49
	Niv30	H60F	Gobos		C	87.77	D	39.28	C	87.77	C	86.04	C	66.84
	Nv9	**H60F**	**Riviersonderend**	D	D	53.57	D	50.41	D	58.14	D	53.51	D	42.25
F9-Lower Riviersonderend	Niv31	H60G	Kwartel		D	90.70	D	53.38	D	90.70	D	90.70	D	63.85
	Niv33	H60H	Soetmelksvlei		D	67.84	D	50.28	D	67.84	D	67.84	D	45.47
	Niv34	H60H	Slang		D	67.89	D	50.28	D	67.89	D	67.89	D	45.50
	Nv10	H60H	Riviersonderend		D	55.01	D	50.40	D	59.29	D	54.96	D	42.80
	Nv11	H60J	Riviersonderend		D	56.34	D	50.14	D	60.43	D	56.21	D	43.46
	Niv35	H60K	Kwassadie		E	84.68	E	57.46	E	84.68	E	84.68	E	54.08
	Nv12	H60K	Riviersonderend		D	56.82	D	50.14	D	60.81	D	56.69	D	43.53
	Ni3	H60L	Riviersonderend		D	56.12	D	50.04	D	60.03	D	55.99	D	42.65

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within these IUAs were limited to tourism values. These values were estimated to total over R50 million per year under present conditions, with 85% of this value coming from the Riviersondered Theewaters IUA (Table 4-4). These values were not expected to change under any of the scenarios apart from ESBC.

Table 4-4 Ecosystem goods, services and attributes values (R million/yr.) for the Riviersonderend Theewaters and Lower Riviersonderend IUAs

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Riviersonderend Theewaters (B4)	Tourism	45	41	45	45	45
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**45**	**41**	**45**	**45**	**45**
Lower Riviersonderend (F9)	Tourism	8	8	8	8	8
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**8**	**8**	**8**	**8**	**8**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

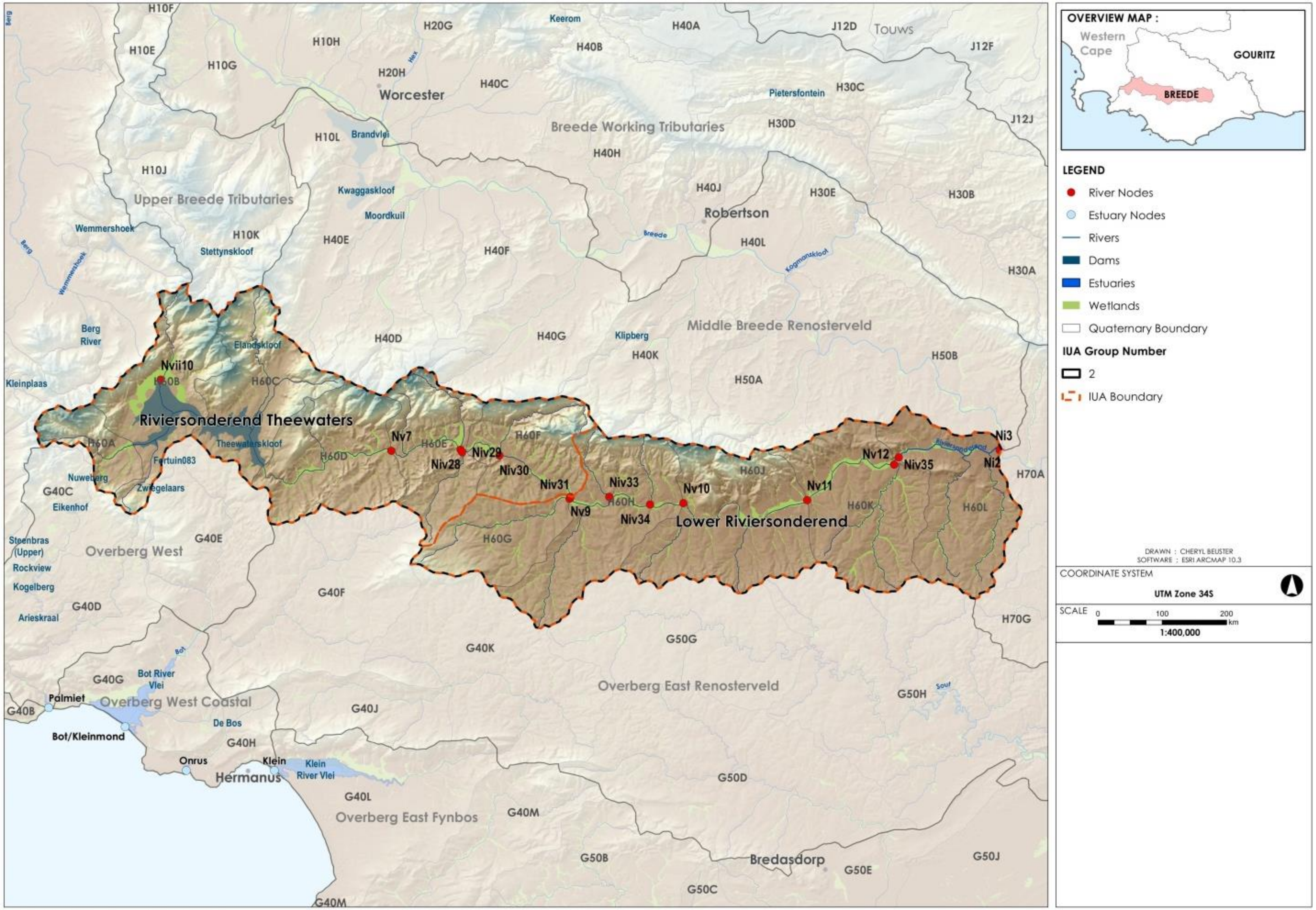

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Figure 4-2. The nodes and significant water resources for the Riviersonderend Theewaters and Lower Riviersonderend IUAs

4.2.1 Maintain PES (“Baseline”)

Rivers

The Du Toits River is situated in a nature reserve, flows close to natural and is in a good B ecological condition. The Riviersondered River downstream of Theewaterskloof Dam and two nearby tributaries coming in at the north bank of the river are in an acceptable C condition, and flows are close to natural. The Kwassadie River is in an unacceptably poor E condition, largely through being exposed to a multitude of agricultural practices that results in poor water quality, a lack of indigenous riparian vegetation and poor diversity of other aquatic biota. The rest and majority of the river reaches and tributaries here, downstream of Theewaterskloof are in a D condition, with the Riviersondered River flowing relatively well and being sustained by irrigation releases made from Theewaterskloof Dam, while the tributaries generally flow less well in the dry season, when compared to natural. There is a high density of Eucalyptus trees along the Riviersonderend River that must be felled and removed along with any attempts to improve ecological conditions in the River. The inflowing tributaries on the Southern bank flow less strongly and are inhabited by a different fauna and flora than those inflowing on the Northern bank, being generally of a drier nature when compared to the more strongly flowing and better vegetated Northern bank tributaries.

There are two river EWR sites here; BRBS EWR site 6 on the Baviaans River Niv28 in a B category and BRBS EWR site 5 (Nv9) on the Riviersonderend River in a D category.

Wetlands

The East Coast Shale Renosterveld Floodplain wetland above Nvii10 within Boland Mountain IBA as well as East Coast Shale Renosterveld Floodplains and Channelled Valley Bottom wetlands above Niv35 and Ni3, within the Overberg Wheatbelt IBA. The poor ecological condition of Niv35 (Kwassadie River) will impact the condition of these wetlands.

Estuaries

There are no estuaries in this IUA.

Water Quality

Water quality in the Riviersonderend Theewaters IUA is in an Ideal category and meets the requirements for its intended uses. It will remain in that category, provided WWTW and other pollution sources are controlled to meet effluent standards. Water quality in the Lower Riviersonderend IUA will continue to exhibit elevated salt concentrations as a result of agricultural return flows keeping it, on average, in an Ideal category but with occasional excursions into Tolerable/Unacceptable categories.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments are in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these two catchments is moderate, and the increase in the use/ recharge ratio (‘stress’) is from 1 to 5% under current PES, to 27 to 39% at the quaternary catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions, the aquatic ecosystems of the Riviersonderend Theewaters IUA contribute an estimated R45 million/yr. in value through tourism, whereas the Lower Riviersonderend IUA contributes R8 million/yr.

4.2.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the nodes, apart from at Niv35 the Kwassadie River, where increasing flow did not improve the EC, which is an E. However, EWR flows were routed down this river to improve the seasonal distribution and increase flow during the dry season.

There was a small deficit in *annual* flow volume relative to current at Nv7 (Riviersonderend) and the last node, in this tier of nodes, indicates a surplus in the outflow from the lower-most quaternary Ni3 (however, on a monthly basis, there are small deficits at several nodes including Ni3, particularly during January to March).

EWR flows were selected at all nodes, i.e. present-day flows were not retained at any node.

The Du Toits River is the only one of conservation interest, where EWR flows were selected that drop the current B to a B/C condition but make surplus water available.

In these IUAs, the present-day flows are higher than the EWR flows required to sustain the D condition of most of the tributaries and the Riviersonderend River.

Wetlands

The wetland above Nvii10 will be maintained in a good condition, whilst the wetlands further down the IUA associated with Niv35 (Kwassadie River) will be impacted by the poor condition of this node.

Estuaries

There are no estuaries in this IUA.

Water Quality

Water quality in the upper reaches of rivers in the Riviersonderend Theewaters IUA will remain in an Ideal category. However, in the reaches just upstream of Theewaterskloof maintaining the Ideal category is dependent on the effluent discharges from WWTW and other pollution sources being controlled to meet effluent standards. Water quality in the Lower Riviersonderend IUA will continue to exhibit elevated salt concentrations as a result of agricultural return flows and it might be higher due to reduced dry season flows in the main stem Riviersonderend River. This may result in a deterioration of half a water quality category.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments are in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these two catchments is moderate, and the increase in the use/ recharge ratio (‘stress’) is from 1 to 5% under current PES, to 27 to 39% at the quaternary catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

The value of tourism under this scenario was slightly lower in the Riviersonderend Theewaters IUA than under PES conditions (loss of R4 million/yr.). The tourism value remained the same for the Lower Riviersonderend IUA.

4.2.3 REC scenario

Rivers

Present-day flows were selected at all nodes in this region. This flow regime meets the flow requirements for the REC of D at Nv9 (Riviersonderend) as the PES is currently a D. This flow regime meets the flow requirements for the REC of B for Niv28 (Baviaans River) as the PES is currently a D.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

There are no estuaries in this IUA.

Water Quality

Water quality in the Riviersonderend IUAs will remain as described for the Baseline scenario.

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in three quaternary catchments (i.e. increases from category I to II or I to III). These three catchments are all in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these three catchments is moderate at two catchments, and significant at one catchment with an increase in the use/ recharge ratio ('stress') is from 0 to 90% at the H60F quaternary catchment.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

The tourism value was not expected to change from the PES condition for all three IUAs.

4.2.4 No EC – High Growth scenario

Rivers

This flow regime indicates only slight decreases in flow at Niv30 (Gobos River) due to abstraction, but this does not affect the EC, nor those of downstream nodes.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

There are no estuaries in this IUA.

Water Quality

This flow scenario will result in little change in water quality (variations within the same category) from those described for the baseline condition.

Groundwater

To achieve this scenario into the future, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments are in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these two catchments is moderate, and the increase in the use/ recharge ratio ('stress') is from 1 to 5% under current PES, to 27 to 39% at the quaternary catchments.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

The tourism value was not expected to change from the PES condition for all three IUAs.

4.2.5 Climate change scenario

Rivers

In this sub-region no EC changes relative to PES are indicated under the climate change scenario.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

There are no estuaries in this IUA.

Water Quality

Water quality in the upper reaches of rivers in the Riviersonderend Theewaters IUA may deteriorate by half a water quality category resulting in quality that fluctuates between Ideal and Acceptable categories. However, this is dependent on the effluent discharges from WWTW and other pollution sources being controlled to meet effluent standard, especially during the low flow season. Water quality in the Lower Riviersonderend IUA will continue to exhibit elevated salt concentrations as a result of agricultural return flows, higher evaporation in the tributaries and Theewaterskloof Dam, and it might be even higher due to reduced dry season flows in the main stem Riviersonderend River. This may result in the river deteriorating to an Acceptable category with excursions into an Unacceptable category during the dry season.

EGSA

The tourism value was not expected to change from the PES condition for all three IUAs.

4.3 Lower Breede Renosterveld

There are ten nodes in the Lower Breede Renosterveld IUA (Figure 4-3). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-5). A short summary of the observed impacts under each scenario is given below.

Table 4-5 Annual flow as as % nMAR, and river condition (A to F) at each node all scenarios for the Lower Breede Renosterveld IUA

IUA	Node	Quat	River	ER - REC	Current PES (2014) EC	Current PES (2014) % nMAR	ESBC EC	ESBC % nMAR	REC EC	REC % nMAR	NoEC EC	NoEC % nMAR	CC EC	CC % nMAR
F11-LowBreede-Renoster	Niv24	H70A	Leeu		E	85.44	E	85.44	E	85.44	E	85.44	E	66.23
	Niv24a	H70B	Klip		E	92.40	E	92.40	E	92.40	E	91.50	E	78.02
	Nv2	H70B	Breede		C	60.15	C	48.90	C	61.54	C	53.89	C	47.82
	Nvii14	H70C	Huis		C	75.01	D	32.83	C	75.01	C	68.52	C	65.21
	Nii3	H70C	Tradouw		B	75.21	D	30.44	B	75.21	B	73.62	B/C	65.37
	Niv25	H70F	Buffeljags		E	73.18	E	65.93	E	73.18	E	72.93	E	59.58
	Niii4	**H70G**	**Breede**	**B/C**	C	60.99	C	49.92	C	62.29	C	55.17	C	48.53
	Nviii3	H70H	Breede		B	61.13	B/C	49.85	B	62.16	B/C	54.90	B/C	48.61
	Niv26	H70J	Slang		E	89.07	E	89.07	E	51.86	E	89.07	E	63.80
	Nxi2	**H70K**	**Breede estuary**	**B**	B	49.53	B	46.89	B	50.20	B	44.53	C	39.35

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Lower Breede Renosterveld IUA included tourism values contributed from the rivers and estuary as well as the nursery function, sustainable fishing and property value premiums associated with the estuary. These values were estimated to total R166 million per year under present conditions (Table 4-6).

These values were not expected to change significantly between the first three scenarios, but would be lower under the CC scenario.

Table 4-6 Ecosystem goods, services and attributes (EGSA) values (R million/yr.) for the Lower Breede Renosterveld IUA

IUA	EGSA value component	Current PES (2014) R million	Scenario ESBC R million	REC R million	NoEC R million	CC R million
Lower Breede Renosterveld (F11)	Tourism	103	103	103	103	99
	Nursery	20	20	20	20	16
	Sustainable Fishing	0.19	0.19	0.19	0.19	0.15
	Property	43	43	43	43	41
	Combined EGSA Value	**166**	**166**	**166**	**166**	**156**

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Figure 4-3 The nodes and significant water resources for the Lower Breede Renosterveld IUA

4.3.1 Maintain PES ("Baseline")

Rivers

The Breede River and two of its tributaries, the Huis and the Tradouw rivers, are in good condition here, despite their being reduced flows when compared to natural in both the wet and dry seasons and on average annually. Four of the tributaries are in an unacceptable poor E condition, the Leeu, Klip, Buffeljags and Slang rivers. The former three are bulldozed stony channels with little in the way of aquatic or riparian biota while the Slang River is a different sort of river that is very much influenced by surrounding agricultural activities. Improving the condition of these poor rivers will require more than changes in flow. Additional non-flow related interventions will be needed to improve the condition of these rivers.

There is one BRBS EWR site 4 on the lower Breede u/s of the estuary, Nviii3 in a C condition category.

Wetlands

East Coast Shale Renosterveld Flats, Floodplains and Channelled valley bottom wetlands are associated with this IUA, in particular between Niii3, Nv2, Niii4 and Niv26 to Breede Estuary. Niv26 (Slang River) has an unacceptable condition, which indicates that the Channelled valley bottom wetlands are degraded.

Estuaries

The Breede estuary is currently in good condition, with a PES of B, which corresponds with the REC for this system.

Water quality

Water quality in the Lower Breede Renosterveld IUA tributaries will remain in an Ideal category and the poor quality (Tolerable to Unacceptable category) in the Breede River at Swellendam will be maintained. It is important that WWTW discharges from Swellendam be controlled to meet effluent standards in order to prevent further degradation of the quality in the lower Klip River and the receiving lower Breede River.

Groundwater

To achieve PES into the future, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments are in the middle reaches of the catchment. The increase in groundwater stress in these two catchments is moderate with an increase in the use/ recharge ratio ('stress') is from 0% and 3% to 28% and 33% respectively.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions, the Lower Breede Renosterveld IUA provides an estimated R166 million/yr. in value, the majority of this value comes from tourism followed by the annual values generated by the estuary contribution to property value.

4.3.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at six of the ten nodes, apart from at Niv24 the Leeu, Niv24a the Klip, Niv25 the Buffeljags and Niv26 the Slang Rivers, where increasing flows does not improve the ecological conditions up from an E (present-day flows were retained at these nodes).

No *annual* deficits in flow volume are indicated at any of the nodes and at the last node in this tier of nodes, an *annual* surplus of outflow into the estuary, the final node Nxi2 is indicated. However, there are monthly deficits at the estuary from December to February.

The Tradouw River is in good condition and is therefore important from a conservation perspective. However, for this scenario EWR flows lower than those of the current day were routed down the river, resulting in deteriorating its ecological condition to a D.

In this IUA, present-day flows are higher than the EWR flows required to sustain the D ECs of most of the tributaries and the Breede River.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

Flow reaching the Breede estuary under this scenario are higher than required to maintain it in a D category – the Breede estuary actually remains in a B category for this scenario – i.e. same as PES..

Water quality implications

Water quality in the Lower Breede Renosterveld IUA tributaries will remain in an Ideal category and the poor quality in the Breede River at Swellendam could be slightly alleviated by the increase in dry season flows in the river mainstem. This may lead to an improvement to an Acceptable category but with excursions into an Unacceptable category as is currently the case. Flow in the Klip River at Swellendam would be largely unchanged and it is therefore important that WWTW discharges from Swellendam be controlled (i.e. meet effluent standards) to prevent further degradation of the quality in the lower Klip River, and the receiving Breede River.

Groundwater

There is no increase in groundwater use in this scenario, and the groundwater status does not change in any quaternary catchment.

EGSA

All the ecosystem goods, services and attribute values were expected to remain the same as the PES condition for this scenario.

4.3.3 REC scenario

Rivers

Present-day flows were selected at five nodes (Niv24-Leeu, Niv24a-Klip, Nvii14-Huis, Nii3-Tradouws, and Niv25-Buffeljags, while alternative EWR flows were routed down the other nodes.

This flow regime meets the flow requirements for the REC at the estuary (based on present-day flows), but not at Niii4 (EWR4).

EWR flows higher than the current day were routed through Nv2, Niii4, Nviii3, and Niv26 (creating deficits in January and February in the former three nodes) and slight deficits at the estuary from December to February

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

The condition of the Breede estuary remains the same as for PES and ESBC – i.e. B category.

Water quality implications

Water quality in the Lower Breede Renosterveld IUA will remain good (Ideal category) in the tributaries but the poor quality in the Breede River at Swellendam will improve slightly due to the increase in flow, especially during the dry season. This may lead to an improvement to an Acceptable category in the Breede River but still with excursions into an Unacceptable category as is currently the case. It remains important that WWTW discharges from Swellendam be controlled to prevent further degradation of the quality in the lower Klip River and the receiving lower Breede River.

Groundwater

To achieve PES into the future, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments are in the middle reaches of the catchment. The increase in groundwater stress in these two catchments is moderate with an increase in the use/ recharge ratio ('stress') is from 0% and 3% to 28% and 33% respectively.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.3.4 No EC – High Growth scenario

Rivers

Abstractions from the Klip, Huis and Tradouw Rivers do not change their ECs.

Abstractions from the Breede River upstream and at Nv2, Niii4 and Nviii3 change the EC of the river at Nviii3 from a B to a B/C.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

Although the percentage of naturalised MAR at the estuary under this scenario falls from 48% to 44% the condition of the Bree estuary would remain the same as for PES, ESBC and REC – i.e. B category.

Water quality

Under this flow scenario there may be little change in water quality from the baseline condition in the Lower Breede tributaries but abstractions from the mainstem Breede River may result in a deterioration from an Acceptable to Tolerable category for most of the time, and excursions into an Unacceptable category during very low flow events.

Groundwater

There is no increase in groundwater use in this scenario, and the groundwater status does not change in any quaternary catchment.

EGSA

All the ecosystem goods, services and attribute values were expected to remain the same as the PES condition for this scenario.

4.3.5 Climate change scenario

Rivers

Deterioration in EC under the climate change scenario relative to PES is indicated at two of the 10 nodes in this sub-region. The impacted river reaches are the Tradouw (B to B/C) and the lower Breede upstream of the estuary (B to B/C).

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

The impact on the Breede estuary is severe. MAR drop to 39.2% of natural and the estuary deteriorates from a B to a C condition.

Water Quality

Water quality in the Lower Breede Renosterveld IUA tributaries will change from Ideal to an Acceptable category, but the poor quality in the Breede River at Swellendam may decrease by half a water quality category, deteriorate from an Acceptable to Tolerable category for most of the time, with excursions into an Unacceptable category during very low flow events. Flow in the Klip River at Swellendam would be lower and therefore the impacts of treated effluent and dry-weather flows in Swellendam will increase (less dilution). WWTW discharges from Swellendam must be controlled better, and meet effluent standards, to prevent further degradation of the quality in the lower Klip River, and the receiving Breede River.

EGSA

The value of ecosystem goods, services and attributes under this scenario was slightly lower than under PES conditions (loss of R10 million/yr). This loss was seen in all components which had value with the largest losses originating from the drop in nursery and tourism values.

4.4 Overberg West and Overberg West Coastal

There are 17 nodes in the Overberg West and Overberg West Coastal IUAs (Figure 4-4). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-7).

Table 4-7 Annual flow as as % nMAR, and river condition (A to F) at each node for all scenarios for the Overberg West and Overberg West Coastal IUAs

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
B5-Overberg West	**Piii1**	**G40C**	**Palmiet**	**B**	C	95.19	D	40.54	C	95.19	C	95.19	C	84.07
	Piv10	G40C	Witklippieskloof		D	58.93	D	49.15	D	58.93	D	58.93	D/E	52.01
	Piv9	G40C	Palmiet		D	42.96	D	39.98	D	42.96	D	41.40	D/E	37.93
	Pvi1	G40C	Palmiet		D	60.68	D	39.36	D	60.68	D	58.94	D	53.55
	Piv8	G40C	Klipdrif		D	93.39	D	60.97	D	93.39	D	93.39	D	82.50
	Piv4	G40D	Klein-Palmiet		D	80.71	D	58.87	D	80.71	D	80.71	D	65.15
	Piv7	G40D	Krom/Ribbok		D	34.85	D	34.85	D	34.85	D	34.85	D/E	30.77
	Piii2	**G40D**	**Palmiet**	**B/C**	B/C	63.71	C	40.96	B/C	63.71	B/C	62.86	B/C	54.60
	Piv12	G40D	Dwars/Louws		C	98.81	C	85.76	C	98.81	C	98.81	C	82.66
	Piii3	**G40D**	**Palmiet**	**B**	B	69.83	C	45.56	B	69.83	B	68.03	B/C	59.49
	Pxi1	**G40D**	**Palmiet estuary**	**B**	C	70.13	C	45.24	C	70.13	C	68.36	C	59.72
H16-Overberg West Coastal	**Bxi1**	**G40B**	**Buffels estuary**	**B**	B	81.86	B	81.86	B	81.86	B	81.86	B	69.91
	Bxi2	**G40B**	**Rooiels estuary**	**B**	B	98.63	D	71.67	B	98.63	B	98.63	C	84.51
	Niv43	G40F	Swart		E	88.83	E	53.26	E	88.83	E	88.83	E	60.81
	Niii5	G40E	Bot		C	84.20	C	50.99	C	84.20	C	84.20	C	57.96
	Nxi6	**G40G**	**Bot estuary**	**B**	C	81.78	D	57.90	C	81.78	C	81.78	D	56.25
	Nxi8	**G40H**	**Onrus estuary**	**D**	D	51.77	D	51.77	D	51.77	E/F	27.18	E	36.68

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Overberg West and Overberg West Coastal IUAs included tourism values occurring along the rivers and within the estuary as well as the nursery function, sustainable fishing and property values of the estuary. These values were estimated to total R268 million per year under present conditions (Table 4-8). These values remained the same under the REC scenario and dropped under the NoEC, ESBC and CC scenarios.

Table 4-8 Ecosystem goods, services and attributes values (R million/yr.) for the Overberg West and Overberg West Coastal IUAs

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NOEC	CC
		R million	R million	R million	R million	R million
Overberg West (B5)	Tourism	57	51	57	57	51
	Nursery	1	1	1	1	1
	Sustainable Fishing	0.1	0.1	0.1	0.1	0.1
	Property	0	0	0	0	0
	Combined EGSA Value	**58**	**52**	**58**	**58**	**52**
Overberg West Coastal (H16)	Tourism	118	117	118	118	117
	Nursery	59	42	59	59	41
	Sustainable Fishing	0.7	0.5	0.7	0.7	0.5
	Property	33	24	33	32	24
	Combined EGSA Value	**210**	**184**	**210**	**209**	**183**

A short summary of the observed impacts under each scenario is given below.

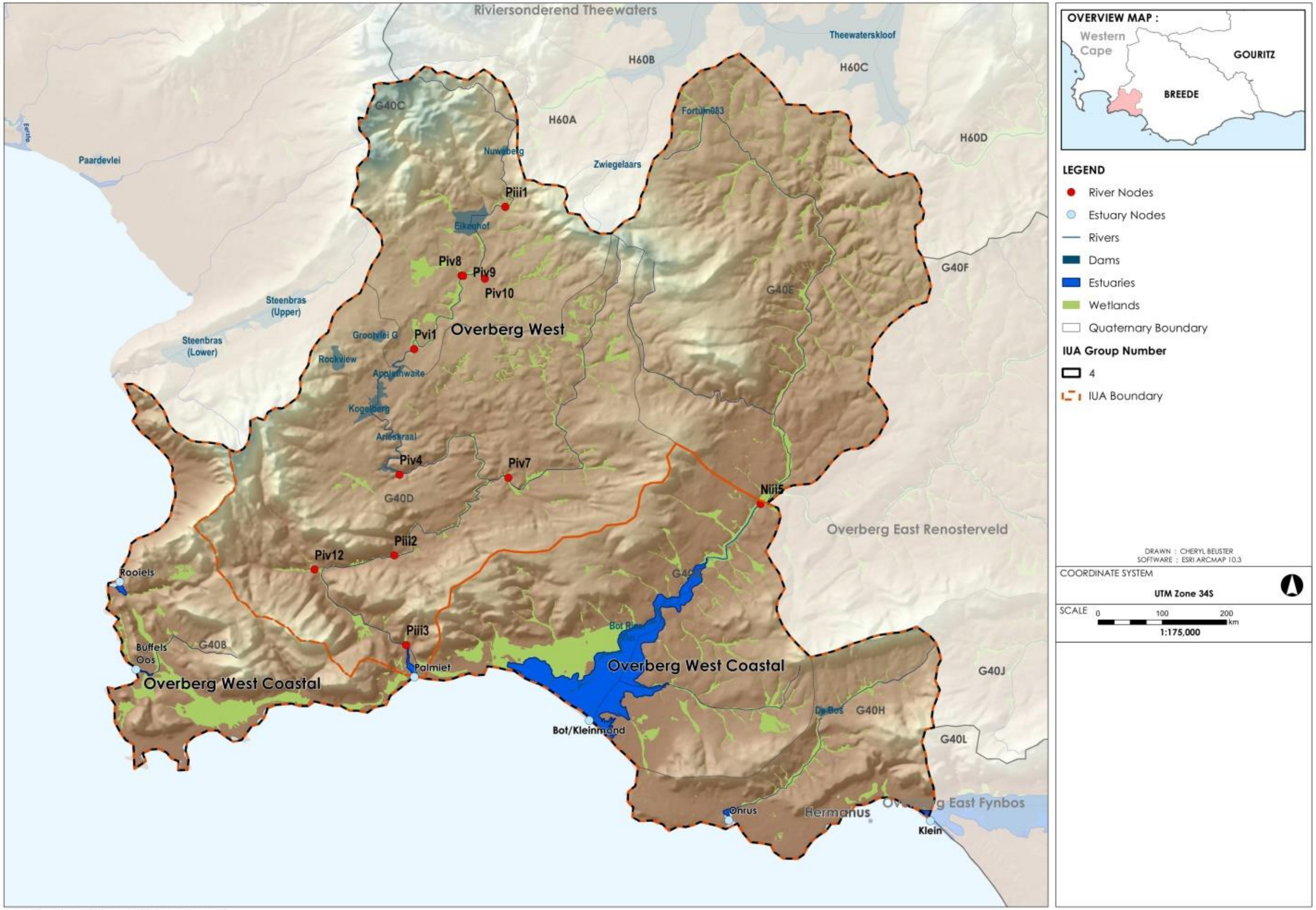

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Figure 4-4 The nodes and significant water resources for the Overberg West Coastal and Overberg West IUAs

4.4.1 Maintain PES ("Baseline")

Rivers

The Palmiet River largely comprises two distinct areas, an upper section up- and downstream of Grabouw that is heavily farmed and where flow is heavily regulated by a series of dams, and a lower section that flows through the Kogelberg Biosphere Reserve where flow improves closer to natural largely due to inflows from the Louws and the Dwars Rivers that flow naturally and provide natural cues upstream of the estuary. The first node on the Palmiet River (Piii1) is upstream of Eikenhof Dam, the first of the large dams in the basin and is in a better ecological condition (category C) and also flows relatively naturally.

Downstream of Eikenhof, the Palmiet River and tributaries here are in a poorer D ecological condition and flows during summer are supressed low when compared to natural. Flows are worst in the Krom/Ribbok tributary, sustains 22% of its mean annual runoff on average. Piii2 on the Palmiet River is situated downstream of Arieskraal dam, the lowest in the series, and from here on flows and river conditions improve. The upper agricultural sections of river are also poor ecologically due to agricultural influences, clearing of banks and discharge of nutrients into the rivers and are also vegetated with a variety of exotic woody and non-woody plants. This is in contract to the lower reaches through Kogelberg where there are no exotic plants and the basin slopes are well vegetated, up to the estuary node pxi1.

There are three river EWR sites on the Palmiet River; EWR sites 1 (piii1), 3 (Piii2) and 4 (Piii3).

The Swart River is a tributary of the Bot River that is in a very poor E ecological condition, largely due to agricultural impacts of a varied nature, while the Bot River is in a better condition, with better flows in the dry season and a greater representation of indigenous riparian vegetation and aquatic biota.

Wetlands

Within the Betty's Bay area there are three isolated freshwater depressions (Groot Rondevlei, Groot Witvlei and Malkopsvlei) (Malan et al., 2015). These wetlands are under a greater influence from changing groundwater condition, but have large biodiversity importance and are under threat by encroaching development. Other wetlands in the area that are the isolated, saline Vermont Pan and two large mountain seeps (Salmonsdam A and Die Diepte Gat). These wetlands are not necessarily impacted by changes to surface flow, although they are still in a good condition which should be maintained.

The Palmiet Estuary has a Southwest Sand Fynbos Channelled valley bottom wetland and Southwest Sand Fynbos Unchannelled valley bottom wetlands within a NFEPA cluster and the Cape Whale Coast IBA. These wetlands are to be maintained in a good condition and as the Palmiet Estuary is in a good condition, this should be maintained. The Buffels Estuary is also associated with Southwest Sandstone Fynbos Channelled and Unchannelled valley bottom wetlands, as well as Floodplain wetlands, within a wetland cluster and the Boland IBA. These wetlands should be maintained in a good condition. The Bot Estuary is a Ramsar site within the Whale Coast IBA. Although there are no delineated wetlands within the Ramsar site delineation, the surrounding Southwest Sand Fynbos Channelled and Unchannelled wetlands should be maintained in a good condition to ensure the good condition of the Ramsar site.

Estuaries

The Palmiet is in a B/C condition (same as RECC), the Buffels (Oos) and Rooiels are in a B (same as REC), the Bot estuary is in a C (REC = B), and the Onrus in a D (same as REC).

Water quality

Water quality in the Overberg West IUA will remain in a good state (Ideal to Acceptable category) provided point sources of pollution and urban runoff are controlled effectively. This is especially relevant to the town of Botrivier, where elevated salts and high phosphate values were recorded in the past which was attributed to treated wastewater discharges into the Bot River (Acceptable category for salts, Tolerable category for nutrients).

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in four (of six) quaternary catchments. These four catchments include all those of the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III).

One of the quaternary catchments impacted by a change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

Under current (PES) conditions, the aquatic ecosystems of the Overberg West and Overberg West Coastal IUAs contribute an estimated R268 million/yr. in value. The majority of this value comes from tourism value in the Overberg West Coastal IUAs.

4.4.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for at least a D at all nodes, apart from at Piii2 and Piii3 (Palmiet River) that drop down in condition from a C to a C/D and a B to a C respectively, and at Niv43 (Swart river) where increasing the flow does not improve the ecological conditions above an E. EWR flows were selected at all these nodes.

No deficit in <u>annual</u> flow volume is indicated at any of the Palmiet River nodes and at Pxi1, the estuary, where there is an <u>annual</u> surplus. However, small deficits arise in November and December at the estuary.

EWR flows were selected at all other nodes.

No deficit in annual or monthly flow volume is indicated at any of the Bot River nodes and a surplus (i.e. present-day flows will more than meet the scenario specifications

In these IUAs, at most nodes, the present-day flows were higher than the EWR flows (where EWR flows were selected) required to sustain D conditions annually and seasonally. However, this was not the case at Piv10 (Witklippieskloof River), and Pvi1 (Palmiet River), both in the Palmiet River catchment, and the Swart River Niv43, where EWR flows are higher in the dry season than natural.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

The Palmiet estuary remains in a C category (same as PES), the Buffels (Oos) stays in a B, the Rooiels deteriorates from a B to a D, the Bot stays in a C condition, and the Onrus estuary remains in an E category.

Water quality

Under the ESBC scenario, water quality in the Overberg West IUA will remain in a good state (Ideal category) provided point sources of pollution and urban runoff are controlled effectively. This is especially relevant to Botrivier town, where elevated salts and high nutrient values were recorded in the past which was attributed to treated wastewater discharges into the Bot River.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in four (of six) quaternary catchments. These four catchments include all those of the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III).

One of the quaternary catchments impacted by a change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

The value of ecosystem goods, services and attributes under this scenario was lower than under PES conditions for both the Overberg West (decrease of R6 million/yr.) and the Overberg West Coastal (decrease of R26 million/yr.). Most of this loss was seen in tourism, nursery and property values..

4.4.3 REC scenario

Rivers

This flow regime meets and exceeds the flow requirements for the REC at Piii3 (EWR site 4) on the Palmiet River using present-day flows. Improvements in flow alone do not improve conditions to the RECs at the Palmiet River EWR sites 1, 3. Improvements may, however, be made by mitigating non-flow related impacts such as the presence of exotic woody vegetation along the rivers and water quality at the Palmiet estuary.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

The Palmiet and Bot estuaries both remain in a C condition (i.e. do not reach the REC of a B as improvements in flow alone could not improve the condition), the Buffels (Oos) and Rooiels estuaries remain in a B (= REC), and the Onrus estuary remains in a D (same as REC).

Water quality

Water quality in the Overberg West IUA will remain in a good state (Ideal category) provided point sources of pollution and urban runoff are controlled effectively. Water quality in the Buffels (Oos) River will benefit from the increased flow, especially during the dry flow months, resulting in slightly better quality water (improve by half a water quality category). The increase in flow in the Onrus River will also result in a slight improvement in water quality (improve by half a water quality category).

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in four (of six) quaternary catchments. These four catchments include all those of the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III).

One of the quaternary catchments impacted by a change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

The value of ecosystem goods, services and attributes under this scenario was was the same as under PES conditions.

4.4.4 No EC – High Growth scenario

Rivers

Abstraction from the Palmiet River at various points along the river and at the estuary does not change their ecological conditions.

Wetlands

The impacts to most of the wetlands will remain as described for the Baseline scenario. The degradation of the Buffels Estuary ecological condition and decreased flow will impact the associated with Southwest Sandstone Fynbos Channelled and Unchannelled valley bottom wetlands, as well as Floodplain wetlands.

Estuaries

Abstraction from the Onrus River causes the estuary to deteriorate from a D to a E/F, but there is no change in any of the other estuaries in this region (Rooiels, Buffels (Oos), Palmiet, Bot all remain the same as PES).

Water quality

Water quality in the Overberg West IUA will remain in a good state (Ideal category) as described for the baseline scenario. The large reduction in flow in the Buffels (Oos) River would have little impact on the quality of the river because the catchment is largely not impacted. The reduction in flow in the Onrus River will result in poorer quality in the lower reaches because less water would be available to dilute urban runoff impacts (deteriorate by half a water quality category). The slight reduction in flow in the Palmiet River will result in a small change from the baseline water quality conditions (fluctuate within the Ideal category).

Groundwater

To achieve this scenario into the future, the groundwater status increases compared to PES in two quaternary catchments (i.e. increases from category I to II). These two catchments include one in the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III).

One of the quaternary catchments impacted by a change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

The value of ecosystem goods, services and attributes under this scenario was slightly lower than under PES conditions (loss of R1 million/yr.). This loss was seen in losses originating from the drop in property values.

4.4.5 Climate change scenario

Rivers

For 6 of the 16 nodes in this sub-region a deterioration in EC relative to PES is indicated under the climate change scenario. The river reaches involved are the Witklippieskloof (D to D/E), upper Palmiet (D to D/E), middle Palmiet (D to D/E), Krom/Ribbok (D to D/E), and Lower Palmiet upstream of the Palmiet estuary (B to B/C).

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

The Buffels (Oos) and Palmiet estuaries remain unchanged under this flow regime, but the ecological condition of the Rooiels, Bot and Onrus estuaries all deteriorate by one category releative to PES (drop from B to C or C to D).

Water quality

Water quality in the Overberg West IUA will remain in a moderately good state (Ideal category) as described for the baseline scenario. The reduction in flow in the Onrus River will result in poorer quality (deteriorate by half a water quality category) in the lower reaches because less water would be available to dilute urban runoff impacts and elevated evaporation in the catchment. The slight reduction in flow in the Palmiet River will result in a small change from the baseline water quality conditions and salinity might be higher due to elevated evaporation in the catchment (deteriorate by half a water quality category).

EGSA

The value of ecosystem goods, services and attributes under the climate change scenario were lower than under PES conditions for both the Overberg West (decrease of R6 million/yr.) and the Overberg West Coastal IUA (decrease of R27 million/yr.). This loss was seen mostly in nursery and property values.

4.5 Overberg East Renosterveld and Overberg East Fynbos

There are 16 nodes in the Overberg East Renosterveld and the Overberg East Fynbos IUAs (Figure 4-5). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-9).

Table 4-9 Annual flow as as % nMAR, and river condition (A to F) at each node for all scenarios for the Overberg East Renosterveld and Overberg East Fynbos IUAs

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
F10- Overberg East Renosterveld	Nii4	G40J	Hartbees		D	87.08	D	55.69	D	99.00	D	87.08	D	61.19
	Niv45	G40K	Steenbok		E	93.40	E	55.69	E	93.40	E	93.40	E	62.11
	Nv23	**G40K**	**Klein**	**C**	C/D	89.23	D	55.69	C	97.60	C/D	89.23	D	60.73
	Nxi7	**G40L**	**Klein estuary**	**B**	C	80.33	D	55.69	B	98.05	C	80.33	D	54.30
H17- Overberg East Fynbos	Nx8	G40M	Uilkraal		C	62.95	C	62.95	C	92.00	C	62.95	C	39.70
	Nxi5	**G40M**	**Uilkraal estuary**	**C**	E	43.93	E	43.93	C	63.69	E/F	40.43	E/F	27.31
	Nxi3	**G50A**	**Ratel estuary**	**C**	C	90.02	D	58.53	C	90.02	C	90.02	C/D	66.01
	Ni4	**G50B**	**Nuwejaar**	**D**	D	49.65	D	58.77	C/D	71.67	D	49.65	D/E	34.98
	Nvii15	G50C	Heuningnes		D	50.14	D	58.77	C/D	71.67	D	50.14	D/E	34.63
	Niv44	G50C	Heuningnes		D	50.20	D	58.77	C/D	71.67	D	50.20	D/E	34.58
F10	**Nv24**	**G50D**	**Kars**	**B**	B/C	89.99	C	58.77	B/C	89.99	B/C	89.99	B/C	65.77
H17	Nii5	G50E	Kars		E	85.84	E	58.77	E	85.84	E	90.61	E	62.68
	Nxi1	**G50F**	**Heuningnes estuary**	**A**	C	68.78	D	58.77	A/B	78.02	C	71.17	D	49.01
F10	Nii6	G50G	Sout		D	73.69	E	35.37	D	73.69	D	73.69	D	55.89
	Nii7	G50H	DeHoopVlei		B	91.96	C	35.37	B	91.96	B	91.96	B	66.92
H17	**Bxi3**	**G50K**	**Klipdrifsfontein estuary**	**A**	A	64.77	A	64.77	A	64.77	A	64.77	C	47.97

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Overberg East Renosterveld and the Overberg East Fynbos IUAs included tourism values occurring along the rivers in the Overberg East Renosterveld as well as the tourism, nursery function, sustainable fishing and property values of the estuaries of the Overberg East fynbos (mainly the Klein estuary). These values were estimated to total R542 million per year under present conditions (Table 4-10). These values increased under the REC scenario and dropped under ESBC and CC scenarios for the Overberg East Fynbos IUA.

Table 4-10 Ecosystem goods, services and attributes (EGSA) values (R million/yr.) for the Overberg East Renosterveld and Overberg East Fynbos IUAs

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Overberg East Renosterveld (F10)	Tourism	43	43	43	43	43
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	43	43	43	43	43
Overberg East Fynbos (H17)	Tourism	467	435	499	467	435
	Nursery	71	51	93	71	51
	Sustainable Fishing	0.19	0.15	0.29	0.19	0.15
	Property	4	3	7	4	3
	Combined EGSA Value	**542**	**489**	**600**	**542**	**489**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

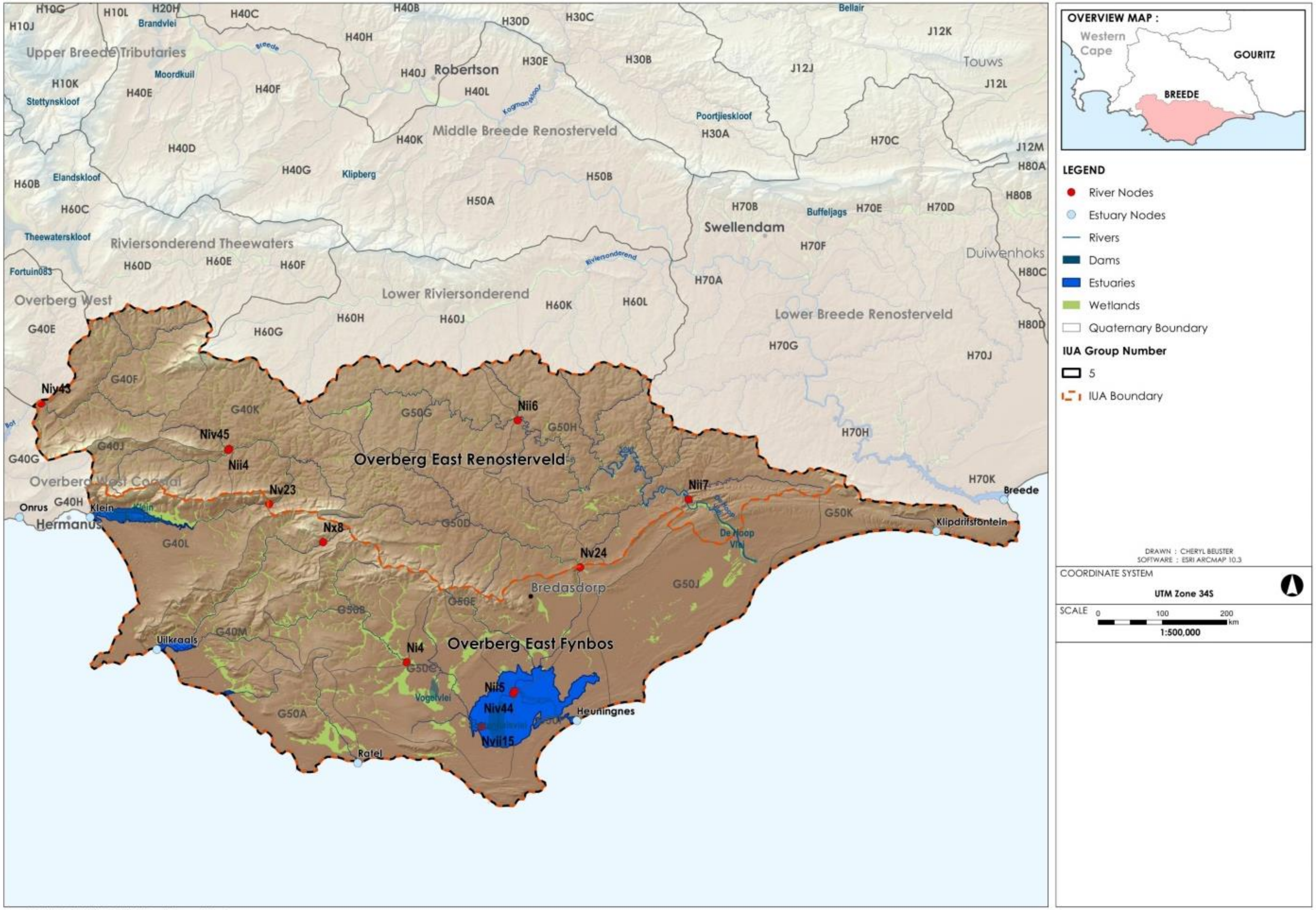

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Figure 4-5 The nodes and significant water resources for the Overberg East Renosterveld and Overberg East Fynbos IUAs

4.5.1 Maintain PES (“Baseline”)

Rivers

The Hartbees and Steenbok Rivers are two tributaries of the Klein River in poorer condition (D and E respectively) than the Klein River itself, a C/D condition river with better seasonal distribution of flow and better representation of aquatic and riparian biota. The Uilkraal River is also in an acceptable C condition despite their being reduced flows in the wet and dry seasons. The Nuwejaar and Heuningnes Rivers are in a C and D conditions respectively, due to a varied combination of agricultural impacts and reductions in flow, while the Kars, despite flowing relatively naturally is in a poor ecological condition B/C. These three rivers all ultimately flow into the Heuningnes estuary. The Sout River is also in a poor D condition, again due to agricultural impacts and reduction in dry season flows, which flows into De Hoop Vlei.

There are three river EWR sites here, Nv23 on the Klein River, Ni4 on the Nuwejaars River and Nv24 on the Kars River.

Wetlands

The Nuwejaars River drains a large part of the Algulhas Plain, to the north the Nuwejaars River flows into the large, shallow freshwater lake Soetendalsvlei and then flows to the sea as the Heuningnes River. There are various Southwest Ferricrete Fynbos wetlands in this area, which is within the Algulhas Plain-Heuningnes Estuary IBA. The Groot Hagelkraal River drains the highlands of the south-western Algulhas plain, flowing south-westerly and entering the sea at Pearly Beach, has associated Southwest Limestone Fynbos wetlands. Other wetlands are saline pans and the Gans Bay depression wetland. Certain wetlands in this area have had rehabilitation work by the Working for Wetlands programme (i.e. Boesmans River (G40M), Upper Ratel River (G50A), Pietersielieskloof (G50B), and Bergplaas (G50C) wetlands) and have management considerations. Pietersielieskloof is a Channelled valley bottom wetland with a poor ecological condition, but very high environmental importance and sensitivity. The node associated with this wetland (Ni4) is in a good condition, which should be maintained. The Ratel River Southwest Fericrete Fynbos Floodplain wetland is in a good condition, as is the associated estuary node (Nxi3).

De Hoop Vlei, below node Nii7, is a Ramsar wetland which is unique in the south-western Cape as it is a coastal lake with no outlet to the sea, with widely fluctuating salinities. There are also a series of coastal flats of national conservation importance (FEPA wetlands: Nel et al. 2011, SANBI 2009; Ollis et al. 2013). The depth of the wetland fluctuates seasonally, with a maximum depth of 7.7 metres. The Sout and Potberg Rivers are the most important rivers feeding the wetland. The wetland is within the De Hoop Nature Reserve, and is managed by Cape Nature. Maintenance of the PES of B is important for the conservation of these important wetlands.

Estuaries

The Heuningnes estuary is in an ecological condition of C, due to reductions in flow in the Nuwejaar, Heuningnes and Kars rivers which flow into the estuary, and land transformation in the estuary functional zone. This is significantly lower than the REC for this system which has been set as A owing to it being located within a protected area. The Ratel estuary is in an ecological condition of C, which corresponds with the REC for this systems, the Klein estuary is in a C (one level lower than REC), while the Uilkraals estuary is in a E category which is two levels lower than the REC for this system (= C). The Klipdrifsfontein estuary is in an A category which also corresponds with the REC for this system.

Water quality

Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations (Unacceptable category) which was largely ascribed to the geology of the region.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in one quaternary catchment (G40L, located in Overberg East Fynbos IUA). The increase in groundwater stress in this catchment is fairly significant, with the catchment increasing its use/ recharge ratio (‘stress’) from 19 to 88%.

The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions, the aquatic ecosystems of the Overberg East Renosterveld and Overberg East Fynbos IUAs provide an estimated R542 million/yr in value, the majority of this value comes from tourism value in the Overberg East Coastal estuaries, in particular the Klein Estuary.

4.5.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the nodes, apart from at Niv45 (Steenbok River), Nv24 and Nii5 (Kars River), where increasing flow did not improve the ecological conditions up from an E; EWR flows were selected at all these nodes,

No deficits in <u>annual</u> flow volume are indicated at any of the nodes. Present-day flows were selected for Ni4 on the Nuwejaar and Nvii15 and N iv44 on the Heuningnes Rivers.

Reserve flows were selected at all other nodes. Here, the present-day flows are higher than the EWR flows (where EWR flows were selected) required to sustain the D conditions annually and seasonally at all nodes apart from Nx8, the Uilkraal River, where Reserve flows are higher in the dry season than natural.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario.

Estuaries

Under this flow regime, the ecological condition of the Uilkraals and Klipdrifsfontein estuaries remain unchanged from PES (E and A, respectively), while the other three estuaries in this IUA (Klein, Ratel, and Heuningnes) all drop by one category (from C to D).

Water quality

Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations (Unacceptable category) which was largely ascribed to the geology of the region.

Groundwater

To maintain ECBS into the future, the groundwater status increases compared to PES in one quaternary catchment (G40L, located in Overberg East Fynbos IUA). The increase in groundwater stress in this catchment is fairly significant, with the catchment increasing its use/ recharge ratio (‘stress’) from 19 to 88%.

The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

The values of EGSAs remained the same as the PES condition for the Overberg East Renosterveld IUA but were lower for the Overberg East Fynbos (decrease of R53 million/yr.)IUA. The highest loss was seen in tourism and nursery values.

4.5.3 REC scenario

Rivers

Present-day flows were selected at all the nodes here and this maintained the REC of D at Ni4, the Nuwejaars River. Routing reserve flows through this tier of nodes does not improve the conditions at the Klein River (Nv23 REC = C) and Kars River (Nv24 REC = B) as these already flow close to natural. Non-flow related improvements would help lift the condition at these rivers slightly into their recommended conditions. Clearing of alien woody vegetation at the Klein River is all that is required and another fish and invertebrate survey at the Kars River will probably result in improved fish and invertebrate score there, since the once off June survey during the Reserve study at this site was ill timed during winter.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario, although the improvement of Uitkraals Estuary ecological condition is preferable for the surrounding South West Sandstone wetlands.

Estuaries

This flow regime meets and exceeds the flow requirements for the REC at Nxi5 (Uilkraal estuary) by routing EWR flows, that are considerably higher than current day, from river node Nx8 along the river to the estuary.

Increasing the flows of the tributaries of the Klein River is able to secure REC status for this system (B category) but this requires restoraing flows to almost 100% of natural.

Flow requirements are met for the REC at Nxi3, the Ratel estuary, and at Bxi3, the Klipdrifsfontein estuary, based on present-day flows, since these estuaries are already in the recommended ecological condition (C and A, respectively).

Flows higher than current significantly improve the condition of the Heuningnes estuary from its current C condition to close to the recommended A condition (= A/B). Further improvements can, however, only be achieved by mitigating non-flow related impacts such as water quality, exploitation of living resources (legal and illegal fishing) and by optimising mouth management.

Water quality

Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations (Unacceptable category), but there could be an improvement in quality as a result of increased flows in the Hartbees, Steenbok, Klein, and Uilkraal rivers (may improve to a Tolerable category).

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in two quaternary catchments (G40L, located in Overberg East Fynbos IUA, and G40J). The increase in groundwater stress in G40L catchment is fairly significant, with the catchment increasing its use/ recharge ratio (‘stress’) from 19 to 88%.

The second catchment (G40J) is located in Overberg East Renosterveld IUA, in which the change in stress is moderate (7% to 41%, category I to II). Groundwater-fed seeps have been identified in this catchment, and it has a high ratio of GWBF/EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

Under the REC Scenario there is an increase in the nursery value (increase of R22 million/yr), of the tourism value (R23 million/yr.) and of the property value (R3 million/yr.) for the Overberg East Fynbos IUA . Values remain the same for the Overberg East Renosterveld IUA.

4.5.4 No EC – High Growth scenario

Rivers

The relatively small abstraction from the Uilkraal does not change its ecological condition.

There is a slight decrease in flow at Nii5 (Kars river) which does not change the condition of the Kars River.

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario

Estuaries

The ecological condition of all the estuaries aside from the Uilkraals remain unchanged under this flow regime. The condition of the Uilkraals estuary drops from an E category to a E/F category.

Water quality

With the minor changes in flow envisaged in this scenario, water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations (Unacceptable category) which was largely ascribed to the geology of the region.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in only one quaternary catchment. This catchment is located in Overberg East Fynbos IUA (G40L). The increase in groundwater stress in this catchment is fairly significant, with an increase in the use/ recharge ratio ('stress') from 19 to 88%.

The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

The values of ecosystem goods, services and attributes were expected to remain unchanged relative to the PES condition for both IUAs.

4.5.5 Climate change scenario

Rivers

The condition of three of the 15 nodes here drops in response to the climate change scenario relative to baseline. These are the Nuwejaars (C to C/E) and two lower Heuningnes nodes (D to D/E).

Wetlands

The impacts to wetlands will remain as described for the Baseline scenario**.**

Estuaries

The ecological condition of the Klein, Uilkraals and Heuningnes estuaries deteriorate from C to D, Uilkraals from a E to a E/F, and the Klipdrifsfontein estuary from an A to an C under this flow regime.

Water quality

Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations (Unacceptable category) and the situation might be aggravated due to elevated evaporation associated with climate change.

EGSA

Under the CC scenario no change is detected for the Overberg East Renosterveld IUA, however there is a decrease in the torism value and estuary nursery and property value in the Overberg East Fynbos IUA. This is associated with the decrease in condition of the Klein, Uikraals and Heuningnes estuaries under this scenario.

4.6 Duiwenhoks and Hessequa

There are nine nodes in the Duiwenhoks and Hessequa IUAs as shown in Figure 4-6.

The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-11).

Table 4-11 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Duiwenhoks and Hessequa IUAs

IUA	Node	Quat	River	ER - REC	Current PES (2014) EC	Current PES (2014) % nMAR	ESBC EC	ESBC % nMAR	REC EC	REC % nMAR	NoEC EC	NoEC % nMAR	CC EC	CC % nMAR
F12- Duiwenhoks	giii5	H80B	Duiwenhoks		E	94.05	E	54.77	E	94.05	E	92.33	E	70.09
	gv11	H80C	Duiwenhoks		D	94.05	D	54.12	D	94.05	D	92.62	D	68.32
	giii8	**H80D**	**Duiwenhoks**	**D**	D	94.35	D	53.17	D	94.35	D	93.06	D	67.91
	Gxi2	**H80E**	**Duiwenhoks estuary**	**A**	B	91.89	C	51.74	B	91.89	B	90.67	B/C	65.70
I18- Hessequa	giii6	H90B	Korinte		D	89.02	D	89.02	D	89.02	D	81.67	D	64.12
	giii7	**H90A**	**Goukou**	**C/D**	C/D	87.67	D/E	33.44	C/D	87.67	C/D	87.67	D	62.55
	gv10	H90C	Goukou		D	84.73	D	52.77	D	84.73	D	82.03	D	60.54
	gv41	H90D	Goukou		C	83.50	C/D	49.15	C	83.50	C	81.12	C	58.50
	Gxi3	**H90E**	**Goukou estuary**	**B**	C	81.41	D	48.30	C	81.41	C	79.15	C/D	56.94

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Duiwenhoks and Hessequa IUAs included tourism values occurring along the rivers and in estuaries as well as the, nursery function, sustainable fishing and property values of the Duiwenhoks and Goukou estuaries. These values were estimated to total R193 million per year under present conditions (Table 4-12). Values decreased under the ESBC scenario for both IUAs, but remained similar to the PES for the other three scenarios.

Table 4-12 Ecosystem goods, services and attributes (EGSA) values (R million/yr) for the Duiwenhoks and Hessequa IUAs.

IUA	EGSA value component	Current PES (2014) R million	Scenario ESBC R million	REC R million	NOEC R million	CC R million
Duiwenhoks (F12)	Tourism	38	38	38	38	38
	Nursery	9	7	9	9	9
	Sustainable Fishing	0.14	0.11	0.14	0.14	0.14
	Property	2	2	2	2	2
	Combined EGSA Value	**50**	**48**	**50**	**50**	**50**
Hessequa (I18)	Tourism	110	102	110	110	110
	Nursery	6	4	6	6	6
	Sustainable Fishing	0.19	0.14	0.19	0.19	0.19
	Property	27	19	27	27	27
	Combined EGSA Value	**143**	**125**	**143**	**143**	**143**

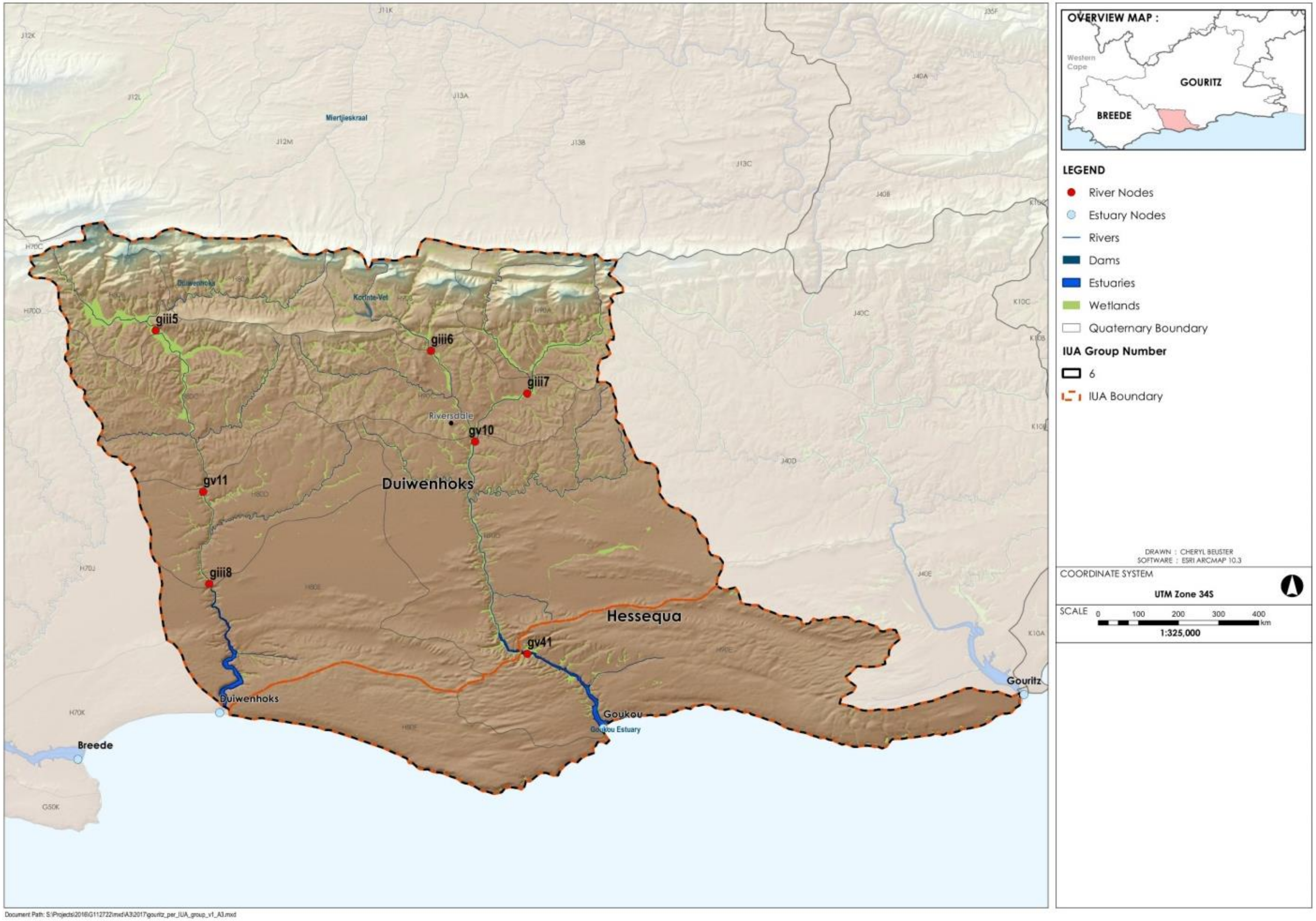

Figure 4-6 The nodes and significant water resources for the Duiwenhoks and Hessequa IUAs

4.6.1 Maintain PES ("Baseline")

Rivers

The rivers of the Duiwenhoks and Hessequa are in moderate to poor condition, despite flowing relatively naturally on average annually and between seasons, due to a range of agricultural impacts such as clearing of riparian vegetation for cultivation and infilling in cultivated areas.

Some channels have been modified and ploughed over, while the presence of livestock impacts on bed and bank stability as well as water quality. Exotic woody plants are present in riparian zones and in some areas where the riparian vegetation is intact it appears as a thin band along the river edges. On this basis there are no obvious areas suited to exclusion from development for conservation purposes.

Wetlands

The Duiwenhoks wetland (within H80A above node giii5) has been assessed through the Gouritz Reserve study (DWS, 2015) as having a moderate importance attributed to functions such as flood attenuation, baseflow maintenance and sediment trapping. Impacts of erosion, together with invasive woody vegetation and encroachment of agricultural areas have meant that the wetland has a PES of D. Management interventions were recommended in order to maintain the current D condition and stop the negative trajectory of change. Working for Wetlands has worked on rehabilitating this wetland. The associated river node (giii5) has a PES of E, which is below the D required.

Other wetlands the Working for Wetlands programme has focused on the Grootbosberg, Lower and Upper Tierkloof and Upper Gaffie channel valley bottom wetlands on Goukou River (within H90A above node giii7). These wetlands are also important in terms of flood attenuation, streamflow regulation and water quality/biodiversity maintenance. As with the Duiwenhoks wetland, these wetlands are also at risk from erosion and rehabilitation efforts have focused on reducing this. The Grootbosberg wetland is peat, with Palmiet being the dominant vegetation species. The Upper Tierkloof wetland is Southern Silcrete Fynbos, considered as critically endangered and the Lower Tierkloof wetland is East Coast Shale Renosterveld, which is also critically endangered. The Upper Gaffie has similar characteristics to the Tierkloof wetlands. Working for wetlands gave these wetlands a PES of D, with associated management interventions. The river node related to these wetlands has a PES of C/D, which should be maintained.

Estuaries

The ecological condition of the Duiwenhoks and the Goukou estuaries are B and C, respectively, which is lower than the Recommended Ecological Condition of A and B, respectively.

Water quality

The good water quality (Ideal category) observed in the upper and middle reaches of the Duiwenhoks IUA will be maintained under this scenario. The elevated salinities (Acceptable to Tolerable categories) observed in the lower reaches of the Duiwenhoks River and the lower Goukou River will continue. Water quality in the Korentepoort Dam will remain in an Ideal category for water supply to domestic and irrigation users.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in one quaternary catchment. This catchment is located in the Duiwenhoks IUA (H90C). The increase in groundwater stress in this catchment is moderate, with the catchment increasing its use/ recharge ratio ('stress') from 21 to 65%, equivalent to category II to III.

The quaternary catchment impacted by the change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

Under the current (PES) conditions, the values of the aquatic ecosystem goods, services and attributes of the Duiwenhoks and Hessequa IUAs total R193 million per year. These values are mainly derived from the tourism value of the rivers in the Duiwenhoks IUA and the tourism value of the Goukou estuary in the Hessequa IUA. Smaller values are also attributable to the nursery and property values in both estuaries.

4.6.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the nodes, except for at giii5 (upper Duiwenhoks), where increasing flow does not improve the E/C from an E, and at giii7, which is in a D/E condition.

No deficits in annual or monthly flow volume are indicated at any of the nodes, i.e. there are surpluses at all nodes, except for small deficits in January and February in the lower Goukou (gv10 to estuary).

Present-day flows were retained at giii6 because routing EWR flows through these nodes deteriorated their ecological condition or that of nodes downstream.

Wetlands

There was also little change with the condition of the node (giii5) associated with the Duiwenhoks wetland which still remains an E. This is below the requirements of at least a D condition for this wetland system. The condition associated with the Goukou River node (giii7) was reduced to D/E, and flow was also reduced.

Estuaries

Under this flow regime, the ecological condition of the Duiwenhoks estuary deteriorates from B to C while the health of the Goukou estuary drops from a C to a D.

Water quality

The good water quality observed in the upper and middle reaches of the Duiwenhoks IUA will deteriorate to a lower category (change from Ideal to Acceptable category) if the water that becomes available in this scenario is used for irrigation in the local catchments, resulting in larger volumes of poor quality return flows (elevated salts and agrochemicals). This will have a cascading effect with higher salinities estimated in the lower reaches of the Duiwenhoks River and the lower Goukou River (change from Acceptable/Tolerable to Tolerable/Unacceptable). Water quality in the Korentepoort Dam will remain in an Ideal category because the present-day flows will remain unchanged.

Groundwater

Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.

EGSA

Under the ESBC scenario a loss in value is predicted in both IUAs, however the loss is much greater in the Hessequa IUA (18 million/yr vs. 2 million/yr in the Duiwenhoks). This change is mainly due to expected losses in property and tourism value in the Goukou estuary.

4.6.3 REC scenario

Rivers

Present-day flows were retained at all nodes. This flow regime meets the REC of D for giii8 (Duiwenhoks River). Flow requirements are met for the REC of C/D at giii7 (Goukou River) with 80% of natural flows.

Wetlands

There was also little change with the condition of the node (giii5) associated with the Duiwenhoks wetland which still remains an E. This is below the requirements of at least a D condition for this wetland system. The condition associated with the Goukou River node (giii7) was maintained at C/D.

Estuaries

This flow regime is unable to meet the REC of A for the Duiwenhoks estuary (gxi2), even though the flow is 91% of natural, and is similarly unable to meet the REC of B at the Goukou estuary (gxi3), even though flow is at 81% of natural. Ecological conditions remain as at present for both systems.

Water quality

Under this scenario there will be no change in flow in the Duiwenhoks IUA. The good water quality described in the baseline section (Ideal category) is therefore expected to prevail in the upper and middle reaches of the IUA, including the elevated salinities observed in the lower reaches of the Duiwenhoks River and the lower Goukou River.

Groundwater

To achieve REC, the groundwater status increases compared to PES in one quaternary catchment. This catchment is located in the Duiwenhoks IUA (H90C). The increase in groundwater stress in this catchment is moderate, with the catchment increasing its use/ recharge ratio ('stress') from 21 to 65%, equivalent to category II to III.

The quaternary catchment impacted by the change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values were expected to remain unchanged from the PES condition for this scenario.

4.6.4 No EC – High Growth (FHG) scenario

The relatively small abstractions from the Duiwenhoks, Korinte and Goukou Rivers do not change the resulting EC at any nodes.

Groundwater

Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.

4.6.5 Climate change scenario

Rivers

Of the 9 nodes in this sub-region only one shows a deterioration in EC relative to PES under the climate change scenario; the Upper Goukou (gii7) C/D to D).

Wetlands

There was also little change with the condition of the node (giii5) associated with the Duiwenhoks wetland which still remains an E. This is below the requirements of at least a D condition for this wetland system. The condition associated with the Goukou River node (giii7) was maintained at C/D.

Estuaries

The ecological conditions of both the Duiwenhoks and the Goukou estuaries decrease under this flow scenario, from a B to a B/C for the former, and from a C to C/D for the latter.

Water quality

The good water quality observed in the upper and middle reaches of the Duiwenhoks IUA will deteriorate to a lower category (change from Ideal to Acceptable category) due to lower flows, increased evaporation, and the impacts of irrigation return flows. This will have a cascading effect with higher salinities estimated in the lower reaches of the Duiwenhoks River and the lower Goukou River. Water quality in the Korentepoort Dam may deteriorate somewhat (Ideal category but more frequent excursions into an Acceptable category) due to the lower inflows and increased evaporation rates.

EGSA

All the aquatic ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.7 Touws

There are 12 nodes along the Touws River and its tributaries (Figure 4-7). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-13). A short summary of the observed impacts under each scenario are given below.

Table 4-13 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Touws IUA

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
E8-Touws	giv30	J12C	Ysterdams		D	50.87	D	50.87	D	50.87	E	39.55	D/E	34.79
	giv31	J12B	Donkies		D	55.52	D	55.52	D	55.52	D	51.24	D/E	40.37
	giv28	J12D	Touws		D	54.57	D	47.50	D	54.57	D	51.57	D/E	36.76
	giv27	J12H	Touws		B	50.24	C	41.20	B	50.24	B	48.38	C	36.56
	giv26	J12K	Brak		C	14.46	C	14.46	C	14.46	C	14.46	C	12.97
	gviii1	**J12L**	**Doring**	**C/D**	C/D	43.39	D/E	26.06	C/D	43.39	C/D	43.39	D	39.25
	gv5	**J12L**	**Touws**	**B/C**	B/C	46.37	C	37.62	B/C	46.37	B/C	44.91	C	34.94
	gv4	**J11H**	**Buffels**	**C**	C	60.32	C/D	52.59	C	60.32	C	60.32	C	50.99
	gv6	J11J	Groot		D	42.70	D/E	35.55	D	42.70	D	42.65	D/E	38.44
	giv32	J11K	Groot		D	38.59	D/E	31.64	D	38.59	D	38.49	D	36.46
	gv7	J13A	Groot		C	41.06	C	34.11	C	41.06	C	40.35	C	34.47
	gii3	J13C	Groot		B	42.79	C	34.59	B	42.79	B	42.13	C	35.79

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Touws IUA included tourism values occurring along the rivers. This value was estimated at R81 million per year under present conditions (Table 4-14). These values decreased under the ESBC scenario and CC scenarios, but remained similar to the PES for the REC and No EC (HG) scenarios.

Table 4-14 Ecosystem goods, services and attributes values (R million/yr) for the Touws IUA

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Touws (E8)	Tourism	81	73	81	81	73
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**81**	**73**	**81**	**81**	**73**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

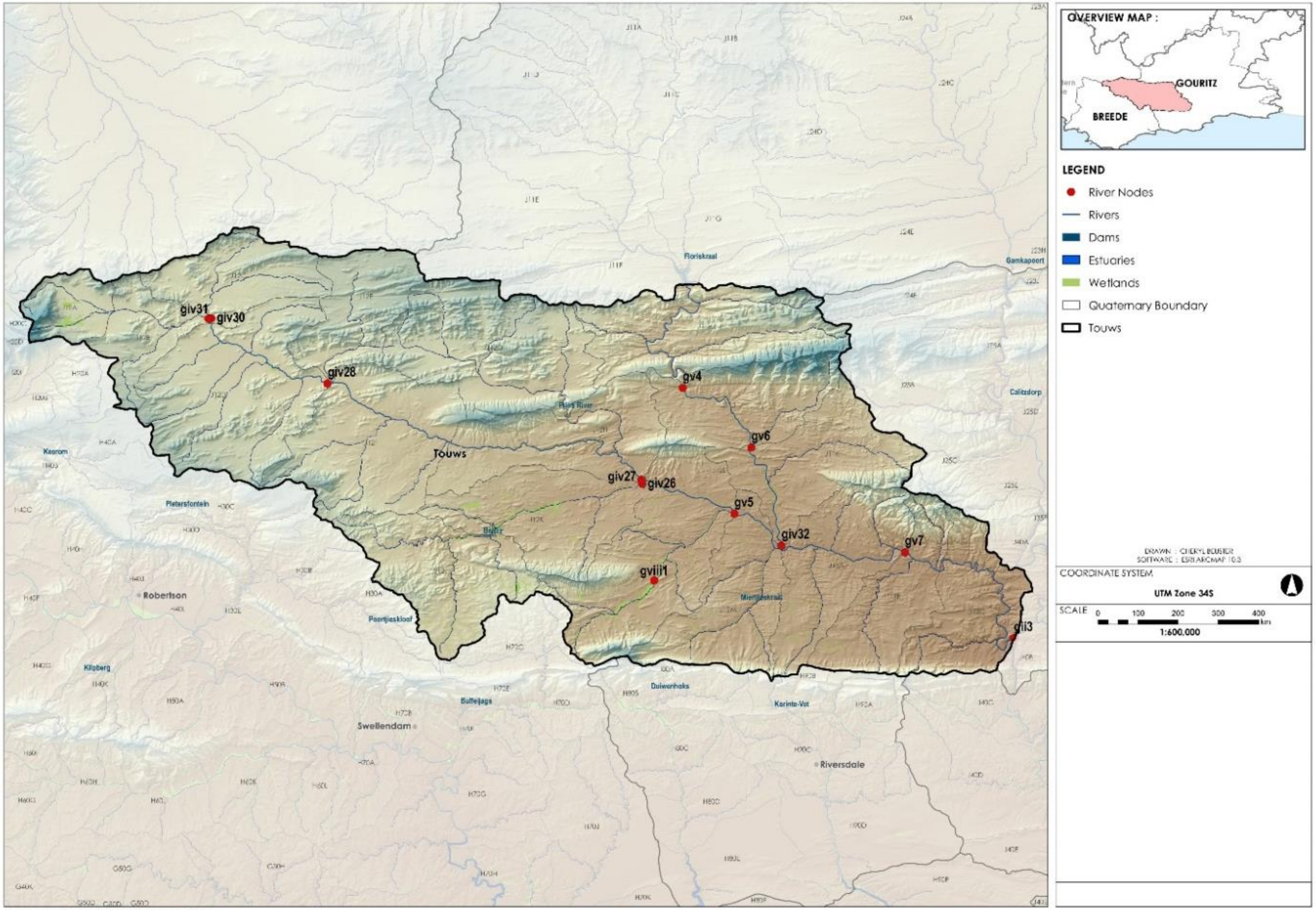

Figure 4-7 The nodes and significant water resources for the Touws IUA

4.7.1 Maintain PES ("Baseline")

Rivers

The Ysterdams, Donkies and upper Touws rivers (giv30, giv31 and giv28) at the upper reaches of this region and the upper Groot River (gv6, giv32) are in poorer condition (D category) than the rest of the rivers, due to some erosion in places and the presence of exotic woody vegetation in other. There is limited riparian vegetation; these Karoo rivers tend to have many terrestrial species and also are vegetated with many pioneering species that take advantage of seasonally abundant water.

Where cultivation occurs, there is some infilling to create fields and also some clearing of river bank vegetation. The lower Touws (giv27, gv5), the Brak (giv26), the Buffels (gv4) and the lower Groot (gv7, gii3) are in better condition (B, B/C or C category), where there is a better representation of indigenous karoid vegetation along the rivers and the impacts of the livestock farming are more remote from the river channel edges.

Wetlands

The upper reaches of Donkies River in Touws IUA have FEPA channelled valley-bottom wetlands in a good condition, which are within the Bokkeriviere Nature Reserve and the Gouritz High Yield Strategic Water Source Area. This region requires natural flow and may be considered for conservation purposes, although currently the associated river nodes are in a poor condition.

Channelled valley wetlands on the Brak and Touws tributaries are associated with nodes in a better condition, and this should be maintained.

Water quality

High salinities (Unacceptable category) occur almost throughout the Touws IUA except in its headwaters (Acceptable to Tolerable categories) making the water less suitable for agricultural purposes. This situation will be maintained under the Baseline scenario. The moderately high pH values (Acceptable to Tolerable categories) that were historically recorded in the Touws IUA will be maintained as well as the elevated phosphate concentrations (Ideal to Acceptable categories) observed in some reaches of the IUA.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in two quaternary catchments. These two catchments are J12B and J13C; located at the northwest (upstream) and southeast (downstream) extremities of the catchment respectively. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio ('stress') from 2 to 100%, corresponding for a change in status category from I to III. The change at J13C is moderate.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions the tourism value of the rivers was estimated at R81 million per year. No other values were associated with this IUA.

4.7.2 ESBC scenario

Rivers

Present-day flows were selected at the distal most nodes on the Ysterdams (giv30), Donkies (giv31) and upper Touws (giv28) Rivers; EWR flows were selected at all other nodes.

This flow regime meets and exceeds the flow requirements for a D at all the nodes, apart from at gviii1 (Doring River), gv6 and giv32 (Groot River), where the condition deteriorated to a D/E category as a result of cascading a mixture of EWR and present-day flows through the catchment.

No deficits in annual flow volume are indicated at any of the nodes. However, individual monthly deficits occur at several nodes, including gii3 which has deficits during April to June.

Current day releases from Floriskraal Dam exceed natural flows in the dry season (September and October specifically, the average of these two months at Gv4 being approximately 123% of nMAR). The average seasonal **EWR** flows in this scenario, therefore, are lower than current flows in the dry season (38% as opposed to 123%), but higher in the wet season (65% as opposed to 47% currently). Implementing these ESBC flows is contrary to the current operation of the dam, and in addition reduces the ecological condition at this node and the two nodes downstream (gv6 and giv32 on the Groot River).

Wetlands

The river nodes (i.e. giv28) are still in a poor condition. The Doring tributary node (gviiii3) and Buffels node (gv4) reduce ecological condition below the condition of the associated wetlands.

Water quality

High salinities (Unacceptable category) occur almost throughout the Touws IUA except in its headwaters making the water less suitable for agricultural purposes. This situation will continue under the ESBC scenario. The moderately high pH values (Acceptable to Tolerable categories) that were historically recorded in the Touws IUA will be maintained, but the elevated phosphate concentrations observed in some reaches of the IUA may deteriorate slightly (change form Ideal/Acceptable to Acceptable/Tolerable categories) due to a reduction in flows.

Groundwater

To achieve this scenario into the future, the groundwater status increases compared to PES in one quaternary catchment. The catchment is J12B; located at the northwest (upstream) extremity of the catchment. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio (‘stress’) from 2 to 100%, corresponding for a change in status category from I to III.

The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

Under the ESBC scenario there was a slight decrease in the value of the tourism in the rivers of this IUA (loss of R8 million/yr).

4.7.3 REC Scenario

Rivers

Present-day flows were retained at all sites, achieving the RECs at the River EWR sites: gviii1 (Doring River = C/D), gv5 (Touws River = B/C) and gv4 (Buffels River = C).

Wetlands

The river nodes (i.e. giv28) are still in a poor condition, much below the condition of the associated wetlands.

Water quality

The high salinities (Unacceptable category) described in the baseline description of the Touws IUA will prevail as no change in flow is envisaged in this scenario.

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in two quaternary catchments. These two catchments are J12B and J13C; located at the northwest (upstream) and southeast (downstream) extremities of the catchment respectively. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio (‘stress’) from 2 to 100%, corresponding for a change in status category from I to III. The change at J13C is moderate.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.7.4 No EC – High Growth scenario

Rivers

Abstraction from the Yesterdams (Giv30) will deteriorate its EC from a D to an E.

Smaller abstractions influencing the Donkies (Giv31) and Touws (Giv28) do not change the resulting EC.

Abstractions affecting the Groot (all four nodes) also do not affect the resulting EC.

Wetlands

The river nodes (i.e. giv28) are still in a poor condition, much below the condition of the associated wetlands.

Water quality

The reduced flows in the upper reaches of the Touws IUA will aggravate the poor salinity status of the affected rivers where the quality is already in an Unacceptable category. In the rest of the catchment, the high salinities described under the baseline condition (Unacceptable category) will be maintained under this scenario as little change in flow is envisaged.

Groundwater

To achieve this scenario into the future, the groundwater status increases compared to PES in one quaternary catchment. The catchment is J12B; located at the northwest (upstream) extremity of the catchment. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio ('stress') from 2 to 100%, corresponding for a change in status category from I to III.

The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.7.5 Climate change scenario

Rivers

The EC at three of the river nodes remain in the baseline condition under the climate change scenario. The rest all deteriorate by a half a category, for example the Ysterdams (giv30), Donkies (giv31) and upper Touws (giv28) Rivers that change from Ds to D/Es, or a full category such as at giv27 on the Touws, from a B to a C. The condition at two of other river EWR sites drop at gviii11 on the Doring River from a C/D to a D, and at gv5 on the Touws River from a B/C to a C, while the condition at the third EWR site on the Buffels River gv4 remains in a C category.

Wetlands

The river nodes (i.e. giv28) are in a worse condition, much below the condition of the associated wetlands. The Doring tributary node (gviiii3) and Buffels node (gv4) reduce ecological condition below the condition of the associated wetlands.

Water quality

The further reduction in flow in the upper reaches of the Touws IUA, due to climate change, will further aggravate the poor salinity status of the affected rivers (the quality is already in an Unacceptable category).

In the rest of the catchment, the high salinities described under the baseline condition will continue (Unacceptable category).

EGSA

Under the CC scenario there was a slight decrease in the value of the tourism in the rivers of this IUA (loss of R8 million/yr).

4.8 Gamka-Buffels

There are ten nodes along the Buffels, Dwyka and Gamka Rivers (Figure 4-8).

The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-15).

Table 4-15 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Gamka-Buffels IUA

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
C6-Gamka-Buffels	giv34	J11C	Buffels		A	97.25	B	54.42	A	97.25	A	97.25	A/B	84.25
	gv25	J11F	Buffels		C	93.27	C	53.20	C	93.27	C	93.27	C	83.89
	gv18	J21A	Gamka		B	77.34	C	42.95	B	77.34	B	72.87	B/C	53.26
	giv3	J21D	Gamka		B	77.81	C	41.91	B	77.81	B	72.93	B/C	54.19
	giv1	J22F	Koekemoers		C	87.87	D	34.68	C	87.87	C	87.87	C	63.50
	giv2	J22K	Leeu		C	44.14	D	19.68	C	44.14	C	44.14	C/D	33.43
	gv17	J23C	Gamka		B	68.99	C	34.04	B	68.99	B/C	66.32	B/C	49.42
	giv21	J23F	Gamka		B	62.35	C/D	33.22	B	62.35	B	59.24	B/C	45.20
	gv27	J23J	Gamka		C	61.87	D	33.11	C	61.87	C	58.92	C	44.90
	gv14	J24D	Dwyka		A	85.15	C	39.29	A	85.15	A	85.15	A	66.83

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Gamka-Buffels IUA included tourism values occurring along the rivers. This value was estimated at R43 million per year under present conditions (Table 4-16). These values decreased under the ESBC scenario and CC scenarios, but remained similar to the PES for the REC and No EC (HG) scenarios.

Table 4-16 Ecosystem goods, services and attributes values (R million/yr) for the Gamka-Buffels IUA

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Gamka-Buffels (C6)	Tourism	43	39	43	43	39
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**43**	**39**	**43**	**43**	**39**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

A short summary of the observed impacts under each scenario are given below.

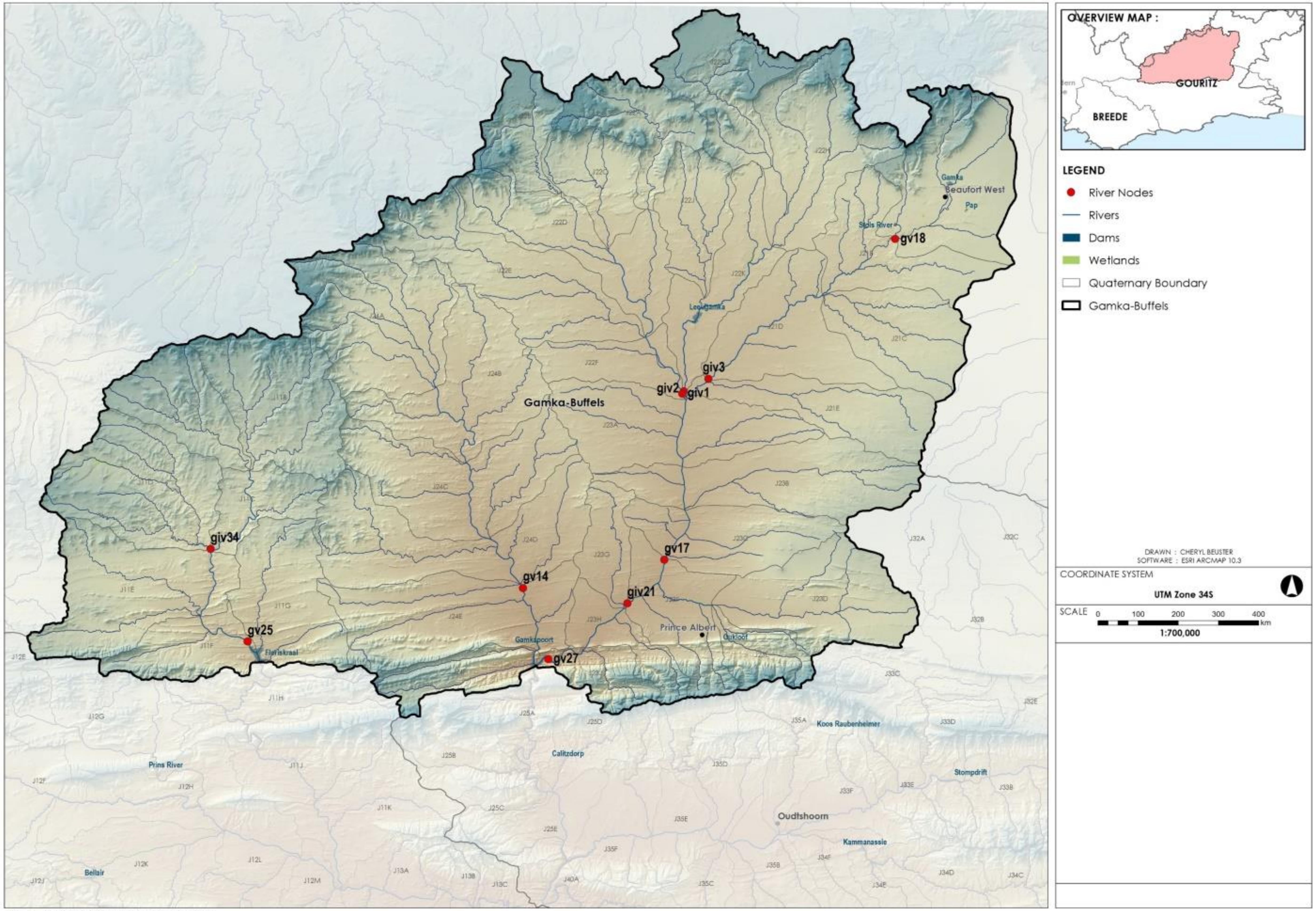

Figure 4-8 The nodes and significant water resources for the Gamka-Buffels IUA

4.8.1 Maintain PES (“Baseline”)

Rivers

The Buffels catchment upstream of Floriskraal Dam (giv34 and gv25) should be considered for conservation priority and any future scenario should maintain present-day flows or better rather than select the EWR flows routed into the Dam as in this scenario. Most of the rivers here are in a good condition and this is well represented by the nodes selected in this region in an A or B condition, along the Gamka and Dwyka Rivers. Some of the small tributaries have sparse trees present in the riparian area of the channels that are dominated by terrestrial vegetation. The larger Gamka River has well established indigenous riparian vegetation along its course with a good diversity of trees, shrubs and graminoids. In general, there is minimal disturbance to the river channel structure and shape even though the rivers’ flow is suppressed somewhat from natural. Flows in the Leeu are altered due to the Leeu-Gamka dam upstream of the node (giv2) but the river channel remains well vegetated and offers suitable habitat to a range of aquatic biota.

Flow in the Buffels upstream of Floriskraal Dam is close to natural. Many of the rivers in the upstream quaternary catchments can be considered for conservation purposes for this reason and also that most are in a good condition. Other regions which may be considered are river reaches within the Gouritz High Yield Strategic Water Source Areas.

Wetlands

The river nodes associated with wetlands in this IUA are in a good condition. The river node associated with the Lower Nama Karoo Floodplain and Channelled Valley Bottom wetlands in the Karoo National Park is in a C ecological condition.

Water quality

Water quality in the Gamka-Buffels IUA, in the upper reaches of the Gamka River will remain in an Acceptable category. The average salinity will remain in an Acceptable category although high concentrations (Unacceptable category) may be observed from time to time, largely due to the arid nature of the catchment and accumulation of salts during prolonged dry periods. Nitrogen concentrations would remain low and in the Ideal category, and phosphate concentrations would remain in an Ideal category although some elevated concentrations may be observed from time to time (Unacceptable category). The poor quality (elevated salinities) downstream of Floriskraal Dam would be maintained under the PES scenario although the quality would vary between Acceptable and Tolerable categories as is currently the case. High phosphate concentrations may still be observed although the quality would remain mostly in an Ideal category with respect to nutrients.

Groundwater

There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.

EGSA

Under current (PES) conditions the tourism value of the rivers was estimated at R43 million per year.

4.8.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the nodes. No deficits in annual or monthly flow volume are indicated at any of the nodes. Flows other than current (i.e. various category EWR flows) were selected at all nodes.

The Dwyka and Gamka Rivers and their tributaries could be considered for conservation potential, being in good condition and flowing relatively naturally.

Wetlands

The river nodes associated with wetlands in this IUA are in a good condition. The river node associated with the Lower Nama Karoo Floodplain and Channelled Valley Bottom wetlands in the Karoo National Park reduces to a D ecological condition, which is below what is required for the associated wetlands.

Water quality

Water quality in the Gamka-Buffels IUA, in the upper reaches of the Gamka River will be affected by the general reduction in flow under the ESBC scenario. The average salinity will deteriorate to a Tolerable category due to less flow being available to dilute the salts originating from the catchment and salts that have accumulated in the river channels during prolonged dry periods. Nitrogen concentrations would remain low and in the Ideal category, and phosphate concentrations would remain low although some elevated concentrations may be observed from time to time. The poor quality (elevated salinities) downstream of Floriskraal Dam would deteriorate further to a Tolerable category. High phosphate concentrations may still be observed although the quality would remain mostly in an Ideal category with respect to nutrients.

Groundwater

There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.

EGSA

Under the ESBC scenario there was a slight decrease in the value of the tourism in the rivers of this IUA (loss of R4 million/yr).

4.8.3 REC Scenario

Rivers

Present-day flows at all nodes were retained. There are no Reserve sites in this section, thus there are no RECs to be met.

Wetlands

The river nodes associated with wetlands are in a similar condition to the baseline.

Water quality

The baseline water quality in the Gamka-Buffels IUA will prevail under this scenario as no change in flow is envisaged.

Groundwater

There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.

EGSA

Values remained the same as the PES condition for this scenario.

4.8.4 No EC – High Growth scenario

Rivers

All nodes were unaffected by this scenario in terms of EC, apart from a reduction in EC (from B to B/C) at gv17 on the Gamka River.

Wetlands

The river nodes associated with wetlands are in a similar condition to the baseline.

Water quality

The baseline water quality in the Gamka-Buffels IUA will prevail under this scenario as only a slight reduction in flow is envisaged in some of the rivers in the IUA.

Groundwater

There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.

EGSA

Values remained the same as the PES condition for this scenario.

4.8.5 Climate change scenario

Rivers

The condition of six of the ten nodes deteriorates under the climate change scenario relative to Current /PES. Four nodes on the Gamka main-stem drop half a category from a B to a B/C and the Buffels River at giv34 drops from an A to an A/B, similarly the Leeu River at giv2 drops from a C to a C/D.

Wetlands

The river nodes associated with wetlands in this IUA are in a good condition. The river node associated with the Lower Nama Karoo Floodplain and Channelled Valley Bottom wetlands in the Karoo National Park reduces to a C/D ecological condition, which is below what is required for the associated wetlands.

Water quality

The baseline water quality in the Gamka-Buffels IUA will deteriorate by one water quality category as a result of reduced flow and elevated evaporation associated with the climate change scenario.

EGSA

Under the ESBC scenario there was a slight decrease in the value of the tourism in the rivers of this IUA (loss of R4 million/yr).

4.9 Gouritz-Olifants and Lower Gouritz IUAs

There are 19 nodes in the Gouritz-Olifants and Lower Gouritz IUAs (Figure 4-9). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-17).

Table 4-17 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Gouritz-Olifants and Lower Gouritz IUAs

IUA	Node	Quat	River	ER - REC	Current PES (2014)		Scenarios ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
D7-Gouritz-Olifants;	**giv20**	**J25A**	**Gamka**	**C**	C/D	55.79	D	34.57	C	66.02	D	51.52	D	40.87
	giv18	J25D	Nels		D	55.82	D	55.82	D	55.82	D	53.19	D	42.21
	gii2	J25E	Gamka		C	48.82	C/D	36.80	C	61.32	C	40.09	C/D	38.68
	giii2	**J31C**	**Olifants**	**C**	C	85.27	C	57.24	C	85.27	C	85.27	C	81.37
	giv15	J32E	Traka		C	81.11	D	41.38	C	81.11	C	81.11	C	76.64
	gv33	J33B	Olifants		D	79.46	D	57.69	D	79.46	D	79.46	D	72.27
	gv21	J33D	Meirings		C	90.58	D	41.06	C	90.58	C	90.58	C	76.80
	giv11	J33F	Olifants		E	47.00	E	48.94	E	47.00	E	47.00	E/F	37.05
	gv36	**J34C**	**Kammanassie**	**C/D**	C/D	75.67	D	40.29	C/D	75.67	C/D	75.67	D	62.25
	giv10	J34F	Kammanassie		E	41.26	D/E	40.62	D	60.46	E	41.26	E	32.81
	gvii2	J35A	Grobbelaars		C	82.76	C	82.76	C	82.76	D	33.93	C	65.40
	giv9	J35A	Grobbelaars		E	65.75	E	65.75	E	65.75	F	39.09	E	51.93
	gv19	J35D	Olifants		E	51.60	E	52.12	E	56.66	E	48.69	F	39.61
	giv17	J35F	Olifants		D	53.21	D	49.53	D	57.70	D	50.63	D	40.72
	giv16	J40A	Gouritz		C	55.30	C	44.09	C	61.72	C	51.18	C	41.53
	gi4	**J40B**	**Gouritz**	**C**	C	54.34	C	41.95	C	59.52	C	51.37	C	41.13
F13- Lower Gouritz	gv28	J40C	Gouritz		D	56.22	D	40.92	D	61.08	D	53.52	D	41.79
	gv9	J40D	Gouritz		C	59.81	D	39.47	C	64.24	C	57.36	C	43.06
	Gxi1	**J40E**	**Gouritz estuary**	**B**	C	61.88	D	39.13	C	66.01	C	59.38	D	43.77

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes (EGSA) associated with the aquatic systems within the Gouritz-Olifants and Lower Gouritz IUAs included tourism values occurring along the rivers as well as tourism, nursery, property value associated with the Gouritz estuary. This value was estimated at R240 million per year under present conditions for these two IUAs (Table 4-18). These values decreased under the ESBC scenario and CC scenarios for the Lower Gouritz IUA but not for the Gouritz-Oilfants IUA.

Table 4-18 Ecosystem goods, services and attributes values (R million/yr) for the Gouritz-Olifants and Lower Gouritz IUAs

IUA	EGSA value component	Current PES (2014)	Scenario ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Gouritz-Olifants (D7)	Tourism	179	179	179	179	179
	Nursery	-	-	-	-	-
	Sustainable Fishing	-	-	-	-	-
	Property	-	-	-	-	-
	Combined EGSA Value	**179**	**179**	**179**	**179**	**179**
Lower Gouritz (F13)	Tourism	38	38	38	38	38
	Nursery	4	3	4	4	3
	Sustainable Fishing	0.22	0.16	0.22	0.22	0.16
	Property	18	13	18	18	13
	Combined EGSA Value	**61**	**54**	**61**	**61**	**54**

Note: only IUAs containing estuaries have values for nursery, sustainable fishing and property components.

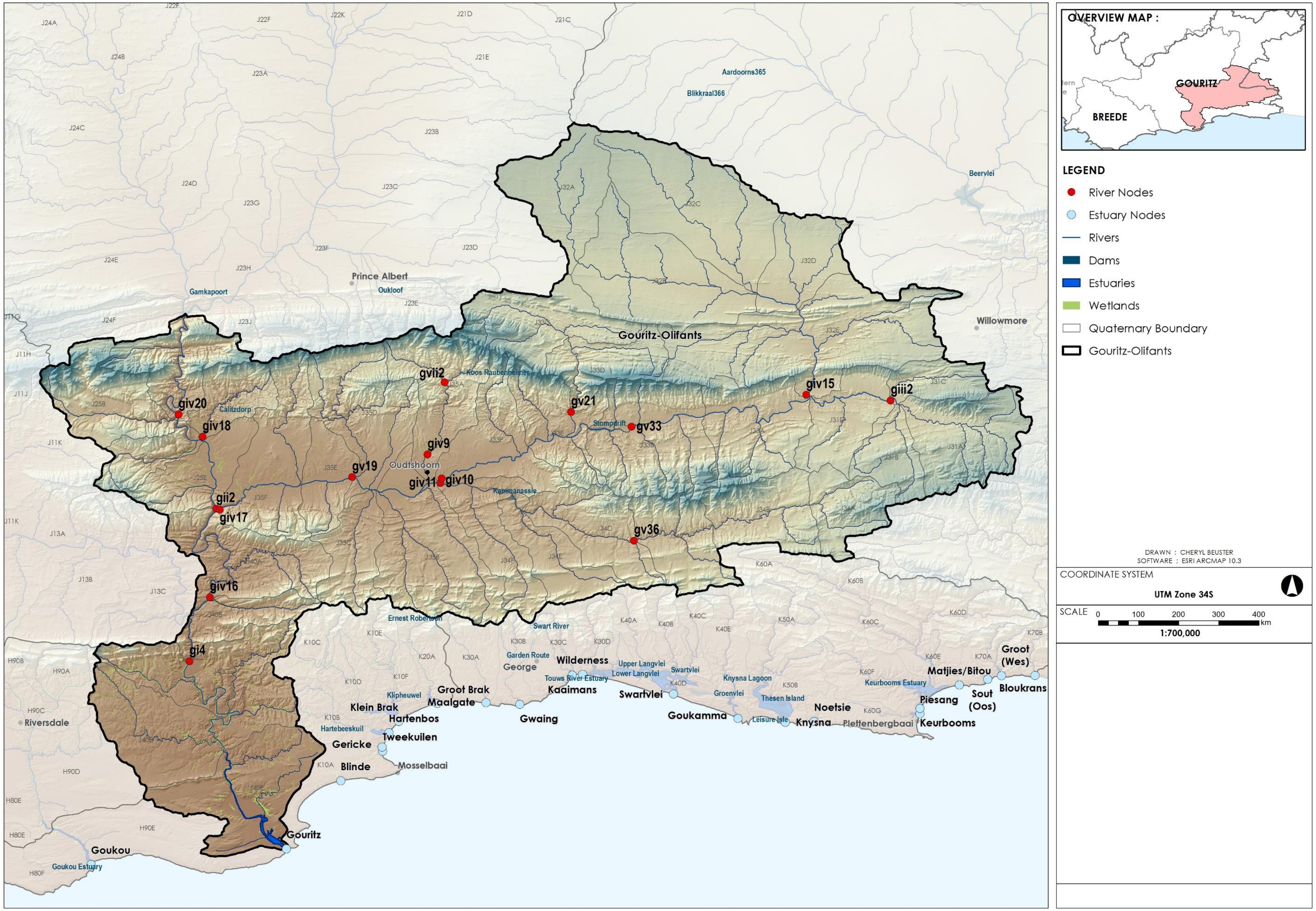

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Figure 4-9 The nodes and significant water resources for the Gouritz-Olifants and Lower Gouritz IUAs

4.9.1 Maintain PES ("Baseline")

Rivers

The rivers here are in a moderate to poor condition and the rivers near and downstream of Oudtshoorn are in an unacceptably poor E condition (Olifants River giv11 and gv19, Kammanassie River giv10, Grobbelaars River giv9), due to impacts from irrigated agriculture, livestock farming, flow modification from the upstream dams and the presence of exotic woody vegetation. The river bed and banks are modified in shape and in some cases position and there have been clearing and removal of indigenous riparian vegetation in parts. The upper reaches of the Olifants River and nearby tributaries are in a better ecological condition with more naturally vegetation channels that are less disturbed from agricultural activities and also flow closer to natural being upstream of Stompdrift Dam.

The Gouritz River in the Gouritz-Olifant IUA is in good condition being naturally vegetated and offering a variety of riparian and aquatic habitat to instream biota, despite the flow here being controlled by the upstream dams (the Kammanassie, Stompdrift, Koos Raubenheimer, Leeu-Gamka, Gamkapoort, Gamka, Calitzdorp and Floriskraal). River bank conditions are varied, mostly naturally shaped and well vegetated but also steeply sloped and eroded. There is some infilling to create cultivated fields but the extent of this relative to the size of the river dwarfs the potential impacts of these activities. The condition of the Gouritz River in the Lower Gouritz IUA is moderate to poor due to water quality issues, as a results of agricultural return flows, that alter the instream aquatic habitat available to biota as a result of algal growth, the presence of some exotic plant species, notably *Nerium oleander*, and some overgrazing in places. Flows are regulated by the combination of dams (described above) and altered from natural.

Wetlands

The river node gi4 and gv9 are in a good condition, which is good for the associated FEPA cluster wetlands.

Estuaries

The ecological condition of the Gouritz estuary is C, which is lower than the REC of B.

Water quality

Water quality in the Gouritz-Olifants IUA will continue to exhibit elevated salt (varies between Tolerable and Unacceptable categories) and nutrient concentrations (Acceptable to Unacceptable categories), especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. Under this scenario the poor water quality (Unacceptable category) in the lower Gouritz IUA at Zeekoei Drift/Die Poort would be maintained. The very high salinities (Unacceptable category) in the lower reaches makes the water almost unsuitable for irrigation use. Water quality in the Weyers River was only moderately impaired (Acceptable category) and this would continue under this flow scenario.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in seven quaternary catchments. These catchments are in the J25 (west of the IUA, west of Gamka River) and J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate to significant, and the increase in the use/ recharge ratio ('stress') ranges from 0 to 20% under current PES, to 26 to 97% at the quaternary catchments. Four of the seven change from a groundwater status of I to III.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under current (PES) conditions, the rivers of the Gouritz-Oilfants IUA hold significant tourism value (R179 milllion/yr). The rivers of the Lower Gouritz IUA and the Gouritz estuary together hold R61 million/yr, mainly derived from tourism value, but also property value of the estuary to some extent.

4.9.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all nodes, apart from at giv11 and gv19 (Olifants River), giv9 (Grobbelaars River), and giv10 (Kammanassie) where applying various EWR flows did not improve the ecological conditions above an E.

The applied EWR flows are predicted to improve the condition of giv10 from an E to a D/E.

Annual and monthly deficits occur at giv11 and at gv19 on the Olifants River, despite there being present-day flows in place at gv19 and some upstream nodes. The deficits at giv11 may be mitigated by selecting present-day flows.

EWR flows rather than present-day flows were used at most of the nodes. This results in an annual surplus in gi4 in the lower Gouritz River (although there is still a small deficit in March).

The annual present-day flows are higher than the EWR flows required to sustain the D conditions but this is not the case when flows are compared seasonally. The scenario flows at giv11, downstream of Stompdrif Dam, are higher in the wet season than current flows down the river, and at giv10, downstream of the Kammanassie Dam, they are higher in the dry season than current flows.

Wetlands

The river node gv9 reduces condition to a D, which impacts the associated FEPA cluster wetlands.

Estuaries

This flow regime reduces the ecological condition of the Gouritz estuary from C to D.

Water quality

Water quality in the Gouritz-Olifants IUA will continue to exhibit elevated salt and nutrient concentrations (Tolerable to Unacceptable categories), especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. Under this scenario the poor water quality (Unacceptable category) in the lower Gouritz IUA at Zeekoei Drift/Die Poort would deteriorate further. The very high salinities in the lower reaches makes the water almost unsuitable for irrigation use. Water quality in the Weyers River was only moderately impaired (Acceptable category) and this would continue in this flow scenario.

Groundwater

To achieve ECBS into the future, the groundwater status increases compared to PES in five quaternary catchments. These catchments are in the J25 catchments (west of the IUA, west of Gamka River), and in the J33 and J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate, with all five catchments increasing from category I to II.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under this scenario the value of the lower Gouritz IUA decreases by R7 million/yr. This is mainly due to deteriorating quality of the Gouritz estuary and its impact on property value.

4.9.3 REC Scenario

Rivers

This flow regime meets that flows required to achieve the REC at the EWRs at giv20 (C) (Gamka), giii2 (C) (Olifants), gv36 (C/D) (Kammanassie), and gi4 (C) (Gouritz) .

Substantial annual (and monthly) deficits are indicated at giv20 and gii2. Thus, in order to provide the flows required REC, adjustments would have to be made to releases from Gamkapoort Dam, for example. The deficit from gii2 is carried through to nodes giv16 and gi4, resulting in a deficit in outflows from the Gouritz-Olifants IUA, and entering the Lower Gouritz IUA and to the estuary.

Wetlands

The river node gi4 and gv9 are in a good condition, which is good for the associated FEPA cluster wetlands.

Estuaries

The deficit from gii2 is carried through to nodes giv16 and gi4, resulting in a deficit in outflows from the Gouritz-Olifants IUA, and entering the Lower Gouritz IUA and to the estuary. This means that flows reaching the estuary under this scenario result in an EC of C (same as PES) and are insufficient to meet the REC requirements for a B. In addition to reducing the shortfall, other non-flow related measures would have to be put in place to achieve the REC at the estuary.

Water quality

The elevated flows in the lower Gouritz River under this scenario will result in an improvement in the poor water quality in the lower reaches (may change from Unacceptable to Tolerable category). The flow and water quality situation will remain largely unchanged in the rest of the IUA.

Groundwater

To achieve REC into the future, the groundwater status increases compared to PES in seven quaternary catchments. These catchments are mostly in the J25 catchments (west of the IUA, west of Gamka River), with two in the J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate to significant, and the increase in the use/ recharge ratio (‘stress’) ranges from between 0 and 20% under current PES, to between 26 and 97% at the quaternary catchments. Three of the seven catchments change from a groundwater status of I to III.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.9.4 No EC – Future High Growth scenario

Rivers

Abstraction from the Gamka (giv20) and Grobbelaars (gvii2 and giv9) Rivers changes their condition down from a C/D to a D, from a C to a D, and from an E to an F respectively based on the annual average monthly flows. The ECs of any other nodes is unaffected.

Wetlands

The river node gi4 and gv9 are in a good condition, which is good for the associated FEPA cluster wetlands.

Estuaries

Under this flow regime, the ecological condition of the Gouritz estuary remains unchanged (C).

Water quality

Under this scenario the poor water quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort would be maintained. The very high salinities (Unacceptable category) in the lower reaches makes the water almost unsuitable for irrigation use. Water quality in the Weyers River was only moderately impaired (Acceptable category) and this would continue in this scenario.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in two quaternary catchments. These catchments are in the J25 catchments (west of the IUA, west of Gamka River), and in the J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate, with both catchments increasing from category I to II.

Neither of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.9.5 Climate change scenario

Rivers

Under the climate change scenario, conditions deteriorate at five of the 19 nodes in this sub-region.

The impacted river reaches are the lower Gamka upstream of the Olifants confluence (2 nodes: giv20 C/D to D and gii2 C to C/D), middle Olifants (giv11 E to E/F), upper Kammanassie (gv36 C/D to D) and lower Olifants (gv19 E to F).

Wetlands

The condition is similar to the baseline.

Estuaries

Under this flow regime, the ecological condition of the Gouritz estuary is reduced from a C to a D.

Water quality

Under the climate change scenario, water quality in the Gouritz-Olifants IUA will continue to exhibit elevated salt and nutrient concentrations (Tolerable/Unacceptable categories), especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. Under this scenario the poor water quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort would deteriorate further (already in an Unacceptable category). The very high salinities in the lower reaches makes the water almost unsuitable for irrigation use.

EGSA

Under this scenario the value of the lower Gouritz IUA decreases by R7 million/yr. This is mainly due to deteriorating quality of the Gouritz estuary and its impact on property and nursery value.

4.10 Groot Brak IUA

There are 8 nodes in the Groot Brak IUA (Table 4-19). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-19). A short summary of the observed impacts under each scenario are given below.

Table 4-19 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Groot Brak IUA

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
G14-Groot Brak	giv25	K10D	Brandwag		D	73.80	D/E	48.98	D	73.80	D	73.80	D/E	49.91
	gv39	**K10E**	**Moordkuil**	**B/C**	D	41.78	D	40.02	D	41.78	D	41.78	D/E	30.71
	Gxi4	**K10F**	**Klein-Brak estuary**	**C**	C	77.05	D	44.02	C	77.05	C	77.05	D	53.42
	gviii2	**K20A**	**Groot-Brak**	**B/C**	B/C	93.79	C/D	39.78	B/C	93.79	B/C	85.29	C	66.26
	gviii12	**K20A**	**Varing**	**C/D**	C/D	97.27	D	55.17	C/D	97.27	C/D	97.27	D	68.72
	gviii3	**K20A**	**Varing**	**C/D**	D	74.73	D	54.31	D	74.73	D	74.73	D	52.80
	gvii7	K20A	Groot-Brak		B/C	45.89	B/C	43.35	B/C	45.89	D	18.21	C	33.12
	Gxi5	**K20A**	**Groot-Brak estuary**	**C**	E	56.20	E	48.61	E	56.20	F	31.14	F	40.22
	Gxi19	**K10A**	**Blinde estuary**	**B**	B	69.23	C/D	40.77	B	69.23	B	69.23	C	46.28
	Gxi20	**K10A**	**Tweekuilen estuary**	**D**	D	96.73	D	72.31	D	72.31	D	96.73	D/E	64.66
	Gxi21	**K10A**	**Gericke estuary**	**D**	D	96.80	D	72.31	D	72.31	D	96.80	D/E	64.70
	Gxi22	**K10B**	**Hartenbos estuary**	**C**	D	65.01	D	71.99	D	80.74	D	65.01	D/E	44.41

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Groot Brak IUA included tourism values occurring along the rivers as well as tourism, nursery, property value associated with the Hartenbos, Klein Brak and Groot Brak estuaries. This value was estimated at R151 million per year under present conditions (Table 4-20). These values decreased under the ESBC, NOEC and CC scenario and increased slightly under the REC scenario.

Table 4-20 Ecosystem goods, services and attributes values (R million/yr) for the Groot Brak IUA

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Groot Brak (G14)	Tourism	108	107	108	95	93
	Nursery	20	15	20	17	12
	Sustainable Fishing	0.7	0.6	0.7	0.3	0.2
	Property	23	23	24	10	9
	Combined EGSA Value	**151**	**145**	**152**	**122**	**114**

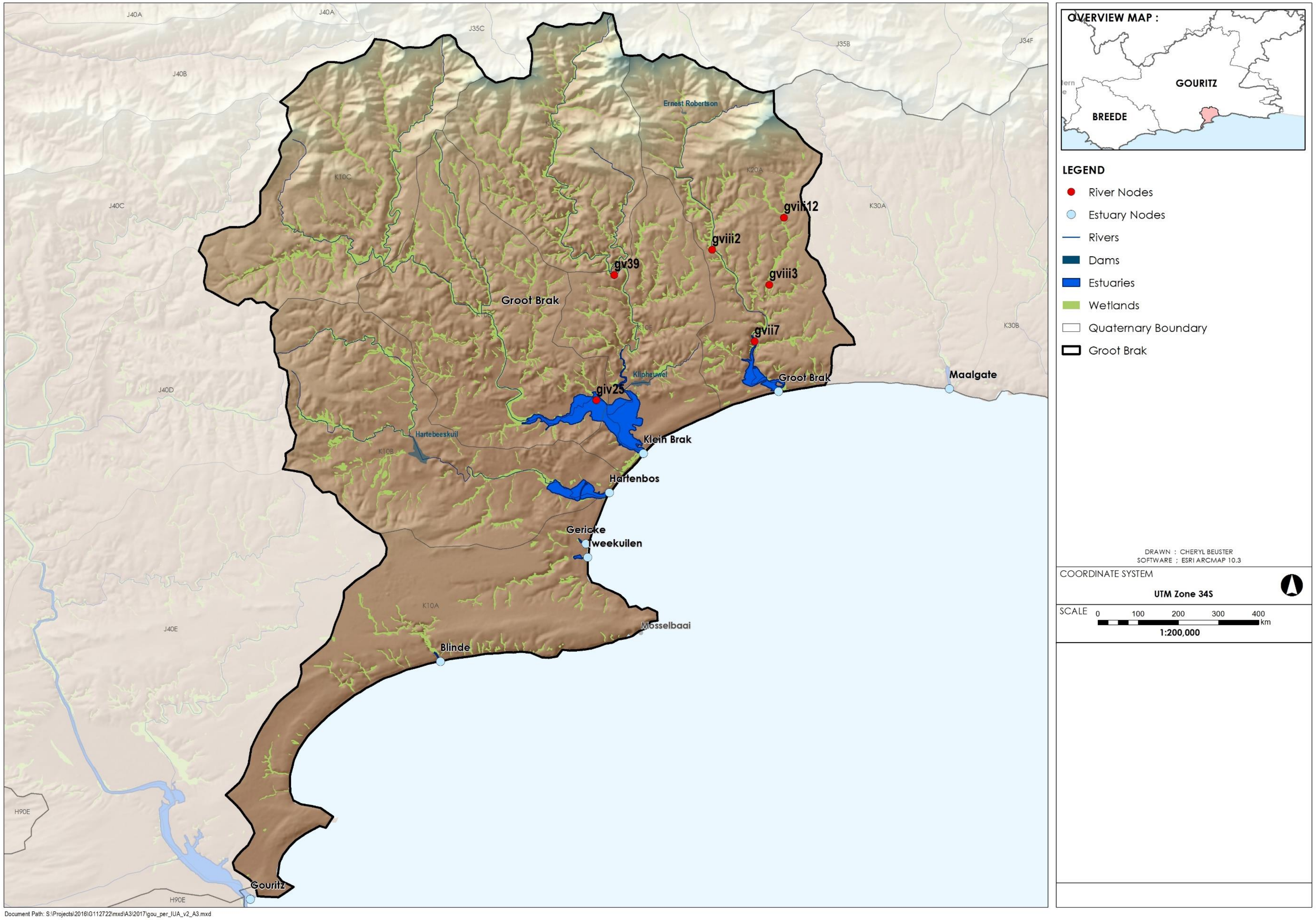

Figure 4-10 The nodes and significant water resources in the Groot Brak IUA

4.10.1 Maintain PES ("Baseline")

Rivers

The Brandwag and Moordkuil Rivers are in a poor condition (D category) largely due to bank instability and channel disturbances, from infilling and bulldozing of the channel, along with the presence of exotic woody vegetation and clearing of indigenous riparian vegetation. The aquatic habitat is poor and dominated by fine sediment particles.

The Varing River is similar to that described above whereas the Groot Brak River is in a considerably better condition and more representative of a coastal river in this region, with a good cover and diversity of indigenous riparian shrubs and trees on the river and upslope, good water quality and a high diversity of instream habitat for aquatic biota.

Wetlands

The poor condition of the Brandwag (giv25) and Moordkuil Rivers (gv39) impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

Estuaries

The ecological condition of the Groot Brak estuary is E, which is lower than the REC of C, while that for the Hartenbos (D) is also lower than the REC of C. The ecological condition of the Blinde, Klein-Brak, Tweekuilen and Gericke estuaries are the same as their respective RECs (B/C/D).

Water quality

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream reaches of the Hartenbos River (Unacceptable category) will be maintained under this scenario. The same would apply to the moderately elevated salinities (Tolerable category) in Wolwedans Dam on the Groot-Brak River. Elevated phosphate concentrations (Ideal but excursions into Tolerable category) observed from time to time in these dams would also be maintained.

Groundwater

To maintain PES in future, the groundwater status increases compared to PES in one quaternary catchment (K20A in the east of the IUA). The increase in groundwater stress in these catchments is low, with the catchment increasing in use/recharge ratio ('stress') from 1% to 24%, corresponding to a change in category from I to II.

The catchment K20A has a high GWBF/EWR ratio, and abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

Under current (PES) conditions the rivers and estuaries of the Groot Brak estuary provide R151 million/yr. The majority of this value is derived from tourism. Considerable value is also derived from the nursery and property values of the estuaries.

4.10.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all river nodes, except for giv25 on the Brandwag River, where the EWR flows deteriorate the condition from a D to a D/E.

No deficits in annual flow volume are indicated at any of the nodes, although there are some small individual monthly deficits at several nodes.

The Groot Brak River could be considered for conservation interest, although the EWR flows applied here reduced the condition of the upper node (gviii2) from a B/C to a C/D.

Present-day flows are higher than the EWR flows required to sustain the D conditions, except for gvii7, the lower node on the Groot Brak River, where the EWR flows exceed the present-day flows during the wet season.

Wetlands

The worsening condition of the Brandwag (giv25) and Moordkuil Rivers (gv39) impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

Estuaries

Under this flow regime, the ecological condition of the Groot-Brak (E category), and Hartenbos, Tweekuilen and Gericke estuaries (D category) remain unchanged from PES. The Klein-Brak estuary deteriorates from an ecological condition of C to D and the Blinde drops from a B to a C/D category.

Water quality

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam (Unacceptable category) and the downstream Hartenbos River will deteriorate slightly (may change form Tolerable to Unacceptable category) as a result of reduction in flows under this scenario. The same would apply to the moderately elevated salinities in Wolwedans Dam on the Groot-Brak River. Elevated phosphate concentrations observed from time to time in these dams would also be maintained**.**

Groundwater

Although there is an increase in total groundwater use for the IUA in this scenario, the groundwater status does not change in any quaternary catchment.

EGSA

Under the ESBC scenario there is a decrease in value (R6 million/yr.) within the Groot Brak IUA, mainly associated with a drop in nursery value of the Klein Brak estuary.

4.10.3 REC scenario

Rivers

Present-day flows were applied at all nodes, therefore the condition of the nodes does not change.

The RECs are met at all EWR sties (gv39-Moordkuils, gviii2-Groot-Brak, gviii12 (Varing), gviii3-Varing), apart from that at gviii12 (lower Varing site).

The REC of C/D for gviii3 on the Varing downstream of gviii12 is not met by increasing flow alone, and other non-flow related improvements are required as the river here is in a similar condition to the Moordkuils, subject to a host of non-flow related impacts.

The REC at gv39 (D, Moordkuils) is met, but note that the Moordkuil River was in a poor condition (D category) largely due to non-flow related disturbances, such as bank instability and channel disturbances, from infilling and bulldozing of the channel, along with the presence of exotic woody vegetation and clearing of indigenous riparian vegetation. The aquatic habitat is poor and dominated by fine sediment particles.

Wetlands

The poor condition of the Brandwag (giv25) and Moordkuil Rivers (gv39) impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

Estuaries

It is possible to meet the RECs with flows current day for most of the estuaries in this IUA (Kleinbrak, Blinde, Tweekuilen, Gericke) with the exception of the Groot Brak and Hartenbos systems due to severe alteration of water quality and manipulation of the mouth. Even increasing flows at Hartenbos to 81% of natural did not change the current status of this system. It was not possible to raise flow above current for the Groot Brak estuary due to the presence of the Wolwedans Dam immediately upstream of the estuary, hence condition of this system does not change under this scenario.

Water quality

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam (Unacceptable category) and the downstream Hartenbos River will be maintained under the REC scenario. The same would apply to the moderately elevated salinities (Tolerable category) in Wolwedans Dam on the Groot-Brak River. Elevated phosphate concentrations observed from time to time in these dams would also be maintained.

Groundwater

To achieve this scenario, the groundwater status increases compared to PES in one quaternary catchment (K20A in the east of the IUA). The increase in groundwater stress in these catchments is low, with the catchment increasing in use/recharge ratio ('stress') from 1% to 24%, corresponding to a change in category from I to II.

The catchment K20A has a high GWBF/EWR ratio, and abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.

EGSA

Under the REC scenario a slight increase in value of the rivers and estuaries of the Groot Brak IUA is predicted. This increase in value of R1 million/yr is associated with a smallincrease in property value, especially along the Groot Brak estuary.

4.10.4 No EC – High Growth scenario

Rivers

Abstraction from the Groot Brak River does not change the EC at the node gviii2, but abstraction from the lower Groot Brak River (gvii7), together with the reduced flows from upstream, severely deteriorates the EC of the river here from a B/C to a D category

Wetlands

The poor condition of the Brandwag (giv25) and Moordkuil Rivers (gv39) impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

Estuaries

The ecological condition of the Groot-Brak estuary deteriorates to F (from E at present), while all other estuaries remain unchanged from present.

Water quality

The elevated salinities observed in the lower Groot Brak IUA will be aggravated due to the higher abstractions (already in Unacceptable category). In the rest of the IUA the quality would remain in the same state as currently experienced.

Groundwater

There is no increase in groundwater use, hence no change in groundwater stress or status, in the IUA under this scenario.

EGSA

Under the ESBC scenario there is a decrease in value (R29 million/yr.) within the Groot Brak IUA, mainly associated with a drop in nursery value of the Klein Brak estuary as well as a decrease in tourism and property value of the Groot Brak estuary.

4.10.5 Climate change scenario

Rivers

Deterioration in EC under the climate change scenario relative to PES takes place at four of the eight river nodes here.

The impacted river reaches are the Moordkuil (gv39 D to D/E), upper and lower Groot Brak (gviii2 B/C to C; gvii7 B/C to C) and upper Varing (gviii12 C/D to D).

Wetlands

The poor condition of the Brandwag (giv25) and the much worse condition of Moordkuil Rivers (gv39) impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

Estuaries

The ecological condition of the Groot-Brak estuary deteriorates to F (from E at present), Klein Brak to a D (from C at present), Blinde to a C (from B at present), while the Hartenbois, Tweekuilen and Gerricke all drop to a D/E category (from D).

Water quality

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream Hartenbos River, will deteriorate under the climate change scenario due to reduced flows and elevated evaporation (it is already in an Unacceptable category). The same would apply to the moderately elevated salinities in Wolwedans Dam on the Groot-Brak River. Elevated phosphate concentrations observed from time to time in these dams would also be maintained.

EGSA

Under the ESBC scenario there is a decrease in value within the Groot Brak IUA, mainly associated with a drop in nursery value of the Klein Brak estuary as well as a decrease in tourism and property value of the Groot Brak estuary.

4.11 Coastal

There are 44 nodes along the Outeniqua coast (Figure 4-11). The resultant ecological condition at each node in each scenario is shown with the percentage of **natural** flow required to sustain this condition (Table 4-21). A short summary of the observed impacts under each scenario are given below.

Table 4-21 Annual flow as % nMAR, and river condition (A to F) at each node for all scenarios for the Coastal IUA

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
G15-Coastal	gviii4	K30A	Maalgate		D	75.80	D	75.80	D	75.80	D	75.80	D	60.10
	gvii8	**K30A**	**Maalgate**	**D**	D	75.80	D	54.82	D	75.80	D	75.80	D	60.10
	Gxi6	**K30A**	**Maalgate estuary**	**B**	B	79.32	C	51.56	B	79.32	B	79.32	B/C	62.83
	gvii9	**K30B**	**Malgas**	**C**	C	95.00	C	95.00	C	95.00	C	50.44	C	75.49
	gviii6	**K30B**	**Gwaing**	**D**	E	82.30	E	64.96	E	82.30	E	62.69	E	65.40
	Gxi7	**K30B**	**Gwaing estuary**	**B**	B	85.00	C/D	55.14	B	85.00	B	72.55	B	67.51
	gviii7	K30C	Swart		D	25.28	D	27.05	D	25.28	E/F	2.66	D/E	20.53
	gvii11	**K30C**	**Kaaimans**	**B**	B	94.07	D	27.05	B	94.07	B/C	60.58	B	74.97
	gviii8	K30C	Silver		B	94.07	D	27.05	B	94.07	B	94.07	B	74.97
	Gxi8	**K30C**	**Kaaimans estuary**	**B**	B	72.45	D/E	27.53	B	72.45	C	52.20	C	58.35
	gvii12	K30D	Touws		B	93.75	C	36.57	B	93.75	B	93.75	B	73.04
	gx8	K30D	Klein		D	93.75	D	57.88	D	93.75	D	93.75	D	73.03
	Gxi9	**K30D**	**Wilderness estuary**	**A**	B	88.59	C/D	34.13	B	88.59	B	88.59	B/C	68.96
	giii10	**K40A**	**Diep**	**A/B**	B	96.53	C/D	39.79	B	96.53	B	96.53	B/C	76.27
	giii13	K40B	Hoekraal		B	92.49	C	34.00	B	92.49	B	92.49	B	75.06
	gvii13	**K40C**	**Karatara**	**A/B**	B	92.99	D	29.54	B	92.99	B	92.99	B	77.40
	giii11	K40C	Karatara		B	92.99	D	26.61	B	92.99	B	92.99	B	77.40

IUA	Node	Quat	River	ER - REC	Current		Scenarios							
					PES (2014)		ESBC		REC		NoEC		CC	
					EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR	EC	% nMAR
	Gxi10	**K40D**	**Swartvlei estuary**	**B**	B	86.61	D	31.14	B	86.61	B	86.61	B	85.50
	gviii9	**K40E**	**Goukamma**	**B/C**	B/C	87.46	C/D	33.24	B/C	87.46	B/C	87.46	B/C	71.04
	Gxi11	**K40E**	**Goukamma estuary**	**A**	B	87.46	D	44.26	A/B	87.46	B	87.46	B/C	71.04
	gvii14	**K50A**	**Knysna**	**B**	B	95.63	D	28.39	B	95.63	B	95.63	B/C	77.03
	giii12	K50A	Knysna		B	94.74	D	28.14	B	94.74	B	85.27	B	76.15
	gviii11	K50B	Gouna	A/B	A/B	92.21	C/D	27.04	A/B	92.21	A/B	76.22	A/B	74.71
	Gxi12	**K50B**	**Knysna estuary**	**B**	B	90.63	C/D	25.64	B	90.63	B/C	80.88	B/C	73.19
G15-Coastal	**gviii10**	**K60G**	**Noetzie**	**A/B**	B	92.46	C	43.51	B	92.46	B	92.46	B	73.53
	Gxi13	**K60G**	**Noetzie estuary**	**A**	B	92.45	D	42.49	B	92.45	B	92.45	B/C	73.53
	gx3	K60G	Piesang		E	92.45	E	64.25	E	92.45	E	92.45	E	73.52
	Gxi14	**K60G**	**Piesang estuary**	**B**	C	73.04	D	53.78	B/C	82.77	C	73.04	C	58.09
	giv6	**K60C**	**Keurbooms**	**B/C**	C	93.22	D	38.13	C	93.22	C	93.22	C	74.88
	giv5	K60D	Palmiet		A	93.24	C	32.35	A	93.24	A	93.24	B	76.09
	gx9	K60E	Keurbooms		B	92.25	C	35.31	B	92.25	B	92.25	C	74.64
	giv4	K60F	Bitou		C	97.47	D	33.99	C	97.47	C	97.47	C/D	77.73
	Gxi15	**K60G**	**Keurbooms estuary**	**A**	A	91.17	D	34.78	A	91.17	B/C	83.52	B/C	73.49
	gx4	K70A	Buffels		B	83.72	C	35.93	B	83.72	B	83.72	B/C	70.75
	Gxi16	**K70A**	**Matjies estuary**	**B**	B	83.73	D	44.10	B	83.73	B	83.73	C	70.75
	gx5	K70A	Sout		B	85.58	D	29.99	B	85.58	B	85.58	B/C	72.32
	Gxi17	**K70A**	**Sout(Oos) estuary**	**A**	A	85.58	D	29.99	A	85.58	A	85.58	B/C	72.31
	Gxi23	**K70A**	**Groot(Wes) estuary**	**B**	B	86.73	C	51.24	B	86.73	B	86.73	B/C	73.29
	gvii15	K70B	Bloukrans		B	82.69	D	29.99	B	82.69	B	82.69	B/C	71.86
	Gxi18	**K70B**	**Bloukrans estuary**	**A**	A	98.00	D	29.99	A	98.00	A	98.00	B	85.17

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 4.

Ecosystem goods, services and attributes associated with the aquatic systems within the Coastal IUA included tourism values occurring along the rivers as well as tourism, nursery, property value associated with the estuaries along this stretch of coastline. This value was estimated at over R3 billion per year under present conditions (Table 4-22). These values decreased under the ESBC scenario but remained similar under all other scenarios.

Table 4-22 Ecosystem goods, services and attributes (EGSA) values (R million/yr) for the Coastal IUA

IUA	EGSA value component	Current	Scenario			
		PES (2014)	ESBC	REC	NoEC	CC
		R million	R million	R million	R million	R million
Coastal (G15)	Tourism	2 808	2 424	2 808	2 808	2 808
	Nursery	182	124	183	182	182
	Sustainable Fishing	2.3	1.6	2.3	2.3	2.3
	Property	122	106	122	122	122
	Combined EGSA Value	3 115	2 656	3 116	3 115	3 115

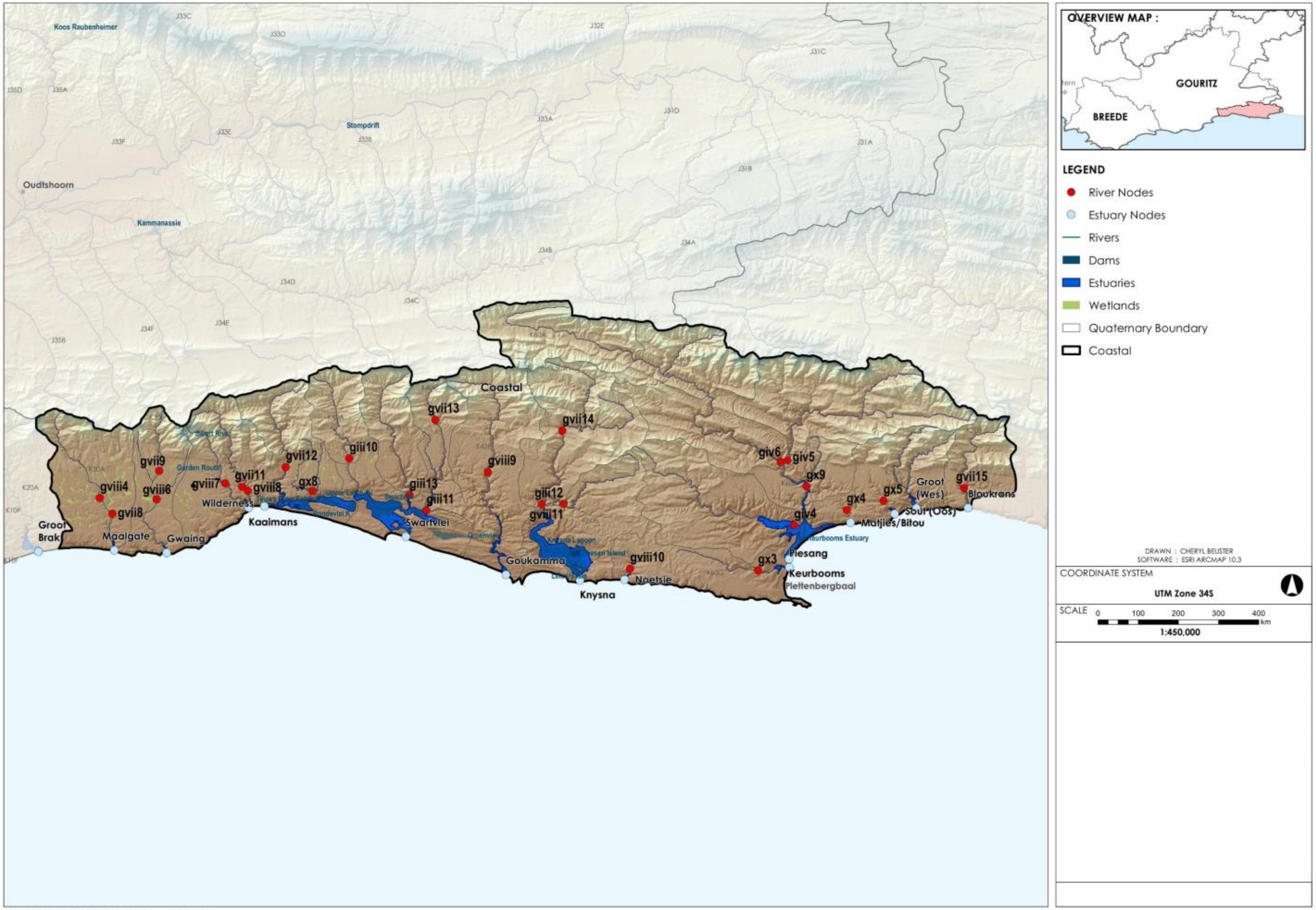

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Figure 4-11 The nodes and significant water resources for the Coastal IUA

4.11.1 Maintain PES ("Baseline")

Rivers

The Maalgate River is in a poor condition (D category) due to the presence of agricultural and peri-urban type of landuse. In places it is severely bulldozed and infilled, and in others there is a great deal of alien riparian vegetation.

The Gwaing River flows through the outskirts of Blanco and the Fancourt Golf Estate. It is in an E-Category, largely as a result of non-flow related issues, such as development in the riparian zone, alien tree infestations, hard engineering structures and pollution. The Malgas River is very much a river of two halves, *viz*, upstream of the cement quarry (the bulk of the river and the basis for this assessment) the river is near natural, whereas downstream it is increasingly impacted by urban activities. These include, localised manipulation of the river channel, the effects of the upstream quarry, cement factory and road (which carries heavy transport to and from the factory and quarry) and heavy invasion by *Acacia mearnsii* and *A. melanoxylon*, amongst others.

The Kaaimans River is in a good condition (B category) largely due to the road reserve impinging on left-bank riparian vegetation and an otherwise relatively undisturbed channel, excellent right-bank vegetation, good habitat conditions for aquatic macroinvertebrates and good water quality conditions. The Garden Route Dam is situated on the Swart River. The location is significant because the ecological condition of the Swart River is markedly lower in the section downstream of the dam, viz. B/C-Category upstream (Dr C. Brown, pers. obs.) and D-Category downstream of the dam. The two facts are not unrelated, and the presence of the dam is a major contributing factor in the decline in ecological condition. Other contributing factors include: encroachment of alien vegetation (partly related to a reduction in floods) and manual manipulation of the river channel (mainly associated with roads).

The bulk of the Touws River flows through undisturbed/protected catchment. There is some farming in the middle reaches, but it does not impinge directly on the river, and the farm dams are not on channel dams. There is quite a high density of peri-urban development in the estuary (Wilderness). The Klein River is in a D condition as it flows through an area of mixed agriculture - mainly dairy farming and there is some infilling in parts.

The Diep River flows through a forestry area so there are some exotic woody plants present but despite this there is a good and diverse array of indigenous riparian species present in the channel and on the channel banks. The river is naturally shaped and flows close to natural offering an abundant variety of instream habitats to aquatic biota with good water quality.

The Hoekraal and the Karatara Rivers are much the same as described for the Diep, despite being impacted in some parts of the remnant forest activities the rivers are well vegetated and offer a variety of good habitat to aquatic biota and flow with good water quality.

The Goukamma River is in a good condition (BC category) due to the generally undisturbed nature of the surrounding river basin despite their being some channel modification and exotic non-woody plants, the fish populations being less resilient due to floods.

The Knysna and Gouna Rivers are in good condition (B and A/B category) and well vegetated with indigenous Afromontane Forest tree species. There are minimal and isolated channel disturbances and some flow modification due to abstraction for farming but despite this the river flows near natural, offers good quality instream habitat to aquatic biota and suffers not water quality problems.
The Noetzie River is near natural, except for some minor impacts in the headwaters.

The Piesang River is in a poor condition (E category) due to the surrounding urban and peri-urban landuse (quarries, urban runoff, mixed agriculture), abstraction for water supply to Plettenberg Bay and significant infilling in the lower reaches along with extensive removal of indigenous riparian vegetation.

The Keurbooms and Bitou Rivers are in a moderate condition (C category) with well vegetated banks, despite their being some exotic woody plants present, and some localized infilling and bulldozing of banks in some farmed areas.

The Palmiet and Bloukrans Rivers on the other hand are largely natural and undisturbed, the latter flowing through a steep gorge with indigenous forest, some pine plantation areas but otherwise little disturbance to the bed and banks since there are no/little anthropogenic activities in the river basins.

Given that so many of the rivers in this IUA are in good condition and many flow close to natural, this is a region of great conservation importance.

Wetlands

The channelled valley bottom wetlands associated with the upper Gwaing River are in a good condition, even though the associated river node is in a poor condition. The Wilderness Lakes is a Ramsar site and needs to be managed accordingly. The rivers in this area are in a good condition and the rivers flow is close to natural. This needs to be maintained in order to meet conservation targets.

The freshwater inputs to the Wilderness Lakes are via Karatara River (giii11 and giii13), Diep River (giii10), Klein River (gx8) and Touws River (gvii12). The associated wetlands and both floodplain and channelled/unchannelled valley bottom wetlands of very high EIS and high ecological condition. The PES of these nodes is good, although the Klein River (gx8) is in a poorer condition as it flows through an area of mixed agriculture. The Wilderness Estuary (gxi9) itself is in a good condition too.

Working for Wetlands has done work in the Palmiet River wetland (above node giv5 within K60D) in order to improve the geomorphological and hydrological health of the wetland.

Estuaries

The PES for nine of the twelve estuaries in this IUA (Maalgate, Gwaing, Kaaimans, Swartvlei, Knysna, Keurbooms, Sout, Bloukrans and Groot (Wes)) are equivalent to REC.

The ecological condition of the Wilderness, Goukamma, Noetzie are all lower than the REC but remain in good condition (B category). The PES for the Piesang estuary (C) is lower than it should be, given the ecological and socio-economic importance of this system.

Water quality

The generally good water quality (Ideal category) in the rivers of the Coastal IUA would be maintained under this scenario, provided that treated effluent discharges into the receiving rivers are controlled to meet their water use licence requirements. The same would apply to maintaining the good water quality in the Garden Route Dam (Ideal category).

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in three quaternary catchments. These catchments are K30B and K30C around George, and K50B around Knysna. The increase in groundwater stress is moderate, with an increase in its use/ recharge ratio ('stress') from between 2 and 9% under current PES, to between 27 and 40% in future, corresponding for a change in status category from I to II.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

Under the current (PES) conditions, ecosystem goods, services and attributes associated with the aquatic systems were estimated at over R3 billion per year. The bulk of this value is derived from the tourism value associated with estuaries, in particular the Knysna and Keurbooms estuaries.

4.11.2 ESBC scenario

Rivers

This flow regime meets and exceeds the flow requirements for a D at all the river nodes, except for gviii6 on the Gwaing River and gx3 on the Piesang River, where increasing flow does not improve the EC above an E. However, the EWR-based flows routed down these rivers did improve the seasonal distribution.

Marginal annual and monthly deficits are indicated at gviii7 on the Swart River, however, surpluses are indicated at the majority of estuary inflows.

The majority of the rivers in this region are of conservation interest and flow is near natural.

Present-day flows are higher than the flows required to sustain D ECs for all the rivers with the exception of the Swart River, where the EWR flows exceed the current dry season monthly average flows.

Wetlands

The freshwater inputs to the Wilderness Lakes are via Karatara River (giii11 and giii13), Diep River (giii10), Klein River (gx8) and Touws River (gvii12). The associated wetlands and both floodplain and channelled/unchannelled valley bottom wetlands of very high EIS and high ecological condition. The PES of these nodes is good, but these will be reduced by the reduction of condition of freshwater inputs and the reduction of flow from associated river nodes. The Wilderness Estuary (gxi9) also reduces condition.

Estuaries

The ecological condition of all of the estuaries in this IUA deteriorate under the scenario, 11 of the 14 by more than one category (e.g. Gwaing, Kaaimans, Wilderness, Swartvlei, Goukamma, Knysna, Noetsie, Keurbooms, Matjies, Sout (Oos) and Bloukrans). Residual scores are well below the REC for all systems.

Water quality

The generally good water quality in the rivers of the Coastal IUA would be maintained or it might deteriorate slightly under this scenario (Ideal/Acceptable category). In rivers receiving large volumes of treated effluent discharges the impacts would be more severe (less dilution of the effluent) (Acceptable/Tolerable category) even if WWTW managed to meet their water use licence requirements. The good water quality (Ideal category) in the Garden Route Dam will be maintained as slightly more water will remain in the Swart River under this scenario.

Groundwater

Although there is an increase in total groundwater use for the IUA in this scenario, the groundwater status does not change in any quaternary catchment.

EGSA

Under the ESBC scenario a drop in value (0.5 billion/yr) of the Coastal IUA is predicted. This change in value is associated with the large decrease in condition of the Knysna estuary (from a B to D). Smaller losses are also observed for nursery and property values of the estuaries.

4.11.3 REC Scenario

Rivers

Present-day flows were applied at most of the nodes (apart from the Piesang estuary, gxi14), because in all cases the flows were high (oftern >90% of natural).

The RECs were not met for gvii6 (Gwaing, E instead of D), gvii13 (Karatara, B instead of A/B), gviii10 (Noetsie, B instead of A/B), and giv6 (Keurbooms, C instead of B/C).

The REC of D at the Gwaing River (gviii6) could not be met by increased flow (current flows are already 82% of natural), so non-flow related measures are needed improve conditions up from the current E. The Gwaing River flows through the outskirts of Blanco and the Fancourt Golf Estate. The E condition is largely as a result of issues such as development in the riparian zone, alien tree infestations, hard engineering structures and pollution.

The REC of A/B at gvii13 on the Karatara River could not be achieved through flow (which is already at 93% of natural). The condition can only be improved by clearing the exotic woody plants present after the remnant forest activities in the river's basin.

The RECs at the Noetzie River (gviii10 REC = A/B) could not be met by flow (which is currently at 92.5% of natural).

The REC (B/C) at giv6 on the Keurbooms River can not met by flow (which are at 93% of natural), the non-flow related impacts, such as exotic woody plants and some localized infilling and bulldozing of banks in some farmed areas will need to be addressed in order improve the conditions up from the current C.

Wetlands

The condition is similar to the baseline.

Estuaries

The RECs at Wilderness, Goukamma, Noetsie, and Piesang were not met, as flows are currently already high percentages of natural. Poor water quality and artificial manipulation of the mouths are the main reasons for this.

Water quality

The generally good water quality in the rivers of the Coastal IUA would be maintained under this scenario provided that treated effluent discharges into the receiving rivers are controlled to meet their water use licence requirements.

Groundwater

To maintain PES into the future, the groundwater status increases compared to PES in four quaternary catchments. These catchments are K30B and K30C around George, and K40E and K50B around Buffelsbaai and Knysna. The increase in groundwater stress is moderate, with an increase in its use/ recharge ratio ('stress') from between 2 and 9% under current PES, to between 26 and 40% in future, corresponding for a change in status category from I to II.

None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario, except for the nursery value which increased slightly by R1 million/yr. .

4.11.4 No EC – High Growth (FHG) scenario

Rivers

Abstraction in the Malgas-Gwaing system deteriorates the EC at gvii9 from C to a C/D. Abstraction from the Swart River deteriorates the EC at gviii7 from D to E/F and at gvii11 on the Kaaimans from B to BC. Abstraction from the Gouna River does not change its condition.

Wetlands

The condition is similar to the baseline.

Estuaries

Increased demand for water in this IUA under the high development scenarios results in deterioration in the health of the Kaaimans, Knysna, and Keurbooms estuaries. The first deteriorates by one category, and the latter two deteriorate by half a category.

Water quality

The generally good water quality in the rivers of the Coastal IUA would be affected by the increased abstractions in the Malgas, Gwaing, and Swart Rivers (change from Ideal to Acceptable category). Lower flows in the Malgas River may increase the impacts of urban runoff and golf estate runoff on water quality. The reduced flows in the Gwaing River may lead to moderate deterioration in water quality, especially downstream of the George WWTW discharge point (change from Ideal to Acceptable category). The impacts of reduced flows on water quality in the Swart and Kaaimans rivers would not be significant. Water quality in the other rivers would remain largely unchanged (Ideal category) from the baseline condition.

Groundwater

Although there is an increase in total groundwater use for the IUA in this scenario, the groundwater status does not change in any quaternary catchment.

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

4.11.5 Climate change scenarios

Rivers

Under the climate change scenario the condition at three of the 39 nodes deteriorates relative to the baseline.

The impacted river reaches are the Swart River (gviii7 from a D to a D/E category), the Diep River (giii10 from a B to B/C category) and Knysna River (gvii14 from a B to a B/C category).

Wetlands

The condition is similar to the baseline.

Estuaries

Ten of the 11 estuaries in this area are impacted under the climate change svenario. The Maalgate, Wilderness, Goukamma, Knysna, Noetsie and Groot estuaries all change from B to B/C, the Keurbooms and Sout estuaries change from A to B/C, the Matjies from B to C and the Bloukrans from A to B.

Water quality

The generally good water quality in the rivers of the Coastal IUA would be affected by climate change due to the reduction in flow, and the increase in evaporation. The result might be a deterioration of half to a full water quality category depending on the severity of the reduction in flow (Ideal category but more frequent excursions into Acceptable category).

EGSA

All the ecosystem goods, services and attribute values remained the same as the PES condition for this scenario.

5 Summary of Results

A summary of the overall impacts of the alternative scenarios for rivers, estuaries, wetlands and groundwater are presented in this section as well as a summary of the overall impact on ecosystems goods, services and attributes (EGSA), water availability and additional water supply infrastructure, and overall socio-economic impacts. These are then used to evaluate the overall impact of alternative scenarios.

5.1 Rivers

5.1.1 Breede and Overberg Catchments

Summary results for the Breede and Overberg catchments are presented in Figure 5-1 and Figure 5-2 in terms of the number of nodes in each category and in terms of percentage change in health relative to PES-baseline. More detail is provided in Figure 5-3.

The bottom line scenario (ESBC) effectively makes a surplus of water available and reduces the conditions of rivers by increasing the number of D condition rivers from 43 to 58, while reducing the number of A to A/B rivers from 4 to 1, the number of B to B/C rivers from 16 to 5 and the number of C to C/D rivers from 24 to 20.

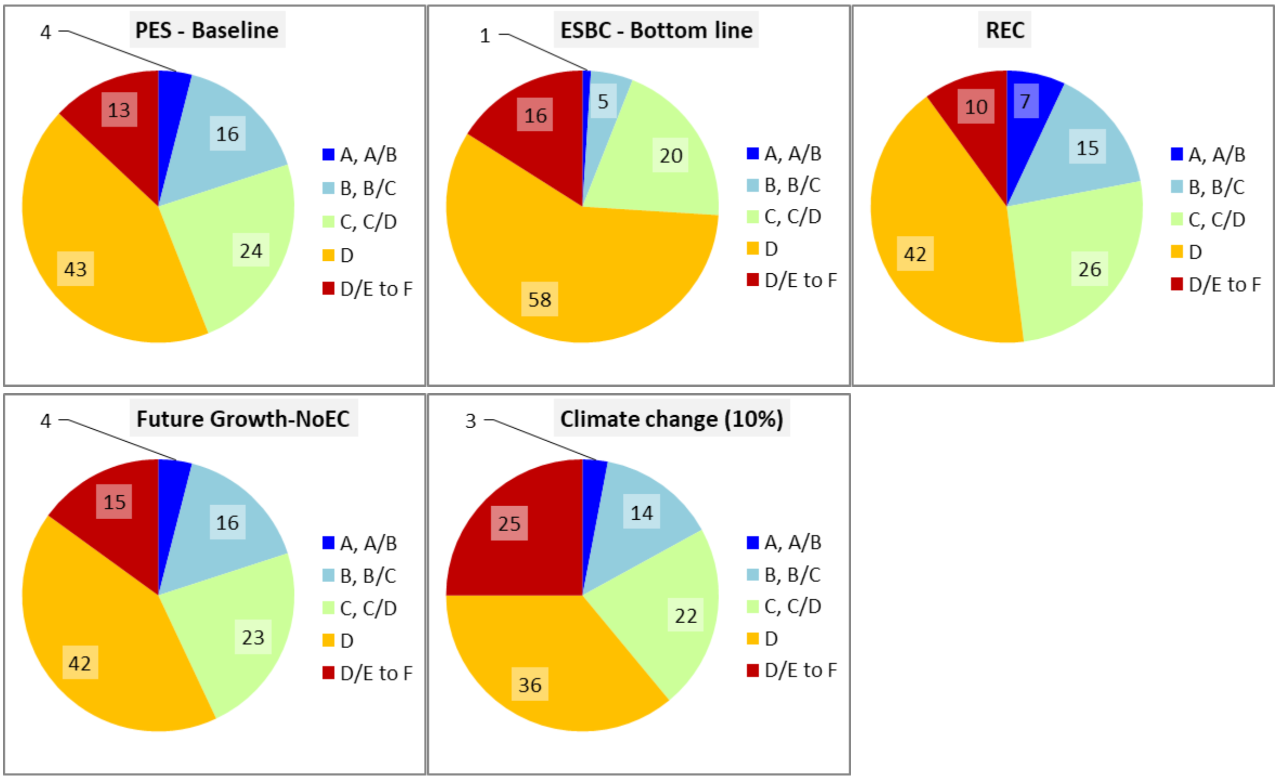


Figure 5-1 The number of nodes in each Ecological Category for the Breede and Overberg Catchments

There is little difference between the baseline and REC scenario overall. The REC improves on the baseline with the following changes (Figure 5-4):

- Klein (Nv23) from a C/D to a C (meeting the REC)
- Klein estuary (Nxi7) from a C to a B (meeting the REC)
- Uilkraals estuary from an E to a C (meeting the REC)
- Nuwejaars (Ni4), Heuningnes (Nvii15) and Heuningnes (Niv44) from Ds to C/Ds

- Heuningnes estuary (Nxi1) from a C to A/B (the REC is an A),
- Breede (Nviii1) from a D/E to a D
- Nuy (Niv11) from an E to a D
- Breede (Ni1) from a B to an A/B, and
- Breede (Nvii19) from a B to an A/B.

The Future Growth-No EC scenario is similar to Baseline, the main difference being an increase in the number of D/E and F rivers from 13 to 15.

The climate change scenario shows a greater reduction in ecosystem health, with the number of D/E to F rivers increasing from 13 to 25, and the number of B to B/C rivers decreasing from 16 to 14.

Overall, the changes equate to an 11% reduction in overall condition in the ESBC scenario (Figure 5-2), relative to the Baseline, and a 6% reduction in the climate change scenario. There is a small improvement of 2.6% in the REC scenario, the slight improvement being largely because most of the river EWR sites in the Breede and Overberg are currently in their Recommended Ecological Condition.

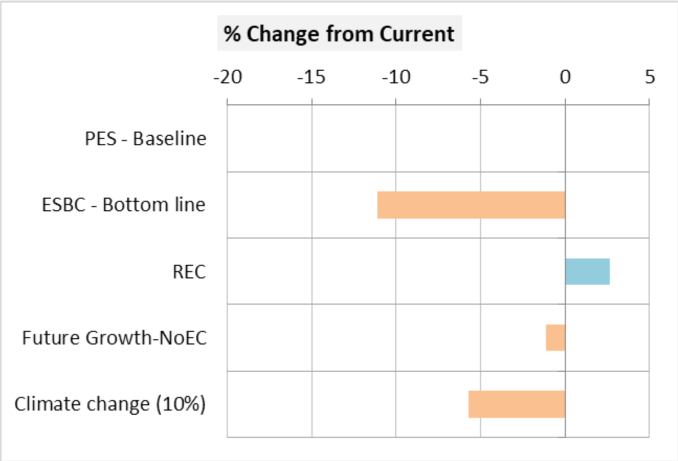


Figure 5-2 Breede: Percentage change in ecosystem health / integrity from the current scenario

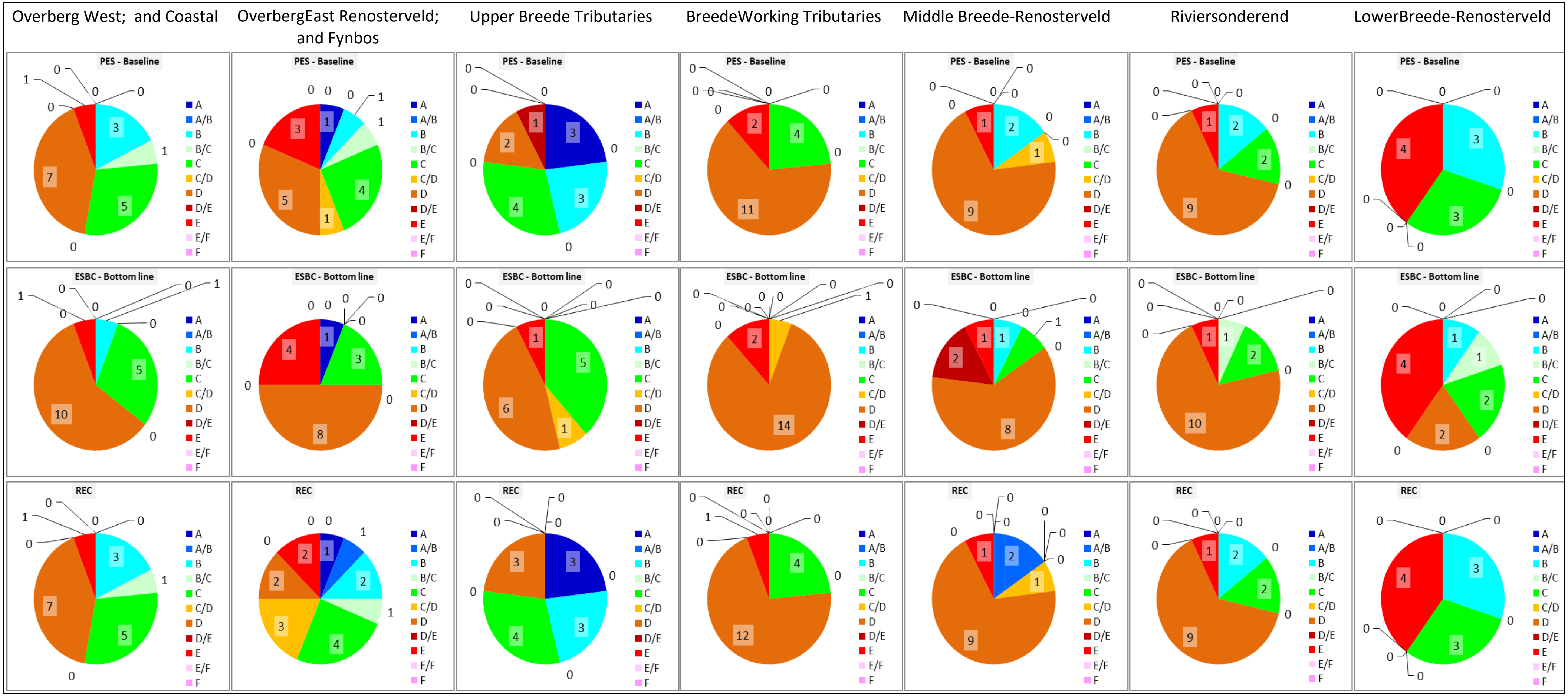
By looking more closely at each IUA (Figure 5-3) it is clear that rivers in the Upper Breede Tributaries IUA are in the best condition (more blue and green) than the rest (that have more orange, brown and red) and are closely followed by the rivers in the Overberg East. Rivers in an E ecological condition occur in all the IUAs apart from the Upper Breede. The Breede Working Tributaries, Middle Breede Renosterveld and Riviersondered IUAs all have the bulk of their rivers in a D condition.

Therefore, and somewhat unsurprisingly, the greatest changes from baseline into the ESBC scenario was in the Upper Breede Tributaries IUA where A, A/B and B condition rivers are replaced by C, C/D and D conditions.

As stated previously, there is little difference between the Baseline (PES) scenario and the REC scenario largely because most of the river EWR sites currently are in their REC condition categories. This is because most of the river Ecological Reserve sites' RECs were set to be the same as their PES (baseline) conditions.

The Future Growth-noEC scenario causes deterioration of one or two nodes in each IUA.

The climate change scenario drives a range of changes in conditions across the different IUAs with all IUAs showing further deterioration compared to the Future Growth-noEC scenario.


Overberg West; and Coastal
OverbergEast Renosterveld; and Fynbos
Upper Breede Tributaries
BreedeWorking Tributaries
Middle Breede-Renosterveld
Riviersonderend
LowerBreede-Renosterveld
PES - Baseline
ESBC - Bottom line
REC
A
A/B
B
B/C
C
C/D
D
D/E
E
E/F
F

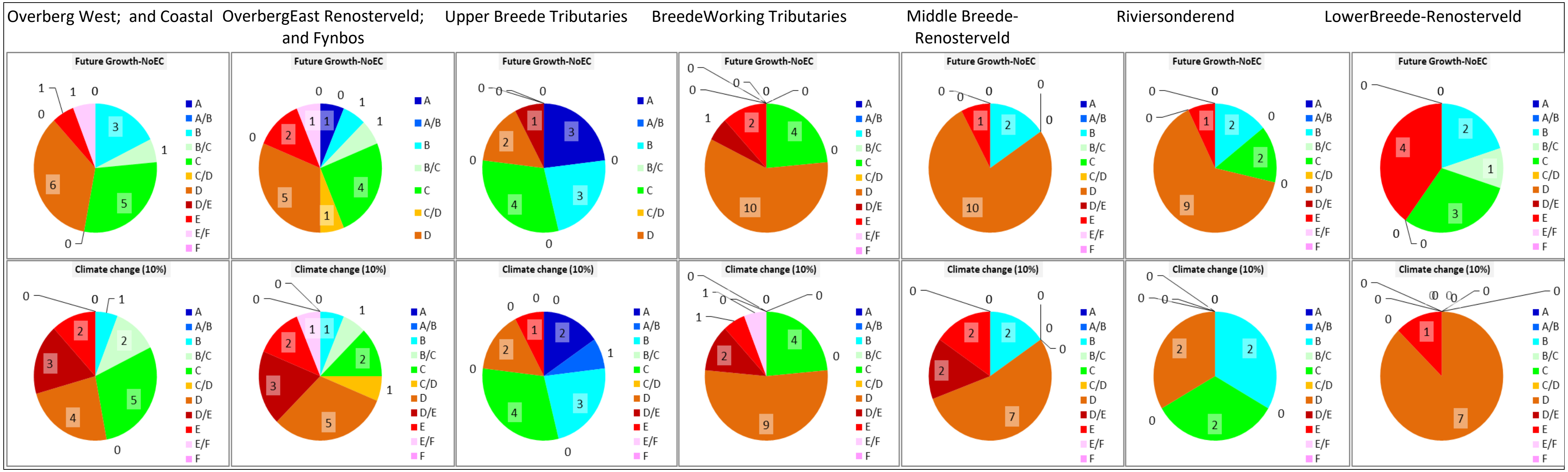


Figure 5-3 Summary of Ecological Categories distributied in each IUA for each scenario in the Breede-Overberg Region

5.1.2 Gouritz and Coastal Catchments

Summary results for the Gouritz and Coastal catchments are presented in Figure 5-4 and Figure 5-5 in terms of the number of nodes in each category and in terms of percentage change in health relative to PES-baseline. More detail is provided in Figure 5-6.

The bottom line scenario (ESBC) effectively makes a surplus of water available by reducing the conditions of rivers by decreasing the number of B, B/C rivers from 36 to 2, increasing the number of C, C/D rivers from 28 to 36, and the number of D rivers from 23 to 50. There is also an increase in the number of D/E and F rivers from 8 to 14.

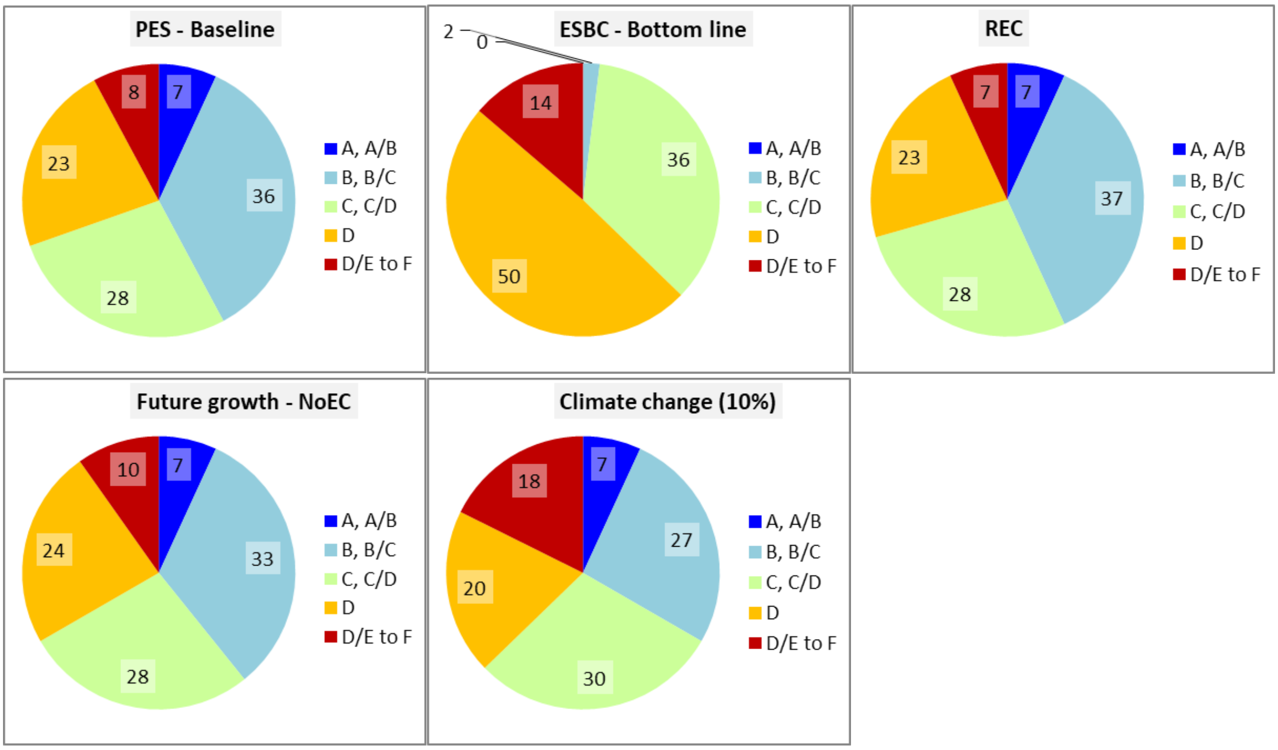


Figure 5-4 Gouritz (Gouritz and Coastal Catchments): number of nodes in each (grouped) EC category

There is little difference between the baseline and REC scenario overall. The REC improves on the baseline with one more B, B/C condition river and one less D/E, F condition river (Figure 5-4). In particular:

- Gamka (giv20) improves from C/D to C (meeting the REC)
- Kammanassie (giv10) improves from an E to a D
- Hartenbos estuary (gxi22) improves from a D to a C (meeting the REC)
- Piesang estuary (gxi14) improves from a C to a B/C (the REC is a B)

The Future growth-noEC scenario is also similar to baseline, but with an increase in the number of D/E to F rivers from 8 to 10.

Under the climate change scenario there is a big increase in D/E, F rivers (from 8 to 18), and a reduction in A,A/B and B, B/C rivers from 43 to 34.

Overall, these changes equate to a 21% reduction in overall condition in the ESBC scenario (Figure 5-5), and a very small improvement of 1% in the REC scenario, largely because most of the river EWR sites in the Gouritz and Outeniqua area are currently in their recommended conditions.

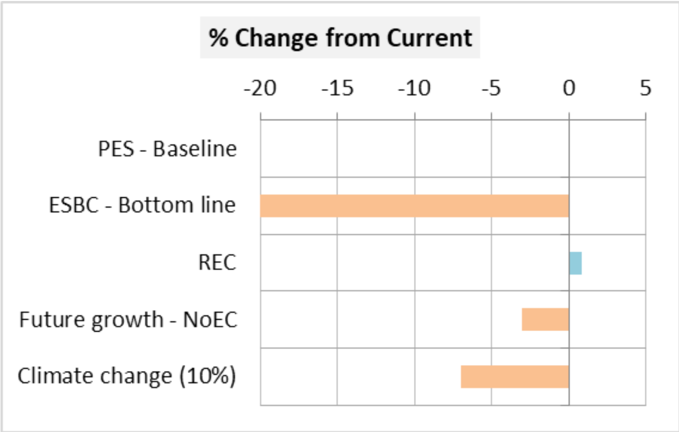


Figure 5-5 Gouritz: Percentage change in ecosystem health / integrity from the current scenario

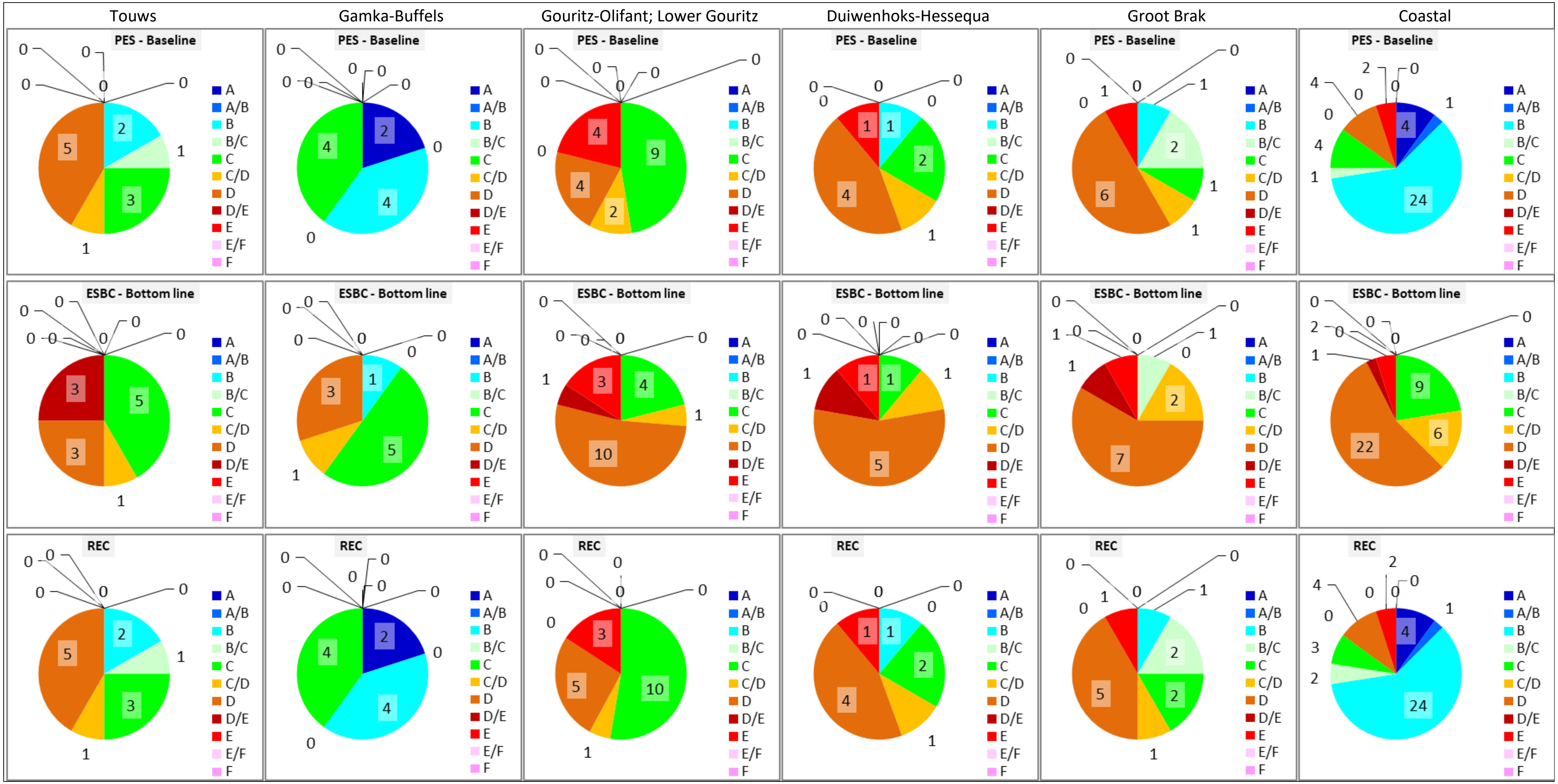
Looking more closely at each IUA (Figure 5-6), it is clear that the rivers in the Gamka-Buffels IUA are generally in better condition (more blue and green) than the rest (that have more orange, brown and red), followed by the Coastal IUA. Rivers in an E condition occur mostly in the Gouritz-Olifants and Lower Gouritz, Duiwenhoks and Hessequa, and the Groot Brak IUAs. The Touws IUA currently has no E condition rivers.

Therefore, unsurprisingly, the greatest changes from Baseline to the ESBC scenario are shown in the Gamka-Buffels and Coastal IUAs where the number of A, A/B and B rivers all but disappear and are replaced by D conditions at these locations.

As stated previously there is very little difference between the baseline-PES and the REC scenario largely because most of the river EWR sites currently are in their REC condition categories. This is because, for various reasons, most of the river reserve sites were set RECs that were the same as their PES (baseline) condition.

The Future growth-noEC scenario does not dramatically alter the status of the IUAs.

All IUAs show marked deterioration in condition under the climate change scenario.


Touws
Gamka-Buffels
Gouritz-Olifant; Lower Gouritz
Duiwenhoks-Hessequa
Groot Brak
Coastal
PES - Baseline
ESBC - Bottom line
REC
A
A/B
B
B/C
C
C/D
D
D/E
E
E/F
F

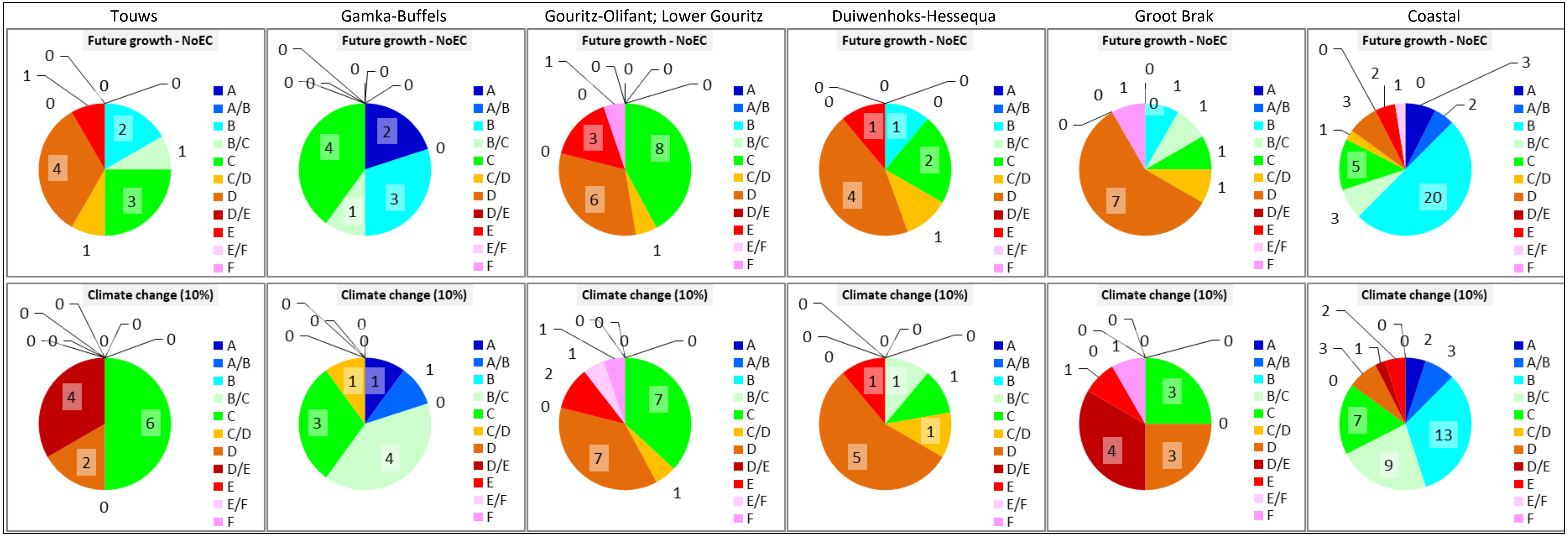


Figure 5-6 Summary of Ecological Categories distributied in each IUA for each scenario in the Gouritz-Coastal Region

5.2 Estuaries

5.2.1 Breede and Overberg Catchments

5.2.1.1 PES Scenario

Under the Present Ecological Status, the significant estuaries within the Breede and Overberg catchments fall into a range of Ecological Categories from A (Rooiels) to E (Onrus). Within this catchment, only one estuary currently has some form of protection, that being the Heuningnes estuary. The NBA (2011) recommended that the Heuningnes estuary be fully protected, and that the Palmiet estuary along with three others be assigned partial protection (50% of habitat and resource protected in each system).

The aggregate ecological category of estuaries (weighted by estuary size) within the Breede catchment area is a C Category. These estuaries provide habitat for approximately 12% of the national coastal waterbird population (based on numbers from NBA dataset which, while being a little dated, provide a consistent set of data that covers all the estuaries in the country and provide a national figure to which conservation targets can be related). Estuaries in the Breede catchment area contain approximately almost a quarter of the national estuary-dependent fish species (based on NBA numbers). These estuaries encompass a range of different estuarine habitats including 23% of the national area of supratidal salt marsh and 15% of the national area of estuarine reeds and sedges.

Under current conditions in the Breede catchment area, less than 1% of the national coastal waterbird population is protected. This includes only 23% of the total population of Red Data species. The estuaries which house the largest bird populations within the Breede catchment area are the Klein and Uikraals estuaries, followed by the Bot/Kleinmond and Heuningnes. The situation is similar for fish, with 7% of the national estuarine fish population being protected within established estuarine protected areas in the catchment area. The proportion of the population that is protected falls far short of the established conservation targets for total numbers as well as for over-exploited species (2% of population protected).

The estuaries which house the most significant estuarine fish populations within the Breede catchment area include the Bot/Kleinmond and Klein estuaries. Conserved macrophyte habitat within the Breede catchment area makes up only 13% of the recommendations set out in the NBA. The estuaries contributing the most area to these habitats are the Bot/Kleinmond, Klein and Heuningnes estuaries.

It is clear that the level of protection applied to estuarine biodiversity in the Breede catchment area is poor under the current situation and that estuarine biodiversity and resources are severe threat due to the poor average state of health of these systems. In order to improve this situation, it is clear that both the number of estuaries under formal protected need to be increased as a matter of urgency and that attention needs to be paid to improving the ecological health of the priority systems as well.

Table 5-1 The state of the different biological components in the Breede catchment area under the Present Ecological Status along with the extent to which the PES meets Conservation goals

Biological component	Total numbers/area	% of conservation goal met
Intertidal salt marsh (ha)	55	21%
Supratidal salt marsh (ha)	548	25%
Submerged macrophytes (ha)	262	6%
Reeds and sedges (ha)	354	18%
All fish (est.) [1]	468	7%
Over-exploited fish species	2524	2%
All birds	71064336	1%

Biological component	Total numbers/area	% of conservation goal met
Red Data birds	55878	23%

[1] Estimated value

5.2.1.2 ESBC Scenario

Under the ESBC scenario some fairly significant changes to estuarine ecological condition from PES are expected. The aggregate ecological category of estuaries (weighted by estuary size) within the Breede catchment area dropped from a C to a D category under this scenario. Macrophytes habitat area under protection is expected to drop by between 7 (intertidal salt marsh) and 28% (supratidal salt marsh). Total numbers of fish are expected to drop by around 18%, numbers of exploited fish species will drop by around 19%, while total numbers of birds are expected to drop by around 28% and red data species by 9%.

Table 5-2 The state of the different biological components in the Breede catchment area under the ESBC scenario, the change from PES and the degree to which the ESBC meets Conservation goals

Biological component	Modelled numbers/ area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	51	-7%	15%
Supratidal salt marsh (per ha)	396	-28%	18%
Submerged macrophytes (per ha)	200	-24%	4%
Reeds and sedges (per ha)	268	-24%	13%
All fish	382	-18%	5%
Over-exploited fish	2037	-19%	1%
All birds	51448326	-28%	1%
Red-data birds	50578	-9%	16%

5.2.1.3 REC Scenario

Under the REC scenario significant improvements in estuarine ecological condition from PES were observed. The aggregate ecological category of estuaries (weighted by estuary size) within the Breede catchment area improved from a C to a B category. The condition categories for three estuaries were improved, namely Klein, Uikraals and Heuningnes. These improvements in health were assumed to result in some significant improvements in the individual biological components as well (viz. macrophytes, fish and birds, Table 5-2). The biggest changes included a 43% increase in the area of submerged macrophytes and 30% increase in supratidal salt marsh area, a corresponding change in the size of the regional population of fish (20% up) and birds (16% up). The total number of exploited fish also increased by approximately 7%.

While efforts were made to lift the ecological category of rivers (and estuaries) to their recommended ecological category, these categories could not always be reached through restoration of flow alone. In the case of estuaries in particular, water quality and other disturbances (such as overfishing) would need to be met in order to be able to raise the ecological category of some of these estuaries to their REC. Addressing overfishing requires that formal protection be assigned to selected (ideally priority) systems.

Table 5-3 The state of the different biological components in the Breede catchment area under the Recommended Ecological Condition (REC), the change from PES and the degree to which the REC meets Conservation goals

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	60	8%	30%
Supratidal salt marsh (per ha)	714	30%	36%
Submerged macrophytes (per ha)	376	43%	9%
Reeds and sedges (per ha)	420	18%	26%
All fish	562	20%	9%
Over-exploited fish	2704	7%	3%
All birds	82446704	16%	1%
Red-data birds	62011	11%	33%

5.2.1.4 No EC – High Growth (HG)

Under the unconstrained (i.e. no EC) High Growth scenario only a few changes to estuarine ecological condition from PES were observed. The aggregate ecological category of estuaries (weighted by estuary size) within the Breede catchment area remained within a C category. Only one estuary (Onrus) changed health category, dropping from D to E. As a result, only marginal changes were seen on an aggregate scale across the catchment area as this estuary is very small and does not contain large populations of birds or fish. The main changes that occurred include a 5% reduction in the area of reeds and sedges. Similar to the REC Scenario, none of these changes altered the extent to which the catchment area Protection Goal was met, as the estuaries for which improvements were seen were not currently protected.

Table 5-4 The state of the different biological components in the Breede catchment area under the Current Development+ High Growth scenario, the change from PES and the degree to which the scenario meets Conservation goals

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	55	0%	21%
Supratidal salt marsh (per ha)	548	0%	25%
Submerged macrophytes (per ha)	262	0%	6%
Reeds and sedges (per ha)	336	-5%	18%
All fish	468	0%	7%
Over-exploited fish	2524	0%	2%
All birds	70974481	0%	1%
Red-data birds	55722	0%	23%

5.2.1.5 Climate change scenario

The impact of the climate change scenario was worse than any of the others considered in this study. The aggregate ecological category of estuaries (weighted by estuary size) within the Breede catchment area dropped from a C to a D category, and the health of six estuaries (Rooiels, Onrus, Klein, Breede, Heuningnes and Klipdrifsfontein) declined. This is expected to result in a significant reduction in macrophytes habitat area (21-29% reduction), and also in fish (20-22% reduction) and bird populations (23-28% reduction).

Table 5-5 The state of the different biological components in the Breede catchment area under the Climate change scenario, the change from PES and the degree to which the scenario meets Conservation goals

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	43	-21%	15%
Supratidal salt marsh (per ha)	396	-28%	18%
Submerged macrophytes (per ha)	200	-24%	4%
Reeds and sedges (per ha)	250	-29%	13%
All fish	376	-20%	5%
Over-exploited fish	1977	-22%	1%
All birds	51127460	-28%	1%
Red-data birds	42969	-23%	16%

5.2.2 Gouritz and Coastal Catchments

5.2.2.1 PES Scenario

Under the Present Ecological Status, the significant estuaries within the Gouritz catchment area fall under a range of Ecological Categories ranging from A to D. Within this catchment area, four estuaries currently have full protection and another five have partial protection status. The NBA indicated that in addition to those estuaries currently protected a further two estuaries should be partially protected and one more fully protected.

The aggregate ecological category of estuaries (weighted by estuary size) within the Gouritz catchment area was a B category. These estuaries provide habitat for approximately 10% of the national coastal waterbird population. The Gouritz catchment area estuaries contain approximately almost 9% of the national estuary-dependent fish species (based on NBA numbers). Estuaries within the Gouritz catchment area encompass a range of different estuarine habitats including most notably 30% of the national area of intertidal salt marsh.

Under current conditions, approximately 5% of the national coastal waterbird population is contained with protected estuaries in the Gouritz catchment area. The Gouritz catchment area estuaries are close to meeting the conservation goal for birds, however, with 84% of the recommended total birds numbers protected and 94% of Red Data species protected. The estuaries which house the largest bird populations within the Gouritz catchment area are the Swartvlei, Wilderness and Knysna estuaries. Similar to birds, less than 4% of the national estuarine fish population is contained within protected estuaries in the Gouritz catchment area, but the portion that is protected makes up 89% of the conservation target for this area in terms of total numbers and 92% for over-exploited species. The estuaries which house the most significant estuarine fish populations within the Gouritz catchment area include the Knysna, Swartvlei and Goukamma estuaries. Conserved macrophyte habitat within the Gouritz catchment area habitats are on average 95% of the recommendations set out in the NBA.

On an aggregate scale the Gouritz catchment area is close to meeting its conservation goals set out in the NBA.

Table 5-6 The state of the different biological components in the Gouritz catchment area under the Present Ecological Status along with the degree to which the PES meets Conservation goals

Biological Component	Total numbers/Area	Percentage of Conservation Goal Met
Intertidal salt marsh (per ha)	728	85%
Supratidal salt marsh (per ha)	203	99%
Submerged macrophytes (per ha)	471	100%
Reeds and sedges (per ha)	332	98%
All fish (est) [1]	1502	89%
Over-exploited fish (est) [1]	2835	92%
All birds	24 776 393	84%
Red Data birds	5 660 615	94%

[1] Estimated value

5.2.2.2 ESBC scenario

Under the ESBC Scenario, decreases in ecological conditions were observed for all but two of the estuaries within the Gouritz catchment area. The aggregate ecological category for all estuaries in this catchment area (weighted by estuary size) dropped to a D category under this scenario. It is estimated that this decrease in ecological condition will result in losses of between 25% and 37% for the various groups of macrophytes (salt marsh, submerged macrophytes and reeds and sedges), a loss of around 20-23% for fish, and around 30-32% for birds.

The reduction of population sizes of the groups will mean that the percentage of the conservation target that is met will drop from 74% at present to around 67%. The decrease in flow to achieve a D condition for all the Gouritz catchment area estuaries has the potential to severely impact biodiversity in estuaries in this region and will impact very negatively on their ability to meet conservation targets.

Table 5-7 The state of the different biological components in the Gouritz catchment area under the Ecologically Sustainable Base Configuration (ESBC), the change from PES and the degree to which ESBC meets Conservation goals

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	547	-25%	63%
Supratidal salt marsh (per ha)	147	-27%	63%
Submerged macrophytes (per ha)	349	-26%	74%
Reeds and sedges (per ha)	209	-37%	61%
All fish	1199	-20%	70%
Over-exploited fish	2176	-23%	70%

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
All birds	17 365 492	-30%	58%
Red-data birds	3 859 654	-32%	62%

5.2.2.3 REC scenario

Under the REC scenario, only a few changes to estuarine ecological condition from PES were observed. The Hartenbos and Piesang estuaries improved by one category each but no other estuary changed health category. These improvements translated into to a modest increase in supratidal salt marsh habitat (3%) but no chnage for other macrophytes , and also modest improvements in total fish numbers and birds in the region (up by 1% each). Overexploited fish and Red-data birds species did not change under this scenario. None of these changes significantly altered degree to which the catchment area Protection Goal was met, as the estuaries for which improvements were seen were not currently protected.

As explained above, while efforts were made to lift the ecological category of rivers (and estuaries) to their recommended ecological category, these categories could not always be reached through increasing flow alone. In the case of estuaries in particular, water quality and other disturbances would need to be addressed as well to raise the ecological category of some of these estuaries to their REC.

Table 5-8 The state of the different biological components in the Gouritz catchment area under the Recommended Ecological Condition (REC), the change from PES and the degree to which the REC meets Conservation goals

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	728	0%	85%
Supratidal salt marsh (per ha)	208	3%	99%
Submerged macrophytes (per ha)	471	0%	100%
Reeds and sedges (per ha)	333	0%	98%
All fish	1521	1%	89%
Over-exploited fish	2841	0%	92%
All birds	25 065 105	1%	86%
Red-data birds	5 677 593	0%	94%

5.2.2.4 No EC – High Growth (HG)

Under the unconstrained (i.e. No EC) High Growth scenario, changes to estuarine ecological condition relative to PES was observed at only three estuaries (Great Brak, Gwaiing and Kaaimans) and aggregate ecological category of estuaries (weighted by estuary size) within the Gouritz catchment area remained in a B category under this scenario. The resultant reduction in area occupied by the different groups of macrophytes ranged from 0 to 13%, fish abundance dropped by 1% and birds by 1-7%. The biggest changes were observed in supratidal and intertidal saltmarsh area and were linked to reductions in flow to the Great Brak estuary. The extent to which conservation targets would be met is also reduced to between 93-97%.

The Current Development + High Growth scenario did have negative impacts on both biodiversity as well as conservation goals. These impacts were, however, not as bad as under the ESBC scenario.

Table 5-9 **The state of the different biological components in the Gouritz catchment area under the Current Development + High Growth scenario, the change from PES and the degree to which the scenario meets Conservation goals**

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	723	-1%	85%
Supratidal salt marsh (per ha)	175	-13%	99%
Submerged macrophytes (per ha)	471	0%	100%
Reeds and sedges (per ha)	329	-1%	98%
All fish	1486	-1%	89%
Over-exploited fish	2814	-1%	92%
All birds	24 436 687	-1%	86%
Red-data birds	5 585 537	-1%	94%

5.2.2.5 Climate change scenario

The Climate Change scenario resulted in seven estuaries dropping in health status – Gouritz, Blinde, Hartenbos, Great Brak, Maalgate, Gwaiing, Kaaimans and Blinde estuaries. Impacts of this on supratidal salt marsh cover was severe, however (16% loss), but effects on fish and birds was modest (1-3% loss). The effect on conservation targets was also minimal.

Table 5-10 **The state of the different biological components in the Breede catchment area under the Climate change scenario, the change from PES and the degree to which the scenario meets Conservation goals**

Biological component	Modelled numbers/area	% change from PES	% of conservation goal met
Intertidal salt marsh (per ha)	717	-2%	85%
Supratidal salt marsh (per ha)	169	-16%	99%
Submerged macrophytes (per ha)	471	0%	100%
Reeds and sedges (per ha)	329	-1%	98%
All fish	1482	-1%	89%
Over-exploited fish	2788	-2%	92%
All birds	24 141 427	-3%	86%
Red-data birds	5 548 896	-2%	94%

5.3 Wetlands

The assessment for wetlands focused on the impacts of surface and groundwater use as well as the indirect impacts of future development scenarios.

5.3.1 Breede and Overberg Catchments

The overall impact for wetlands in the Breede and Overberg Catchments was assessed by determining how the changes to ecological condition and flow in river nodes would impact the associated floodplain and channelled/unchannelled valley bottom wetlands in terms of surface water use and how the change to groundwater status would impact all wetlands in terms of groundwater use The indirect impacts of future development were also assessed.

The threats associated with the wetlands in the Wetland Regions are:

- Western Folded Wetland Region (WR1)
  - Agriculture impacts, wetland drainage, encroachment of cultivation and transformation to farm dams (WfW working in the area).
- Coastal Southern Folded Wetland Region (WR2)
  - Urban development and nutrient enrichment.
- Southern Coastal Wetland Region (WR3)
  - There has been erosion of peat wetlands (WfW working in the area). De Hoop Vlei is a Ramsar protected wetland, and occurs within the De Hoop Nature Reserve. Three wetland types occur, namely coastal freshwater lagoon, coastal brackish lagoon and seasonal freshwater marshes. There is high species richness and biodiversity within the site. Protection of the site is enacted through restriction of human activities within the reserve borders, although outside of the reserve there is extensive agriculture land use. Possible threats are eutrophication and siltation due to land use surrounding the reserve. De Mond (Heuningnes Estuary) is also a Ramsar wetland, located within the De Mond Nature Reserve. Protection of the site is enacted through restriction of human activities within the reserve borders.
- Coastal Sediment Wetland Region (WR4)

5.3.1.1 Clearing of natural vegetation, cultivation and alien invasive plants; too frequent or infrequent fire; and alien plant invasion (WfW working in the area).PES Scenario

Under the Present Ecological Status most wetlands are in a good condition (i.e. AB or C), and the associated river nodes are similar. There are certain river nodes that are very poor in comparison to the condition of the associated wetlands, mainly due to the surrounding agricultural activities and transformation of the riverbanks. Most of the wetlands in the high-lying areas are within high yield Strategic Water Source Area (Breede), and within protected areas, with various areas being targeted by the Working for Wetlands rehabilitation programme.

Within this catchment, only one wetland has had a Floodplain Reserve conducted. Papenkuils floodplain wetland has a REC of C. Although the Smalblaar River node (Niv42) has a low ecological category (E), the Breede River nodes (Niii1 and Nv3) are in better condition (D and C, respectively), and are thus better able to support the preliminary Reserve determined for the Papenkuils (at an ecological condition of C).

De Hoop Vlei, below node Nii7, is a Ramsar wetland which is unique in the south-western Cape as it is a coastal lake with no outlet to the sea with widely fluctuating salinities. The depth of the wetland fluctuates seasonally, with a maximum depth of 7.7 metres. The Sout and Potberg Rivers are the most important rivers feeding the wetland. The wetland is within the De Hoop Nature Reserve, and is managed by Cape Nature. Maintenance of the PES of B is important for the conservation of these important wetlands.

5.3.1.2 ESBC scenario

Under the ESBC scenario the condition of rivers is reduced. As most wetlands have a current good condition, this will negatively impact the condition of wetlands. There is also a reduced flow in some instances, which will impact floodplain wetlands. Papenkuils floodplain wetland will not be maintained according to management conditions in this scenario. The river node associated with De Hoop Vlei (Nii7) dropped to a C from a B category.

5.3.1.3 REC scenario

The REC scenario is similar to the Present Ecological Status. Wetlands are maintained in a similar ecological condition to current.

5.3.1.4 No EC – High Growth (HG)

The demand driven scenario will likely result in increased indirect impacts to wetlands, such as increased agricultural transformation of seep and depression wetlands and increased stormwater runoff from hardened surfaces in urban areas.

5.3.1.5 Climate change scenario

Under the Climate change scenario the condition of rivers are reduced, to a greater extent than the ESBC scenario.

5.3.2 Gouritz and Coastal Catchments

The overall impact for wetlands in the Gouritz and Coastal Catchments was assessed by determining how the changes to ecological condition and flow in river nodes would impact the associated floodplain and channelled/unchannelled valley bottom wetlands in terms of surface water use, and how the change to groundwater status would impact all wetlands in terms of groundwater use. The indirect impacts of future development were also assessed.

The threats associated with the wetlands in the Wetland Regions are:

- Nama Karoo Wetland Region (WR5)
    - Transformation into dams and transformation through cultivation, invasive alien Prosopis glandulosa infestations; mining for salt, and trampling and overgrazing.
- Great Karoo Wetland Region (WR6)
    - Direct transformation of the wetlands due to grazing pressure, cultivation and building of dams and other infrastructure; increased nutrient inputs, and invasive alien plants.
- Cape Fold Wetland Region (WR7)
    - Limited threats which include physical alterations from agriculture; trampling and grazing.
- Southern Folded Wetland Region (WR8)
    - Transformation for cultivation and building of roads; increased nutrient inputs, and invasive alien plants.
- Southern Cape Folded Wetland Region (WR9)
    - Too frequent fires; cultivation within wetland areas, expansion of afforestation, and invasive alien woody species into wetlands.
- South East Coastal Wetland Region (WR10)
    - The Wilderness Lakes consist of three permanent, interconnected coastal lakes linked to the ocean. The lakes are considered important due to the biodiversity they host, as well as the flood control benefits. Risk to this important system and other wetlands in this resource unit are 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.
- Sedimentary Lakes Wetland Region (WR11).

- 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.

5.3.2.1 PES Scenario

Under the Present Ecological Status most wetlands are in a good condition (i.e. AB or C), and the associated river nodes are not necessarily in a similar condition. The Duiwenhoks wetland has a PES of D which needs to be maintained, although the PES of the associated river node is E. The Grootbosberg, Lower Tierkloof and Upper Gaffie wetlands on Goukou River are also at risk from erosion. The associated river node for these wetlands has a PES of C/D. The upper reaches of Donkies River in Touws IUA have FEPA channelled valley-bottom wetlands in a good condition, which are within the Bokkeriviere Nature Reserve and the Gouritz High Yield Strategic Water Source Area. This region requires natural flow and may be considered for conservation purposes. Channelled valley wetlands on the Brak and Touws tributaries are associated with nodes in a better condition, and this should be maintained. The poor condition of the Gouritz, Brandwag and Moordkuil Rivers impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

The Wilderness Lakes is a Ramsar site and needs to be managed accordingly. The rivers in this area are in a good condition and the rivers flow is close to natural. This needs to be maintained in order to meet conservation targets.

5.3.2.2 ESBC scenario

Under the ESBC scenario the condition of rivers was reduced. As most wetlands have a current good condition, this will negatively impact the condition of wetlands. There is also a reduced flow in some instances, which will impact floodplain wetlands.

There was little change with the condition of the node (giii5) associated with the Duiwenhoks wetland which still remains an E. This is below the requirements of at least a D condition for this wetland system. The condition associated with the Goukou River node (giii7) was reduced. The upper reaches of Donkies River in Touws IUA do not change condition from a D. Although the condition of the Brak river node (giv26) remains a C, the flows are low. The poor condition of the Gouritz, Brandwag and Moordkuil Rivers (in the Lower Gouritz and Groot Brak IUAs) is maintained and impacts associated FEPA floodplain wetlands and valley bottom wetlands.

The Wilderness Lakes site associated river nodes meet the C or D condition, which is a poor condition for conserving the Ramsar site.

5.3.2.3 REC scenario

The REC scenario is similar to the Present Ecological Status. Wetlands are maintained in a similar ecological condition to current.

5.3.2.4 No EC – High Growth (HG)

The demand driven scenario will likely result in increased indirect impacts to wetlands, such as increased agricultural transformation of seep and depression wetlands and increased stormwater runoff from hardened surfaces in urban areas.

5.3.2.5 Climate change scenario

Under the Climate change scenario, the conditions of rivers are reduced, to a greater extent than the ESBC scenario in some cases. There was little change with the condition of the node (giii5) associated with the Duiwenhoks wetland which still remains an E. This is below the requirements of at least a D condition for this wetland system. The condition associated with the Goukou River node (giii7) was reduced. The upper reaches of Donkies River in Touws IUA are reduced. The poor condition of the Gouritz, Brandwag and Moordkuil Rivers (in the Lower Gouritz and Groot Brak IUAs) is maintained and impacts associated FEPA floodplain wetlands and valley bottom wetlands.

The Wilderness Lakes site associated river nodes meet the B/C condition, which is an improvement from the ESBC scenario.

5.4 Water Quality

5.4.1 Breede and Overberg Catchments

5.4.1.1 Maintain PES ("Baseline")

Under the baseline scenario, water quality in the Upper Breede Tributaries will remain in an ideal category, except in the Breede River downstream of Ceres where slightly elevated salts, as a result of return flows and treated wastewater effluents in the Ceres area, will prevail. Water quality in Brandvlei Dam and Roode Elsberg Dam will remain in a very good state. Water quality in the Breede Working Tributaries will probably continue to exhibit good quality in the upper reaches of the tributaries, but high salinities in the lower reaches of the tributaries due to agricultural return flows and intensive irrigation practices in their catchments. Water quality in the Middle Breede Renosterveld IUA will continue to exhibit high salinities as a result of the geology of the area, intensive irrigation practices, and saline irrigation return flows. However, the freshening releases from Brandvlei Dam during the summer months (dry season) to maintain a quality suitable for irrigation agriculture up to the Sanddrift Canal, will maintain the quality in the middle Breede River in an acceptable state and mitigate the impacts of poor quality inflows from the Breede Working Tributaries. Water quality in Klipberg Dam and Kwaggaskloof Dam will probably remain in a very good state (Ideal category). The impacts of WWTW discharges on elevated nutrient concentrations and elevated bacterial counts from urban runoff in the middle Breede River will probably continue, unless point source control measures are enforced more strictly.

Water quality in the Lower Breede Renosterveld IUA will probably remain good (Ideal category) in the tributaries and the poor quality (Tolerable to Unacceptable category) in the Breede River at Swellendam will probably continue. It is important that WWTW discharges from Swellendam be controlled to prevent further degradation of the quality in the lower Klip River and the receiving lower Breede River.

Water quality in the Riviersonderend Theewaters IUA is good and mostly ideal for its intended uses and will probably remain so provided WWTW and other pollution sources are controlled effectively. Water quality in the Lower Riviersonderend IUA will probably continue to exhibit elevated salt concentrations as a result of agricultural return flows.

Water quality in the Overberg West IUA will probably remain in a good state provided point sources of pollution and urban runoff are controlled effectively. This is especially relevant to the town of Botrivier where elevated salts and high phosphate values were recorded in the past which was attributed to treated wastewater discharges into the Bot River. Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations which was largely ascribed to the geology of the region.

5.4.1.2 ESBC Scenario

Under the ESBC scenario, water quality in the Upper Breede Tributaries will probably remain ideal. Water quality in the Breede River downstream of Ceres would probably deteriorate more due to less dilution of irrigation return flows and WWTW discharges, and more poor quality (unacceptable category) irrigation return flows if the surplus water generated in this scenario is used locally to support expanded irrigation activities. Under the ESBC scenario wet season flows would probably decrease and the dry season flows would increase. The impacts on water quality is that the increase in flow during the dry season would dilute the poor quality in the lower reaches of the river impacted by large irrigation return flows. The reduction in flow during the wet season may not result in a major change in the water quality. Under this scenario lower volume freshening releases will probably be made from Brandvlei Dam during the summer months (dry season) which may result in elevated salinity in the river reach up to Sanddrift Canal. This may impact negatively on the irrigation farmers. The impacts of WWTW discharges on elevating nutrient concentrations and elevated bacterial counts from urban runoff in the middle Breede River will probably reduce during the dry season due to higher dilution as a result of the elevated flows. The poor quality in the Breede River at Swellendam could be slightly alleviated by the increase in dry season flows in the main stem river. Flow in the Klip River at Swellendam would be largely unchanged and it is therefore important that WWTW discharges from the Swellendam be controlled.

In the Riviersonderend Theewaters IUA will probably remain in a good state provided the effluent discharges from WWTW and other pollution sources being controlled effectively. Water quality in the Lower Riviersonderend IUA will probably continue to exhibit elevated salt concentrations as a result of agricultural return flows and it might be higher due to reduced dry season flows in the main stem Riviersonderend River.

Under the ESBC scenario, water quality in the Overberg West IUA will probably remain in a good state provided point sources of pollution and urban runoff are controlled effectively. The reduction in flow during the wet season would mean that less flow is available to dilute effluent discharges and irrigation return flows resulting in poorer quality in the river. Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations which was largely ascribed to the geology of the region.

5.4.1.3 REC Scenario

In the REC scenario, water quality in the Upper Breede Tributaries will probably remain in the same state as described for the Baseline scenario. Water quality in Brandvlei Dam and Roode Elsberg Dam will probably remain in a very good state. Water quality in the Breede Working Tributaries will probably continue to exhibit good quality in the upper reaches, and high salinities in the lower reaches. Water quality in the Middle Breede Renosterveld IUA will continue as described in the baseline scenario. The freshening releases from Brandvlei Dam will maintain the quality in the middle Breede River in an acceptable state. Water quality in Klipberg Dam and Kwaggaskloof Dam will probably remain unchanged. The impacts of WWTW discharges on elevating nutrient concentrations and elevated bacterial counts from urban runoff in the middle Breede River will probably continue. Water quality in the Lower Breede Renosterveld IUA will probably remain good in the tributaries but the poor quality in the Breede River at Swellendam will probably improve slightly due to the increase in flow, especially during the dry season.

Water quality in the Riviersonderend Theewaters IUA will remain as described for the Baseline scenario.

Water quality in the Overberg West IUA will probably remain as described for the Baseline scenario.

5.4.1.4 No EC – High Growth Scenario

Under the High Future Demands scenario, most of the increase in demand would come from a growth in urban/industrial demands. This would result in increased return flows of treated wastewater from municipal WWTWs, and possibly increased urban runoff from seepage from aging sewerage infrastructure, and seepage from leaking potable water infrastructure into the urban stormwater system. The impacts of treated effluent discharges and urban runoff on receiving rivers can be mitigated through compliance to discharge standards, and improved maintenance of water supply and sewerage infrastructure.

Water quality in the Upper Breede Tributaries will be impacted in the rivers where substantial reductions in flow will occur. The reduction in flow in the Koekedou River as a result of raising Koekedou Dam, will result in less dilution of agricultural runoff generated in the Dwars River catchment, upstream of Ceres. The increase in municipal wastewater discharges into the upper and middle Breede River from town such as Ceres, Worcester, Robertson and Ashton will probably result in higher nutrient loads into the Breede River.

Although it was assumed that no future increases in irrigation water allocations will be allowed by DWS across the whole catchment area, under this scenario increased allocations from Brandvlei Dam may occur. This would result in larger flows of freshening releases into the middle Breede River. The increase irrigation agriculture would probably result in higher salt and agro-chemical loads into the Breede River, either through the working tributaries, of direct return flows into the Breede River. Dry season freshening releases from Brandvlei Dam will probably mitigate the municipal and agricultural impacts in the middle Breede River, However, when no freshening releases are made, the impacts of continued urban and agricultural return flows would probably lead to higher salt and nutrient concentrations.

Water quality in the Riviersonderend Theewaters IUA will remain good provided WWTW and other pollution point sources are controlled effectively. Water quality in the Lower Riviersonderend IUA will remain as described in the baseline scenario.

Water quality in the Overberg West IUA will probably remain in a good state as described for the baseline scenario. The reduction in flow in the Onrus River will probably result in poorer quality in the lower reaches. The slight reduction in flow in the Palmiet River will probably result in a small change from the baseline water quality conditions.

With the minor changes in flow envisaged in this scenario, water quality in the Overberg East Renosterveld IUA will remain as described in the baseline scenario.

5.4.1.5 Climate change scenario

The lower flows in the rivers and increased evaporation under the climate change scenario will aggravate the impacts of irrigation return flows as well as the impacts of effluents and urban runoff on receiving rivers.

5.4.2 Gouritz and Coastal Catchments

5.4.2.1 Maintain PES ("Baseline")

Water quality in the Gamka-Buffels IUA, in the upper reaches of the Gamka River will probably remain in a generally good state. The average salinity will probably remain in an Acceptable state although high concentrations may be observed from time to time large due to the arid nature of the catchment and accumulation of salts during prolonged dry periods. Nitrogen concentrations would probably remain low, and phosphate concentrations would probably remain low although some elevated concentrations observed from time to time. The poor quality (elevated salinities) downstream of Floriskraal Dam would probably be maintained under the baseline scenario and the current variability would remain. Water quality in the Gouritz-Olifants IUA will probably continue to exhibit elevated salt and nutrient concentrations, especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. Poor water quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort would probably be maintained. Water quality in the Weyers River was only moderately impaired and this would probably continue.

High salinities occur almost throughout the Touws IUA. This situation will probably be maintained under the Baseline scenario.

The good water quality observed in the upper and middle reaches of the Duiwenhoks IUA will probably be maintained, as well as the elevated salinities observed in the lower reaches of the Duiwenhoks River and the lower Goukou River. Water quality in the Korentepoort Dam will probably remain in an ideal state.

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream Hartenbos River will probably be maintained. The same would probably apply to the moderately elevated salinities in Wolwedans Dam on the Groot-Brak River. Elevated phosphate concentrations observed from time to time in these dams would also be maintained.

The generally good water quality in the rivers of the Coastal IUA would probably be maintained under this scenario provided that treated effluent discharges into the receiving rivers are controlled. The same would be true for the good water quality in the Garden Route Dam.

5.4.2.2 ESBC Scenario

Water quality in the Gamka-Buffels IUA, in the upper reaches of the Gamka River will probably be affected by the general reduction in flow under the ESBC scenario. The average salinity will probably deteriorate to a Tolerable state due to less flow being available to dilute the salts originating from the catchment and salts that have accumulated in the river channels during prolonged dry periods. The poor quality (elevated salinities) downstream of Floriskraal Dam would probably deteriorate further. Water quality in the Gouritz-Olifants IUA will probably continue to exhibit elevated salt and nutrient concentrations, especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. The poor water quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort would probably deteriorate further. Water quality in the Weyers River would remain as described under the baseline scenario.

High salinities that occur throughout the Touws IUA will probably continue under the ESBC scenario.

Water quality in the upper and middle reaches of the Duiwenhoks IUA will probably deteriorate to a lower category. This will have a cascading effect with higher salinities estimated in the lower reaches of the

Duiwenhoks River and the lower Goukou River. Water quality in the Korentepoort Dam will probably remain ideal.

The elevated salinities in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream Hartenbos River will probably deteriorate slightly. The same would probably apply to the moderately elevated salinities in Wolwedans Dam.

The generally good water quality in the rivers of the Coastal IUA would probably be maintained or it might deteriorate slightly under this scenario.

5.4.2.3 REC Scenario

Water quality in the Gouritz will probably remain as described under the Baseline scenario.

The baseline water quality in the Gamka-Buffels IUA will probably prevail under this scenario as no change is envisaged.

The elevated flows in the Gamka River upstream of the confluence with the Olifants River could probably lead to an improvement in quality in the Gamka. In the Olifants River the situation will remain largely similar to that described for the baseline water quality.

The elevated flows in the lower Gouritz River under this scenario will probably result in an improvement in the poor water quality in the lower reaches. The flow and water quality situation will remain largely unchanged in the rest of the IUA

The high salinities described in the baseline description of the Touws IUA will probably prevail as no change in flow is envisaged in this scenario.

Under this scenario there will be no change in flow the Duiwenhoks IUA.

The elevated salinities observed in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream Hartenbos River will probably be maintained under this scenario.

The generally good water quality in the rivers of the Coastal IUA would probably be maintained under this scenario.

5.4.2.4 No EC – High Growth Scenario

Water quality in the Gamka-Buffels IUA, in the upper reaches of the Gamka River will probably remain in a generally good state. The poor quality (elevated salinities) downstream of Floriskraal Dam would probably be maintained under the PES scenario.

The increased abstractions in the Grobbelaars will probably have a negative impact on water quality. The rest of the IUA will probably continue to exhibit elevated salt and nutrient concentrations, especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows.

Under this scenario the poor water quality in the lower Gouritz IUA at Zeekoei Drift/Die Poort would probably be maintained.

The reduced flows in the upper reaches of the Touws IUA will probably aggravate the poor salinity status of the affected rivers.

The good water quality observed in the upper and middle reaches of the Duiwenhoks IUA will probably be maintained.

The elevated salinities observed in the lower Groot Brak IUA will probably be aggravated due to the higher abstractions. In the rest of the IUA the quality would probably remain in the same state.

The generally good water quality in the rivers of the Coastal IUA would probably be affected by the increased abstractions in the Malgas, Gwaing, and Swart Rivers. Lower flows in the Malgas River may increase the impacts of urban runoff and golf estate runoff on water quality. The reduced flows in the Gwaing River may lead to moderate deterioration in water quality especially, downstream of the George WWTW discharge. The impacts of reduced flows on water quality in the Swart and Kaaimans rivers would probably not be significant. Water quality in the other rivers would probably remain large unchanged from the baseline condition.

5.4.2.5 Climate change scenario

The lower flows in the rivers and increased evaporation under the climate change scenario will aggravate the impacts of irrigation return flows as well as the impacts of effluents and urban runoff on receiving rivers.

5.5 Groundwater

5.5.1 Present Groundwater Status (PES Scenario)

The results of the present status assessment (with current water demands) indicate that:

- 149 catchments (71%) have a groundwater stress of <20%, and present status I
- 35 catchments (17%) have a groundwater stress of 20-65%, and present status II
- 26 catchments (12%) have a groundwater stress of >65%, and present status III. Of these, 21 catchments have a stress of >90%.

The distribution of these catchments is shown in Figure 5-7. At the GRU scale (Figure 5-8), similarly 63% of GRUs (20/32) have a groundwater stress of <20%, and present status I. However, the frequency of high stress / present status III is reduced due to consideration of larger areas reducing the impact of more localised high groundwater use areas. Only 1 GRU has a groundwater stress >65% and present status III. Based on the limitations of a water balance approach, and the limitations of the Present Status definition, it is noted that high stress / present status of III does not necessarily equate to an area where abstraction is not maintainable, or has unacceptable impacts.

5.5.2 Scenario summary

The increased groundwater demand per scenario was assessed against the availability resulting from the groundwater balance model. Where groundwater can meet demand (or part of demand), the future groundwater use increases. The resulting impact of each scenario on the groundwater status for all catchments are presented in **Appendix B**, with only a summary presented here.

The unconstrained (i.e. no EC) high growth scenario represents a more ecologically stressed scenario for surface ecosystems but alleviates pressure on groundwater somewhat (because of the lack of 'shortfalls' being assessed against groundwater). The Maintain PES and REC scenarios both similarly see significant increases in groundwater use (increases of 132 and 142% respectively) increasing the number of heavily used (use/recharge > 65%) quaternary catchments from 26 to 43.

Table 5-11 Summary of impact of each scenario on groundwater condition due to increased groundwater use to meet future demand and shortfalls in demand after meeting required ECs

Scenario	PES (current)	Maintain PES	ECBS	REC	No EC - high growth
Total groundwater use (million m^3/a)	215	461	338	482	293
Total groundwater use as a % total balance	19%	40%	29%	42%	26%
Increase in groundwater use (%)	n/a	114%	57%	124%	36%
Number of catchments with (use/recharge) status I	149	125	135	122	142
Number of catchments with (use/recharge) status II	35	48	46	51	40
Number of catchments with (use/recharge) status III	26	37	29	37	28

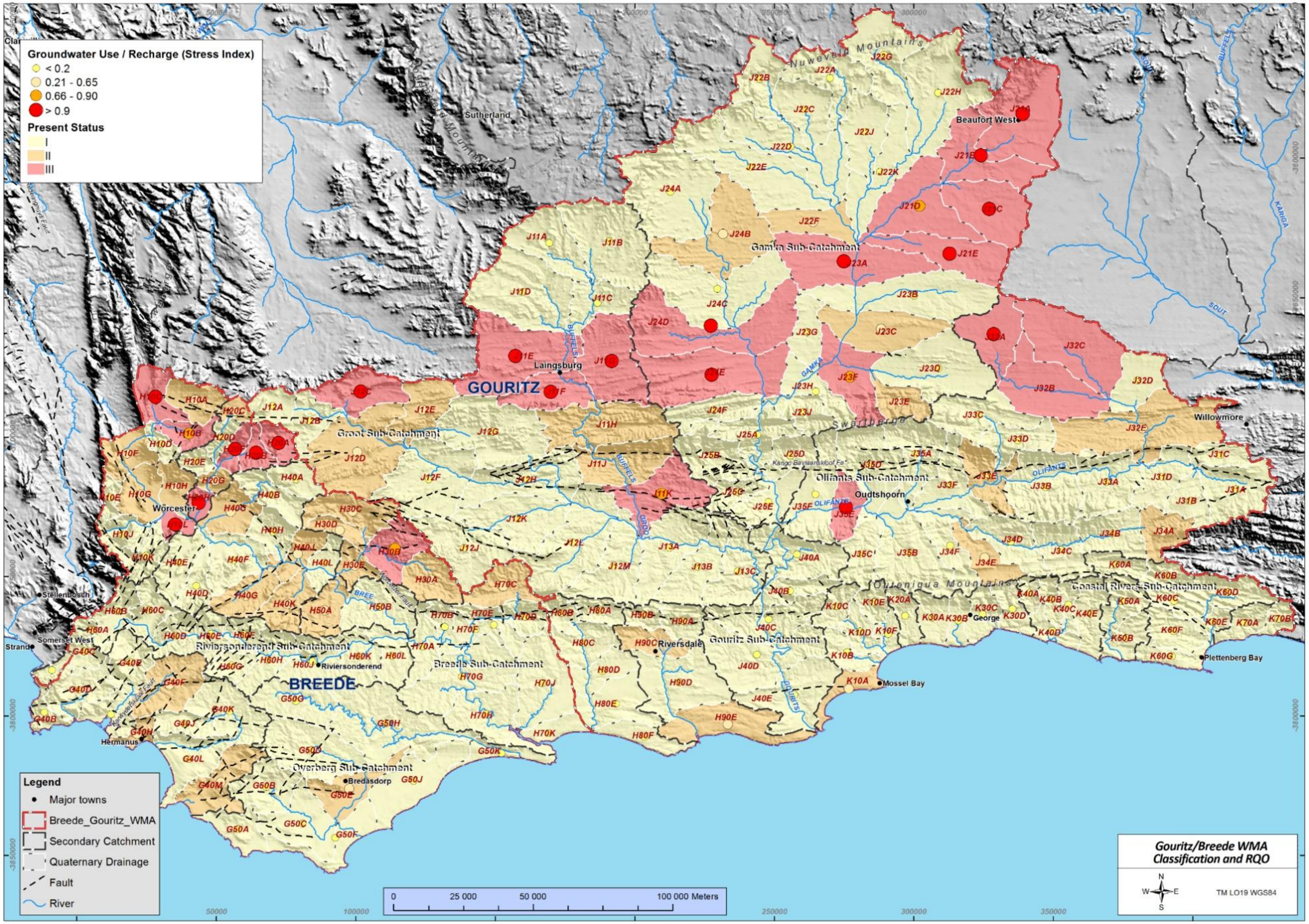


Figure 5-7 Groundwater Stress and Status (quaternary catchment scale) under current demands and PES conditions

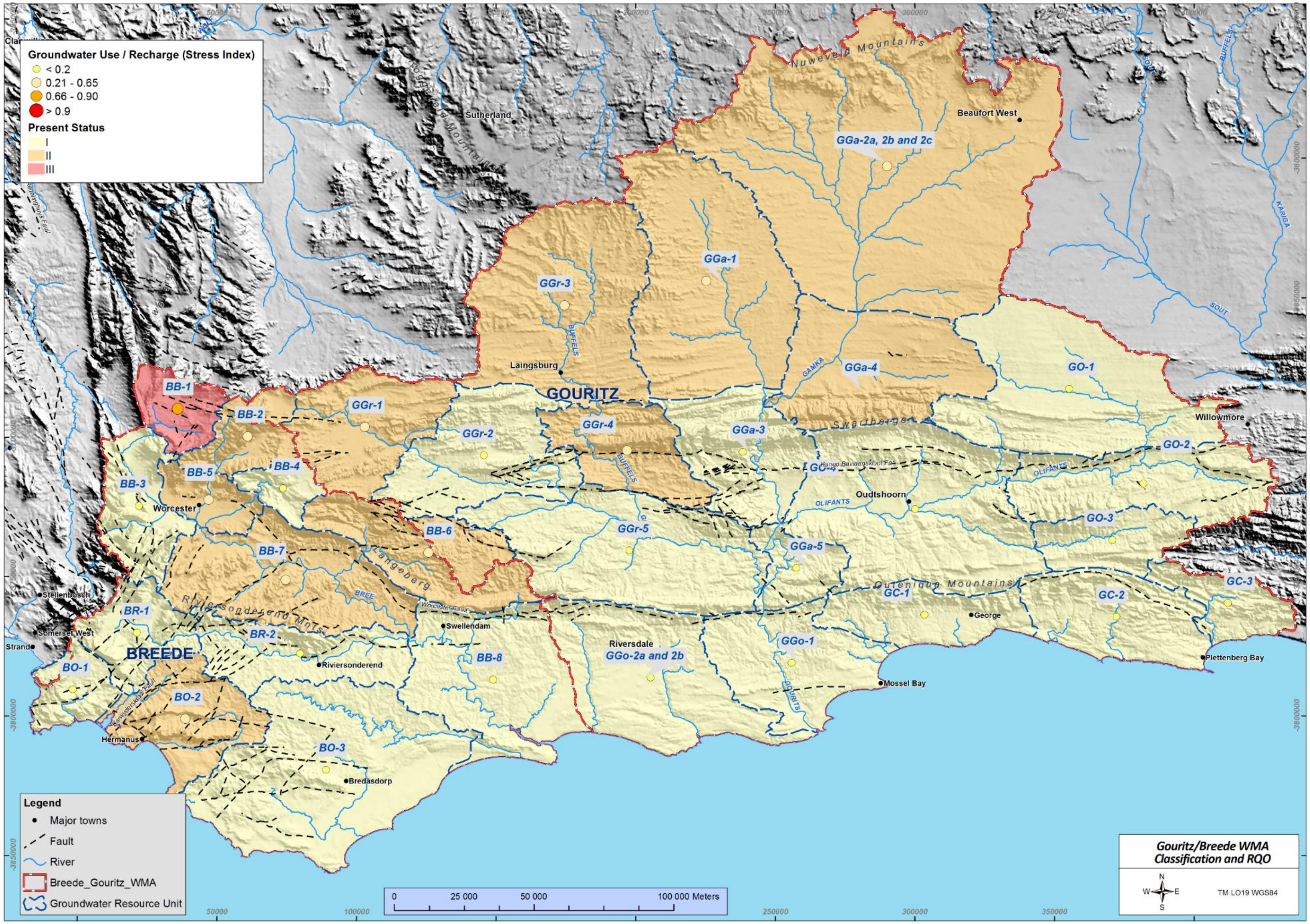


Figure 5-8 Groundwater Stress and Status (GRU scale) under current demands and PES conditions

5.6 Ecosystem Goods, Services and Attributes

Models of the relationships between freshwater flows, estuary characteristics, estuary health and the delivery of Ecosystem Goods, Services and Attributes (EGSAs), hereafter referred to as ecosystem services, were developed to allow the prediction of the changes to ecosystem services under different flow scenarios. These models were applied to estimated values of ecosystem services for significant estuaries within the Study Area. The resulting changes that would be expected under each scenario are outlined in the following sections for the tourism, property value, subsistence fishing value and nursery value.

5.6.1 Breede and Overberg catchments

5.6.1.1 Subsistence fishing

Within the study area subsistence fishing mainly occurs within estuaries. While subsistence fishing does occur in some places along river reaches, it is negligible and unlikely to be a main contributor to people's livelihoods. In addition, there are no data on either the extent or distribution of these activities throughout the region. Thus, the subsistence values express below pertain to estuaries, and the corresponding values for rivers are considered negligible.

Subsistence fishers in the study area harvest a wide range of macro-invertebrates as food (e.g. mussels) and bait (e.g. mud prawns), as well as several species of fish that can be targeted using rods, set lines, hand lines, cast nets and gill nets. Net fishing is illegal in estuaries, and thus only line fish species are of relevance here. For this study, changes in the capacity to deliver this service were approximately estimated by changes in the fish score that result from a change in Ecological Category.

The total value of this service was estimated at R1.2 million per year within the Breede-Overberg Region (Status Quo Report DWS, 2016). Change in value under the different scenarios ranged from 74% of current value under the climate change scenario to 108% of current under the REC scenario. Economic losses stand to be in the order of R10 000 per year for the Current Demand + High Growth scenario and up to R300 000 per year under the Climate Change scenario.

Table 5-12 Changes to subsistence fishing values under the different scenarios

Baseline valuation presented in Status Quo Report (DWS, 2016)

Subsistence Fishing	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	1.20	0.94	1.29	1.18	0.89
% of current value		79%	108%	99%	74%
Change in value (Rm/yr.)		-0.25	+0.09	-0.01	-0.30

5.6.1.2 Nursery value

This ecosystem service is specific to estuaries. Numerous species use estuaries as nursery areas and many of these are important in marine line fisheries. Most estuary-dependent fish species enter the estuary as larvae or post larvae and once the estuary dependent phase is complete, they leave the estuary for the marine environment where they become available to marine fisheries, and upon maturity contribute to the spawning stock.

The total value of this service was estimated at R151 million per year within the Breede-Overberg Region (Status Quo Report DWS, 2016). The change in value was highest under the climate change and ESBC scenarios with losses in value of 72% and 75%, respectively. Under the REC scenario nursery value was expected to increase by 15% or R22 million per yr. Most of the estuaries holding high nursery function value within the Breede-Overberg Region had small changes in condition under the different scenarios. The largest differences were seen under the climate change scenario where a loss of R42 million/yr. was predicted.

Table 5-13. Changes to the nursery value of estuaries under the different scenarios

Nursery Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	151.1	113.4	173.1	150.7	109.2
% of current value		75%	115%	100%	72%
Change in value (Rm/yr.)		-37.7	+22.1	-0.4	-41.9

Baseline valuation presented in Status Quo Report (DWS, 2016)

5.6.1.3 Tourism value

All types of aquatic ecosystems in the study area contribute to tourism value in the Western Cape, through their aesthetic beauty and provision of suitable locations for recreational activities such as swimming, boating, river rafting, kloofing, birdwatching and fishing. Most of these activities are sensitive to both the quantity and quality of water flowing through these systems. The Breede-Overberg Region contains many rivers in which river-rafting and kloofing activities are offered through tourism operators as well as conducted privately. Within the Breede-Overberg Region, kloofing activities occur in the upper tributaries of the Breede and Riviersonderend Rivers. Paddling and angling are also popular activities along the Palmiet and Breede Rivers. Nevertheless, our baseline study showed that estuaries are far more valuable in terms of tourism than the freshwater aquatic ecosystems. This has to do with their size, coastal location, accessibility to the public, and high level of productivity relative to other aquatic ecosystems. Indeed, estuaries are the dominant natural feature of many coastal resort areas within the study area.

The current tourism value of the aquatic ecosystems within the Breede-Overberg Region estimated at around R1 billion per annum. Negligible difference was noted between the different scenarios with a slight increase in value for the REC and a slight decrease in value for the ESBC, No EC High Growth scenario and Climate Change scenario. The resulting changes were not large in terms of percentage of the total tourism value, but amounted to losses of R50 million per year for the ESBC and R43 million per year under the CC scenario. Under the REC scenario tourism value was expected to increase by 3% or R32 million per year,

Table 5-14 Changes to the tourism value of aquatic ecosystems under the different scenarios

Tourism Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	1044.4	994.8	1076.8	1044.2	1001.5
% of current value		95%	103%	100%	96%
Change in value (Rm/yr.)		-49.6	+32.4	-0.2	-42.9

5.6.1.4 Property value

Property value within the Breede-Overberg Region was estimated at approximately R80 million per year. The climate change scenario exhibited the largest losses, followed by the ESBC and NoEC scenarios. Conversely the REC scenario showed increases in value of 4% or R3.3 milllion per year. Most of the value within this region comes from the Bot/Kleinmond and Breede Estuaries, neither of which changed under the different scenarios.

Table 5-15 Changes to the property value of estuaries under the different scenarios

Property Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	79.4	70.5	82.8	78.2	68.4
% of current value		89%	104%	99%	86%
Change in value (Rm/yr.)		-8.9	3.3	-1.2	-11.0

Baseline values presented in Status Quo Report (DWS, 2016)

5.6.1.5 Combined Aquatic Ecosystem services

A significant difference was observed in the delivery of aquatic ecosystem services under the different scenarios, in particular under the ESBC, CC and REC scenarios. The ESBC and climate change scenarios showed decreases of R96 million per year, the REC scenario resulted in gains of R58 million per year, whereas the Current Demand + High Growth (No EC) scenario showed losses of R1.8 million/yr.

Table 5-16 Summary of changes to the aquatic ecosystem services under the different scenarios

Aquatic Ecosystem Service	Scenario			
	ESBC	REC	No EC	CC
Subsistence Fisheries Value	-0.3	+0.1	0.0	-0.3
Nursery Value	-37.7	+22.1	-0.4	-41.9
Property Value	-8.9	+3.3	-1.2	-11.0
Tourism Value	-49.6	+32.4	-0.2	-42.9
Total (Rm/yr.)	**-96.4**	**+57.9**	**-1.8**	**-96.1**

Within the Breede-Overberg Region the changes in ecosystem health observed under the different scenarios are relatively small and therefore the changes in value per year are not that large. However, where the health of these estuaries do decline, as seen in the Climate Change and ESBC scenarios, we expect to see larger losses in ecosystem service value.

5.6.2 Gouritz and Coastal catchments

5.6.2.1 Subsistence fishing

Within the study area subsistence fishing mainly occurs within estuaries. While subsistence fishing does occur in some places along river reaches, it is negligible and unlikely to be a main contributor to people's livelihoods. In addition, there are no data on either the extent or distribution of these activities throughout the Gouritz catchment area. Thus, the subsistence values express below pertain to estuaries, and the corresponding values for rivers are considered negligible.

Subsistence fishers in the Gouritz and Coastal catchments harvest a wide range of macro-invertebrates as food (e.g. mussels) and bait (e.g. mud prawns), as well as several species of fish that can be targeted using rods, set lines, hand lines, cast nets and gill nets. Net fishing is illegal in estuaries, and thus only line fish species are of relevance here. For this study, changes in the capacity to deliver this service were approximately estimated by changes in the fish score that result from a change in Ecological Category.

The total value of this service was estimated at R3.5 million per year within the Gouritz-Coastal Region (Status Quo Report: DWS, 2016). Changes under the different scenarios ranged from 75% of the current value through to a 0% increase from PES. The ESBC scenario resulted in the largest loss of value among the different scenarios (over R960 000 per year). The REC scenario showed similar values as current conditions. The Current Demand + High Growth and Climate Change scenarios showed a decrease in subsistence fishing value of 11% and 15%, respectively. This decrease in value is mainly due to the changes observed in the Knysna and Keurbooms estuaries.

Table 5-17 Changes to subsistence fishing values under the different scenarios

Subsistence Fishing	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	3.5	2.6	3.5	3.1	3.0
% of current value		75%	100%	89%	85%
Change in value (Rm/yr.)		-0.9	0.0	-0.4	-0.5

5.6.2.2 Nursery value

This ecosystem service is specific to estuaries. Numerous species use estuaries as nursery areas and many of these are important in marine line fisheries. Most estuary-dependent fish species enter the estuary as larvae or post larvae and once the estuary dependent phase is complete, they leave the estuary for the marine environment where they become available to marine fisheries, and upon maturity contribute to the spawning stock.

The total value of this service was estimated at R222 million per year within the Gouritz-Coastal Region (Status Quo Report: DWS, 2016). The largest changes were seen under the ESBC Scenario where losses of over 31% or R68 million per year occurred. The REC, Current Demand + High Growth and CC scenarios comparatively showed far less loss of value, changing less than a few percent of their value. The high losses incurred under the ESBC scenario were due to the changes in health scores for Knysna and Swartvlei, both of which held high values.

Table 5-18 Changes to the nursery value of estuaries under the different scenarios

Nursery Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	221.6	153.7	222.6	218.3	211.9
% of current value		69%	100%	99%	96%
Change in value (Rm/yr.)		-68.0	+1.0	-3.3	-9.8

5.6.2.3 Tourism value

All types of aquatic ecosystems in the study area contribute to tourism value in the Western Cape, through their aesthetic beauty and provision of suitable locations for recreational activities such as swimming, boating, river rafting, kloofing, birdwatching and fishing. Nevertheless, our baseline study showed that estuaries are far more valuable in terms of tourism than the freshwater aquatic ecosystems. This has to do with their size, coastal location, accessibility to the public, and high level of productivity relative to other aquatic ecosystems. Indeed, estuaries are the dominant feature of many coastal resort areas in the study area. The attractions of estuaries as recreational areas are many, and include their aesthetic beauty, opportunities for water sports and fishing. These attractions, combined with other attractions, provide the amenity values that drive people to visit or even invest in property to remain in these areas.

The current tourism value of the aquatic ecosystems within the Gouritz-Coastal Region was estimated at R3.4 billion per annum. The ESBC scenario led to losses of R405 million per year in tourism value, whereas Current Demand + High Growth and Climate Change scenarios had losses less than 1%. The REC scenario had similar values as current day, The biggest impact on tourism value came from the reduction of flow at Knysna Estuary. This estuary provided a large proportion of the tourism value along this coastline. River condition on average did not change much within the IUAs, with only a few IUAs dropping from an average of C to D under the different scenarios.

Table 5-19 Changes to the tourism value of aquatic ecosystems under the different scenarios

Tourism Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	3405.3	2999.7	3405.6	3392.4	3378.4
% of current value		88%	100%	99%	99%
Change in value (Rm/yr.)		-405.6	+0.3	-12.9	-26.8

5.6.2.4 Property value

Property value within the Gouritz-Coastal Region was estimated at approximately R193 million per year. The greatest change to this value was seen under the ESBC scenario where losses of 26% were predicted, totalling R30 million per year. These changes were mainly due to the slight decreases in ecosystem health experienced at the Gouritz, Swartvlei and Knysna estuaries. The REC scenario resulted in a less than 1% increase in value (valued at R0.5 million/yr.). Losses under the Current Demand + High Growth and Climate Change scenarios were both less than 10%.

Table 5-20 Changes to property values under the different scenarios

Property Value	Scenario				
	PES	ESBC	REC	No EC	CC
Total Value (Rm/yr.)	192.8	162.6	193.3	179.5	172.8
% of current value		84%	100%	93%	90%
Change in value (Rm/yr.)		-30.2	+0.5	-13.3	-20.0

5.6.2.5 Combined Aquatic Ecosystem services

When the above losses of ecosystem services for each scenario are combined it becomes more obvious that an ESBC scenario would result in significant losses of value each year equating to over R500 million. This loss in value is almost entirely derived from changes in estuary condition. While the Current Demand + High Growth and Climate Change scenarios also result in losses, these are much less than that of the EBSC (about R30-60 million in losses each year). The REC scenario results in a slight increase in value of R2 million per year. It should however be noted that where the REC Scenario was unable to meet the recommended ecological categories outlined in the NBA as fixing flow volume alone cannot restore the estuaries without addressing other issues like water quality and disturbance from people.

Table 5-21 Summary of changes to the value of aquatic ecosystem services under the different scenarios (Rm per year)

Ecosystem Service	Change in value relative to PES scenario			
	ESBC	REC	No EC	CC
Subsistence Fisheries Value	-0.9	0.0	-0.4	-0.5
Nursery Value	-68.0	+1.0	-3.3	-9.8
Property Value	-30.2	+0.5	-13.3	-20.0
Tourism Value	-405.6	+0.3	-12.9	-26.8
Total (Rm/yr.)	**-504.7**	**+1.8**	**-29.9**	**-57.1**

The results of this analysis show that changes in ecosystem services are very specific to the location of any change in water flow. Some rivers and estuaries have much higher value than others due to the location of towns and infrastructure. Within the Gouritz-Coastal Region, Knysna is a good example of this. It has significantly higher values for property and tourism and consequently any changes in estuary condition resulted in changes in these values. Conversely, if small systems with fewer ecosystem services are impacted, then the loss of value of ecosystems is much lower.

5.7 Water Supply Consequences

5.7.1 Current water requirements and water supply infrastructure

The average annual volume of surface water supplied to all user categories to meet current water requirements in the Breede and Gouritz portions of the WMA are 627.7 and 275.1 million m^3/a, respectively. This is summarised per IUA in Table 5-22. The net surplus/deficit in supplying the current day water requirements under each of the PES, ESBC and REC scenarios is also given in Table 5-22.

It should be noted that these surplus and deficit values are the net outcomes of adding together the individual surpluses/deficits at all the nodes in each IUA. Hence, an IUA-consolidated surplus might include deficits at one or more nodes in that IUA and vice versa. Many of the IUAs are also hydrologically connected which means that any surplus or deficit is then passed on to the lower IUA. The resulting cumulative surplus or deficit is indicated by the value in brackets in Table 5-22.

Under the PES scenario there are no deficits with present-day levels of demand.

Under the ESBC scenario, in which less surface water is reserved for environmental flows, all the IUAs are in net surplus relative to the Ecological Reserve requirements by a total of 245.4 and 533.8 million m^3/a respectively.

Under the REC scenario, in which more surface water is reserved for environmental flows, several IUAs are in net deficit relative to current-day flows by a total of 37.9 and 28.1 million m^3/a, respectively.

Table 5-22 Current annual average surface water supply and net surplus/deficit volumes under current water supply infrastructure (million m3/a)

WMA portion	IUA	Current surface water supply (million m^3/a)	Net surplus/deficit (million m^3/a) relative to the Reserve under current water demands		
			Maintain PES	ESBC	REC
Breede	B5	56.2	0.0	82.0	0.0
	H16	13.1	0.0	1.0	-2.7
	H17	9.0	0.0	1.9	-17.4
	F10	8.4	0.0	44.9	-2.5
	A1	60.1	0.0	101.2	0.7
	A2 + A3	383.5	0.0	46.1 (147.3)	-4.8 (-4.1)
	B4	41.3	0.0	13.1	-18.9
	F9	17.4	0.0	16.3 (29.4)	0.0 (-18.9)
	F11	38.5	0.0	-61.1 (115.6)	7.7 (-15.3)
	Sub-Total	627.5	0	245.4	-37.9
Gouritz	E8	48.9	0.0	6.4	0.0
	C6	22.1	0.0	21.6	0.0
	D7	130.0	0.0	32.6	-25.3
	F13	3.9	0.0	78.7	0.0
	F12	12.0	0.0	71.2 (139.3)	0.0 (-25.3)
	I18	4.7	0.0	0.5	0.0
	G14	14.8	0.0	23.6	0.0

WMA portion	IUA	Current surface water supply (million m³/a)	Net surplus/deficit (million m³/a) relative to the Reserve under current water demands		
			Maintain PES	ESBC	REC
	G15	38.8	0.0	299.2	-2.8
	Sub-Total	275.2	0	533.8	-28.1
TOTAL FOR WMA		**902.7**	**0**	**779.2**	**-66**

For each node with a deficit, the availability of local groundwater to cover such a deficit was determined from the quaternary catchment groundwater availability information. In cases of inadequate local groundwater availability, additional sources of water indicated in Golder (2016) were accepted as suitable for the purposes of this exercise. The outcomes of the above exercise are presented in for the ESBC and the REC scenarios, respectively.

Under the ESBC scenario nodal deficits are indicated in only two IUAs, namely D7, which includes the town of Oudtshoorn, and for which adequate groundwater is available, and in the Middle Breede (IUA 2 and 3). In IUA 2 and 3 there is insufficient groundwater available and a new surface water scheme is needed.

Under the REC scenario nodal deficits are indicated in nine IUAs, of which six require additional water sources beyond groundwater: For H16 a new surface water scheme could serve the Greater Hermanus area, while for H17 a groundwater scheme targeting the TMG could serve the Greater Gansbaai area. Local groundwater as well as the TMG aquifer could also potentially supply the shortfall in D7.

Table 5-23 ESBC scenario: Sources of additional water and related annual average volumes required to cover the sum of the individual nodal deficits in each IUA for current conditions (million m^3/a)

WMA portion	IUA	Total nodal deficits under ESBC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG Aquifer	Action to supplement ESBC shortfall under current demands.
Breede	B5	-	-			none
	H16	-	-			none
	H17	-	-			Although IUA in surplus there is a 0.5Mm^3 deficit at G50F. Brought about by a decreasing surplus between G50D (in F10) and a smaller surplus in G50F. SO DO NOT COST
	F10	-	-			IUA in surplus and no individual nodes have a deficit.
	A1	-	-			none
	A2+A3	4.2	1.7	2.5		Must treat A2 and A3 as one due to IUA delineation. Although there are deficits in the ESBC most are the result of subtracting large upstream surpluses and are not meaningful. One node (Niv11) in H40C (GW= 1.7Mm^3) is in deficit of 4.2Mm^3. Cost 1.7Mm3@R5 and 2.5Mm^3@Regional Scheme (R13). Used some of surplus in A1 (20Mm^3) to put ESBC in positive
	B4	-	-			none
	F9	-	-			none
	F11	-	-			Although the IUA is in a deficit of 72.6Mm^3 this arises from accounting for large upstream surpluses that get reduced in IUA F11. The IUA is still in a surplus and has no individual nodal deficits.

WMA portion	IUA	Total nodal deficits under ESBC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG Aquifer	Action to supplement ESBC shortfall under current demands.
Gouritz	E8	-	-			none
	C6	-	-			none
	D7	2.8	2.8			Although the IUA is in surplus there is a deficit at J33F of $1.6Mm^3$. GW availability is $1.49Mm^3$. Get deficit of 0.11 from J35A (GW=$5.6Mm^3$). Also, a deficit of $1.2Mm^3$ at J35D. GW availability is $4.92Mm^3$
	F13	-	-			
	F12	-	-			none
	I18	-	-			none
	G14	-	-			none
	G15	-	-			none

Table 5-24 REC scenario: Sources of additional water and related annual average volumes required to cover the sum of the individual nodal deficits in each IUA for current conditions (million m^3/a)

WMA portion	IUA	Total nodal deficits under REC (million m^3/a)	From Ground water	From Surface water scheme	From TMG aquifer	Action to supplement REC shortfall under current demands.
Breede	B5	-	-	-	-	
	H16	4.3	-	4.3	-	IUA has surplus groundwater G40H has EC deficit of 4.33Mm^3. All 4.33Mm^3 from Regional Scheme @R13.0/m^3
	H17	17.7	4.2	-	13.4	GW surplus is 0Mm^3 for G40L and 2.62Mm3 for G40M. Deficit is 16.05 Mm^3 Cost at 2.62Mm3@R5.0/m^3 Remaining deficit of 13.43Mm^3 at TMG groundwater @R12.6/m^3. Also, a 1.61Mm^3 deficit at G50F (GW = 4.96Mm^3). So total GW is 4.23Mm^3
	F10	3.1	3.1	-	-	Deficit of 2.37Mm^3 in G40J. GW = 3.91. Remaining deficit of 0.71Mm3 in G40K. Groundwater availability from G40K is 4.27Mm^3. Cost is 3.08Mm3 @R5.0/m^3
	A1	1.6	1.6	-	-	Although IUA is in a surplus there is a deficit of 1.55Mm^3 at H10D. GW at H10D is 11.M52m^3. Use GW to cost.
	A2 + A3	4.4	1.7	2.7	-	Must treat A2 and A3 as one due to IUA delineation. There are only 2 deficits in the REC and one is the result of subtracting upstream surpluses and are not meaningful. One node (Niv11) in H40C (GW= 1.7Mm^3) is in deficit of 4.4Mm^3. Cost 1.7Mm^3@R5 and 2.7Mm^3@Regional Scheme (R13).
	B4	18.9	6.9	12.0	-	IUA is in a deficit of 18.92Mm^3 at Nv6 in H60F with GW=6.88. So, cost at 6.88Mm^3 @ R5 and the rest (12.04Mm^3) as a regional scheme
	F9	-	-	-	-	none
	F11	23.8	18.5	5.3	-	Although the IUA is in a surplus as a result of low upstream surpluses the IUA has nodal deficits. GW availability at H70B is 18.39Mm^3. Deficit in H70B is 23.68Mm^3. Cost 18.39@R5.0/m3. Rest is 5.29Mm^3 at regional scheme costs. GW availability from H70G is 2.66 Mm^3. Deficit in H70G is 0.09Mm3@R5.0/m^3 From here on deficit reduces so no additional costing.

WMA portion	IUA	Total nodal deficits under REC (million m^3/a)	From Ground water	From Surface water scheme	From TMG aquifer	Action to supplement REC shortfall under current demands.
Gouritz	E8	-	-	-	-	none
	C6	-	-	-	-	none
	D7	25.3	11.2	-	14.1	The initial deficit occurs at J25A to J25E (14.0Mm^3). Only 6.6 Mm^3 of this deficit can be supplied by GW. Rest (7.4Mm^3) supplied by TMG. Then big jump to deficit of 25.3Mm^3 at J40A. Incremental deficit is 11.3Mm^3 with no deficit on Olifants. Groundwater at J40A is 4.64Mm^3 and rest (6.66Mm^3) supplied by TMG
	F13	-	-	-	-	none
	F12	-	-	-	-	none
	I18	-	-	-	-	none
	G14	-	-	-	-	none
	G15	2.8	2.8	-	-	none

A 2040 “high-growth” water requirement scenario was super-imposed on the current-day model configurations and monthly flow sequences (each 90 year in length) were simulated. The 2040 urban/industrial water requirements for all towns throughout the WMA were sourced from the “*Situation Assessment Report”* produced as part of the Breede-Gouritz Catchment Management Strategy Study (Golder, 2016). These values are presented in Table 5-25 and include both urban/industrial and irrigation requirements and are consolidated per IUA. It was assumed that future increases in irrigation water allocations will be allowed by DWS for increased allocations from Brandvlei Dam, through increased capacity for the Smalblaar-Holsloot diversions as well as for the Papenkuils pump station in the Breede River and additional irrigation allocations from a raised Gamkapoort Dam in the Gouritz system. This is consistent with DWS policy on future allocations to agriculture as defined in the National Water Resource Strategy (NWRS). In addition, it is possible that small-scale agricultural development may take place in small chunks throughout the WMA. Such dispersed irrigation development could have an influence on rural populations, although much of the labour would be seasonal, and difficult to plan for. The influence that such potential small-scale development can have on the growth rates of rural populations are currently not known, although the influence would likely be within the level of uncertainty associated with the forecasted growth rates.

Total 2040 water requirements in the Breede and Gouritz catchments are 776.6 and 337.8 million m^3/a, respectively. The large proportional increases in H16, H17, G14 and G15 are related to the high growth projected for most coastal towns in the WMA. The high proportional increase in A1, the Upper Breede, is mainly due to the Michell’s Pass and Brandvlei schemes in the Breede catchment.

Table 5-25 IUA-based consolidation of current and future water requirements (million m^3/a)

WMA	IUA	Current surface water requirements (million m^3/a)	Future total water requirements (million m^3/a)	Percentage increase
Breede	B5	56.19	60.4	107%
	H16	13.14	32.7	249%
	H17	9.01	20.4	226%
	F10	8.41	9.8	117%
	A1	60.11	111.8	186%
	A2 + A3	383.53	442.3	115%
	B4	41.33	42.0	102%
	F9	17.44	17.7	101%
	F11	38.5	39.5	103%
Gouritz	E8	48.9	50.4	103%
	C6	22.1	23.3	105%
	D7	130	151	116%
	F13	3.9	4.6	118%
	F12	12	13.1	109%
	I18	4.7	4.7	100%
	G14	14.8	22.3	151%
	G15	38.8	68.4	176%

The future (2040) total water requirements and the resulting net surpluses and deficits under each of the Maintain PES, ESBC and REC scenarios with future demands are summarised in Table 5-26.

Under the Maintain PES scenario all but one of the IUAs are in net deficit under future demands, with totals deficits of 127 and 62 million m^3/a in the Breede and Gouritz portions of the WMA, respectively.

Under the ESBC scenario, in which less surface flows are required for environmental flows, only one of the IUAs is not in net surplus under future demands, with a net total surplus of 117 and 435 million m^3/a in the Breede and Gouritz portions of the WMA, respectively.

Under the REC scenario, in which increased surface flows are required for environmental flows, all of the IUAs are in net deficit under future demands, with a total net deficit of 173 and 94 million m^3/a, in the Breede and Gouritz respectively.

Table 5-26 Projected water requirements and related net surpluses and deficits (million m^3/a) under a 2040 high-growth scenario which includes planned additional bulk water supply infrastructure

WMA portion	IUA	Future (2040) total water requirements (million m^3/a)	Net surplus/deficit (million m^3/a) under 2040 water requirements		
			Maintain PES	ESBC	REC
Breede	B5	60.4	-4.5	77.5	-4.5
	H16	32.7	-9.3	-8.3	-12.0
	H17	20.4	0.5	2.4	-17.1
	F10	9.8	-	44.9	-2.5
	A1	111.8	--34.1	67.1	-33.3
	A2 + A3	442.3	-70.9 (-105.0)	-24.8 (42.3)	-75.7 (-109.0)
	B4	42.0	-0.2	12.8	-19.2
	F9	17.7	-0.4 (-0.6)	16.0 (28.8)	-0.4 (-19.6)
	F11	39.5	-8.3 (-113.9)	-70.4 (1.71)	-8.3 (-136.9)
	Sub-total	776.6	-127.2	117.2	-173
Gouritz	E8	50.4	-0.8	5.9	-0.8
	C6	23.3	-2.1	19.5	-2.1
	D7	151.0	-11.9	20.7	-36.8
	F13	4.6	-0.8 (-15.6)	77.9 (124.0)	-0.8 (-40.8)
	F12	13.1	-3.6	40.0	-3.6
	I18	4.7	-	0.5	-
	G14	22.3	-7.5	16.2	-7.5
	G15	68.4	-35.4	254.7	-42.4
	Sub-total	337.8	-62.1	435.4	-94
Total for WMA		**1114.4**	**-121.1**	**552.6**	**-267**

5.7.2 Future water requirements and additional supply infrastructure

Table 5-27, Table 5-28 and Table 5-29 present the consolidated totals of individual nodal deficits under the Maintain PES, ESBC and REC scenarios, respectively, with planned additional surface water infrastructure in place. For each node with a deficit, the availability of groundwater to cover such a deficit was determined from the quaternary catchment groundwater availability information. In cases of inadequate local groundwater availability, additional surface water sources of water, including re-use and desalination for the coastal towns, as indicated in Golders (2016), were accepted as suitable for the purposes of this exercise. The actions needed to address any shortfalls are described in the table.

To maintain PES, Table 5-27 shows that deficits could be covered by local groundwater in all but one of the IUAs, while surface water schemes are required for the Greater Hermanus (H16), Ceres (A1) and Beaufort West (C6) areas, as well as borehole schemes to extract TMG groundwater for the Greater Gansbaai (H17) and Ceres (A1) areas.

For the ESBC scenario, Table 5-28 shows that deficits could be covered by local groundwater in eight IUAs, while a surface water scheme is required for the Greater Hermanus (H16) area.

For the REC scenario, Table 5-29 shows that deficits could be covered by local groundwater in all but one of the IUAs, while surface water schemes are required for the Greater Hermanus (H16), Ceres (A1) and Beaufort West (C6) areas, as well as borehole schemes to extract TMG groundwater for the Greater Gansbaai (H17), Ceres (A1) and Oudtshoorn (D7) areas.

Table 5-27 Maintain PES scenario: Sources of additional water and related annual average volumes (million m^3/a) required to cover consolidated individual nodal deficits in each IUA for future (2040) conditions

WMA portion	IUA	Total nodal deficits under Maintain PES (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement PES shortfall under future demands.
Breede	B5	4.5	4.5	-	-	Deficit of 1.75 at G40C (GW=16.59) Rest of deficit is 2.75Mm^3 at G40D (GW= 40.07).
	H16	9.4	7.1	-	2.3	Total deficit is 9.3Mm^3. G40B deficit is 7.1Mm^3. G40B GW is 10.29Mm^3. Supply full amount. Separate deficit at G40H of 2.25Mm3. GW = 0. Cost 7.1Mm^3 with GW and 2.25Mm^3 with TMG.
	H17	0.5	0.5	-	-	IUA is in a surplus of 0.52Mm^3 but there is a deficit of 0.54Mm^3 at G40M. GW surplus is 3.17 Mm^3 Cost 0.54Mm3@R5/m^3
	F10	-	-	-	-	None
	A1	37.2	30.0	3.1	4.0	Ceres EC deficit is 3.09Mm^3 No available groundwater. Cost using Regional Schemes 3.09Mm^3 @R13.0/m^3 Michell's Pass Diversion (H10D) creates EC deficit of 34.07Mm^3. GW availability is (12.72-1.2=11.52). H10F GW avail is (18.66-0.14=18.52). Cost EC deficit 30.04Mm^3@R5.0/m^3 Cost rest of EC deficit of 4.03Mm^3 using TMG at@R12.6/m^3. Worcester (NOW IN A2) creates deficit of 9.81Mm^3 in H10K GW availability is (35.42-0.42=35.0) Cost at 9.81@R5.0/m^3
	A2 + A3	70.9	70.9	-	-	EC deficit for IUA A2 and A3 mostly a result of abstractions to Brandvlei Dam. Available GW in H10J=51.12 H10K=35.0 H10H=18.23 Total=104.77 Cost is 70.9Mm^3@R5.0/m^3.
	B4	0.2	0.2	-	-	IUA is in a deficit of 0.24Mm^3 at Nv6 in H60F with GW=6.98. So cost at 0.24Mm^3 @ R5.
	F9	0.4	0.4	-	-	EC deficit of 0.35Mm^3 supplied by available groundwater at H60L of 1.94Mm^3. Cost at 0.35Mm^3@R5.0/m^3
	F11	8.3	2.1	6.2	-	Deficit in this IUA increased by 8.3 Mm^3. Deficits increase gradually down IUA and can be costed with GW. H70B uses 0.2Mm^3. (GW is 18.39-0.2 = 18.19). H70G uses 1.1Mm^3 (GW is 2.66-1.1 = 1.56) H70H uses 7.0Mm^3 (GW is 0.84-7.0 = 0) Rest (6.16) is costed at regional scheme

WMA portion	IUA	Total nodal deficits under Maintain PES (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement PES shortfall under future demands.
Gouritz	E8	0.8	0.6	0.2	-	Shortfall of 1.38Mm^3 to Touws River. Also EC shortfall of 0.3Mm^3. After Touws River shortfall only 0.14 supplied from groundwater @R5/m^3. Rest (0.16Mm^3) from Regional Scheme@R13. Also shortfall of 1.39Mm^3 to Ladismith (supply with GW). And EC shortfall of 0.5Mm^3 at J13C (met by GW).
	C6	2.1	0.5	1.6	-	Shortfall of 1.5Mm^3 to Beaufort West. Also a 1.2 Mm^3 EC shortfall at J21A.No groundwater so use regional scheme. An additional 0.4Mm3 EC deficit at J21D. Only 0.07Mm^3 from GW and rest (0.33Mm^3) from RS. Then last deficit of 0.5Mm^3 at J23F. Only 0.44Mm^3 from GW and 0.06 from RS.
	D7	18.0	12.2	-	5.8	Calitzdorp shortfall is 0.13 Mm^3 Gamkapoort Irrigation Supply has 0.16 Mm^3 shortfall. The EC shortfall at J25E (9.8Mm^3) is result of shortfalls from J25A to E and can partly be supplied by GW from these 5 quats (6.6Mm^3). Rest (3.2Mm^3) from TMG. Then deficit at J35A of 8.2Mm^3 which decreases down the Olifants. GW at J35A is 5.6Mm^3 and rest (2.6Mm^3) supplied by TMG.
	F13	0.8	0.8	-	-	EC deficit at J40E of 0.8Mm3 (GW is 3.48Mm^3). Cost using GW.
	F12	3.6	3.5	0.1	-	EC deficit at H80B is 1.1Mm^3 (GW is 17.56Mm^3) so cost using GW. Also deficit at H90C of 2.5Mm^3 (GW is 2.44Mm^3) so cost 2.44Mm^3 using GW and 0.06Mm^3 using RS.
	I18	0.0	-	-	-	none
	G14	7.5	4.7	2.8	-	K20A is in a deficit of 7.5Mm^3. However as a result of abstractions to Mossel Bay (Helen's data) there is only 4.66Mm^3 GW available. Cost rest (2.84Mm^3) as a RS.
	G15	35.4	27.2	8.2	-	George shortfall (0.39 Mm^3). Apart from this there is a number of shortfall at different locations in the IUA. At K30B EC deficit is 7.7Mm3 (GW is 15.52Mm^3). K30C is 9.9Mm3 (GW is 12.58). K50A and B is in a deficit of 8.8Mm3…split into these 2 quats. K60F is 9.0Mm^3 (GW is 0.76) so also use RS to cost 8.24Mm^3.

Table 5-28 ESBC scenario: Sources of additional water and related annual average volumes (million m^3/a) required to cover consolidated individual nodal deficits in each IUA for future (2040) conditions.

WMA portion	IUA	Total nodal deficits under ESBC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement ESBC shortfall under future demands.
Breede	B5	0.2	0.2	-	-	Although there is a surplus there is a small deficit of 0.18 Mm^3 near Grabouw (G40C). GW availability is 38.51 Mm^3.
	H16	13.6	7.1	6.5	-	Total deficit is 13.6Mm^3. G40B deficit is 7.1Mm^3. G40B GW is 10.29Mm^3. Supply full amount. Separate deficit at G40H of6.49Mm3. GW = 0. Cost 7.1Mm^3 with GW and 6.49Mm^3 with TMG.
	H17	0.5	0.5	-	-	Although ESBC for H17 is in surplus there is a EC deficit of 0.54Mm^3 in G40M. Cost is 0.54Mm^3@R5.0/m^3 (Residual GW availability is 2.63Mm3)
	F10	0.0	-	-	-	none
	A1	2.5	-	2.5	-	Ceres deficit is 2.49Mm^3. No GW available. Cost as regional scheme. So 2.49Mm3@R13/m^3
	A2 + A3	24.8	24.8	-	-	EC deficit for IUA A2 and A3 is complicated. The IUA has a deficit of 24.8Mm^3 (down from 63.8Mm^3). This is despite adding surplus from H10J and H10K to reduce the deficit in H10H and H20H. These 4 quats combined due to abstractions to Brandvlei Dam. Resultant deficit of 24.8Mm^3 includes abstractions to Worcester as well as Brandvlei. (H10K=35.42 H10H=18.23 Total=104.77) Cost is 24.8Mm3@R5.0/m^3
	B4	0.0	-	-	-	none
	F9	0.0	-	-	-	none
	F11	0.2	0.2	-	-	The overall IUA is in a large deficit as a result of large upstream IUA surpluses decreasing to end in a deficit in this IUA. Apart from a small local deficit in Klip River (H70B) of 0.24Mm^3 (GW available is 18.38Mm^3) all nodes are in a surplus.
Gouritz	E8	0.3	0.1	0.2	-	Although there is a IUA surplus there is a EC shortfall of 0.3Mm^3. Only 0.14 supplied from groundwater @R5/m^3. Rest (0.16Mm^3) from Regional Scheme@R13.
	C6	0.0	-	-	-	none

WMA portion	IUA	Total nodal deficits under ESBC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement ESBC shortfall under future demands.
	D7	7.7	6.5	-	1.2	Although there is a IUA surplus there is a 1.6Mm^3 EC shortfall at J33F. GW available is 1.49Mm^3. Rest (0.11Mm^3) from GW at J35A. At J35D this deficit has increased to a 7.7Mm^3 and includes J33F. Incremental deficit is 6.1Mm3. GW availability at J35D is 4.92Mm^3. Rest (1.18Mm^3) supplied by TMG.
	F13	0.0	-	-	-	none
	F12	0.0	-	-	-	none
	I18	0.0	-	-	-	none
	G14	2.1	2.1	-	-	Although there is a surplus in the IUA there is a deficit of 2.1Mm^{3}in K20A. GW availability is 13.56Mm^3
	G15	0.0	-	-	-	none

Table 5-29 REC scenario: Sources of additional water and related annual average volumes (million m^3/a) required to cover consolidated individual nodal deficits in each IUA for future (2040) conditions

WMA portion	IUA	Total nodal deficits under REC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement REC shortfall under future demands.
Breede	B5	4.5	4.5	-	-	Deficit of 1.75 at G40C (GW=16.59) Rest of deficit is 2.75Mm^3 at G40D (GW= 40.07).
	H16	12.0	5.5	-	6.5	Total deficit is 12.04Mm^3. G40B deficit is 5.46Mm^3. G40B GW is 10.29Mm^3. Supply full amount. Separate deficit at G40H of6.58Mm^3. GW = 0. Cost 5.46Mm^3 with GW and 6.58Mm^3 with TMG.
	H17	20.4	6.4	-	14.0	Deficit at G40L is 7.7 Mm^3 and GW is 0. Deficit at G40M is 8.89Mm^3 and GW=2.62. Also a 0.54Mm^3 deficit at G50F (GW = 4.96Mm^3). So cost of GW is 6.39Mm^3@R5 and remaining deficit of 13.97Mm^3 at TMG groundwater @R12.6/m^3.

WMA portion	IUA	Total nodal deficits under REC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement REC shortfall under future demands.
	F10	3.1	3.1	-	-	Deficit of 2.37Mm^3 in G40J. GW = 3.91. Remaining deficit of 0.71Mm^3 in G40K. Groundwater availability from G40K is 4.27Mm^3. Cost is 3.08Mm^3 @R5.0/m^3
	A1	38.7	30.0	3.1	5.6	Ceres EC deficit is 3.09Mm^3 No available groundwater. Cost using Regional Scheme is 3.09Mm^3 @R13.0/m3. Mitchell's Pass Diversion (H10D) creates EC deficit of 35.62Mm^3. GW availability is (12.72-1.2=11.52). H10F GW avail is (18.66-0.14=18.52). Cost EC deficit 30.04Mm^3@R5.0/m^3 Cost rest of EC deficit of 5.58Mm^3 using TMG at@R12.6/m^3. Worcester (NOW IN A2) creates deficit of 9.81Mm^3 in H10K GW availability is (35.42-0.42=35.0) Cost at 9.81@R5.0/m^3
	A2 + A3	75.7	75.7	-	-	EC deficit for IUA A2 and A3 mostly a result of abstractions to Brandvlei Dam. Available GW in H10J=51.12 H10K=35.0 H10H=18.23 Total=104.77 Cost is 75.7Mm^3@R5.0/m^3.
	B4	19.2	6.9	12.3	-	IUA is in a deficit of 19.2Mm^3 at Nv6 in H60F with GW=6.88. So cost at 6.88Mm3 @ R5 and the rest (12.32Mm^3) as a regional scheme
	F9	0.4	0.4	-	-	EC deficit of 0.35Mm^3 supplied by available groundwater at G60L of 1.94Mm^3. Cost at 0.35Mm3@R5.0/m^3
	F11	8.3	2.1	6.2	-	Deficit in this IUA increased by 8.3 Mm^3. Deficits increase gradually down IUA and can be costed with GW. H70B uses 0.2Mm^3. (GW is 18.39-0.2 = 18.19) H70G uses 1.1Mm^3 (GW is 2.66-1.1 = 1.56). H70H uses 7.0Mm^3 (GW is 0.84-7.0 = 0). Rest (6.16) is costed at regional scheme
Gouritz	E8	0.8	0.6	0.2	-	Deficit of 0.3Mm^3 in J12B and GW availability is 0.14Mm^3. Deficit of 0.16Mm^3 costed from Regional Scheme at R13. Deficit of 0.5Mm^3 in J13B and J13C and GW availability is 2.77Mm^3 in J13C
	C6	2.1	0.5	1.6	-	In J21A Beaufort West deficit of 1.6 Mm^3 cannot be met by GW. Cost using regional scheme. Then for EC there is a 1.6Mm^3 at J21D. Cost using a RS. Downstream there is a cumulative deficit of 2.1Mm^3 at J23F. The inc. deficit (2.1-1.6=0.5Mm^3) and GW availability is 0.44Mm^3. Cost 0.06Mm^3 with RS.

WMA portion	IUA	Total nodal deficits under REC (million m^3/a)	From Groundwater	From Surface water scheme	From TMG aquifer	Action to supplement REC shortfall under future demands.
	D7	41.5	11.5	-	30.0	The initial deficit occurs at J25A to J25E (35.0Mm^3). Only 6.6 Mm^3 of this deficit can be supplied by GW. Rest (28.4Mm^3) supplied by TMG. Then another deficit at J35D of 6.5Mm^3. Groundwater at J35D is 4.92Mm^3 and rest (1.58Mm^3)
	F13	0.8	0.8	-	-	EC deficit at J40E of 0.8Mm^3 (GW is 3.48Mm^3). Cost using GW.
	F12	3.6	3.5	0.1	-	EC deficit at H80B is 1.1Mm^3 (GW is 17.56Mm^3) so cost using GW. Also deficit at H90C of 2.5Mm^3 (GW is 2.44Mm^3) so cost 2.44Mm^3 using GW and 0.06Mm^3 using RS.
	I18	0.0		-	-	none
	G14	7.5	4.7	2.8	-	K20A is in a deficit of 7.5Mm^3. However as a result of abstractions to Mossel Bay there is only 4.66Mm^3 GW available. Cost rest (2.84Mm^3) as a regional scheme.
	G15	42.4	34.2	8.2	-	George shortfall (0.39 Mm^3). Apart from this there is a number of shortfall at different locations in the IUA. At K30B EC deficit is 7.7Mm^3 (GW is 15.52Mm^3). K30C is 9.9Mm^3 (GW is 12.58). K40E deficit is 6.6 (GW is 15.55). K50A and B is in a deficit of 8.8Mm^3, split into these 2 quats. K60G deficit is 0.4 (GW is 5.5Mm^3). K60F is 9.0Mm3 (GW is 0.76) so also use RS to cost 8.24Mm^3.

5.8 Socio-Economic Consequences

5.8.1 Water supply infrastructure costs

The estimated additional infrastructure costs to meet the current day water demands in each IUA under the different scenarios are given in Table 5-30. Under current water demands, maintaining PES does not incur any additional cost to meet water demands, but it should be noted that PES is below D in some cases.

The ESBC scenario does, however incur costs, since some areas will have to be restored from below a D. The cost of construction of the additional infrastructure needed is estimated to be R55 million (2016 values).

Implementing the REC across the catchments would mean allocating more water to the ecological Reserve, and this means finding other means of meeting the current water demands to off-set restrictions on supply. In order to maintain the current demands would require additional infrastructure costs of around R913 million.

Table 5-30 Infrastructure construction costs required to covering water supply deficits relative to current-day water requirements for different scenarios with current-day water supply infrastructure (R million)

WMA portion	IUA	Maintain PES (R million)	ESBC (R million)	REC (R million)
Breede	B5	0.0	0.0	0.0
	H16	0.0	0.0	56.3
	H17	0.0	0.0	190.4
	F10	0.0	0.0	15.4
	A1	0.0	0.0	7.8
	A2 + A3	0.0	41.0	43.6
	B4	0.0	0.0	190.9
	F9	0.0	0.0	0.0
	F11	0.0	0.0	161.2
	Total	0.0	41.0	665.6
Gouritz	E8	0.0	0.0	0.0
	C6	0.0	0.0	0.0
	D7	0.0	14.0	233.4
	F13	0.0	0.0	0.0
	F12	0.0	0.0	0.0
	I18	0.0	0.0	0.0
	G14	0.0	0.0	0.0
	G15	0.0	0.0	14.0
	Total	0.0	14.0	247.4
Total for WMA		0.0	55.0	913.0

However, it is more important to consider the potential differences in the impacts of the scenarios under a high water demand scenario, using projected water demands at 2040 under a high growth scenario. The total cost of the infrastructure required to meet these demands is estimated to be in the order of R1335 million in 2016 Rand.

Maintaining PES would require the same annual volume of water allocated to the environment as at present. The additional infrastructure to meet the higher water demand, however, results in additional shortfalls that would require additional infrastructure cost of approximately R1267 million in today's terms. Infrastructure costs would thus rise to R2602 million.

Under the ESBC scenario, which meets the minimum requirement in terms of the National Water Act, additional infrastructure worth R339 million in today's terms would be required to meet future water demands, bringing the total infrastructure cost to R1674 million.

Implementing the REC across the WMA would mean allocating more water to the ecological Reserve, and this makes the provision of water more expensive, at an estimated extra cost of water supply infrastructure which if constructed today would cost approximately R2107 million, bringing the total to R3442 million.

Under the scenario where projected high future demands are met without any EC constraint, no further costs would need to be incurred over and above those estimated for the ESBC scenario.

Table 5-31 Costs of covering water supply deficits relative to 2040 water requirements for different scenarios, as well for a scenario with no EC constraint, with planned additional water supply infrastructure (R million). All costs in 2016 Rand.

WMA portion	IUA	Costs of planned infrastructure costs (R million)	Total infrastructure costs to meet both demands and EWR requirements under each scenario.				
			Maintain PES	ESBC	REC	No EC Constraints	No EC (CC)
Breede	B5	29.6	52.1	30.5	52.1	30.5	30.5
	H16	189.2	253.1	306.5	299.4	306.5	306.5
	H17	100.0	102.7	102.7	308	102.7	102.7
	F10	11.2	11.2	11.2	26.6	11.2	11.2
	A1	42.7	283.8	75.2	303.4	75.2	75.2
	A2 + A3	172.0	526.5	296	550.5	296	296
	B4	2.7	3.9	2.7	197.3	2.7	2.7
	F9	2.8	4.8	2.8	4.8	2.8	2.8
	F11	8.0	98.8	9.2	98.8	9.2	9.2
	Total	**558.2**	**1336.9**	**836.8**	**1840.8**	**836.8**	**836.8**
Gouritz	E8	19.1	24.4	21.9	24.4	21.9	21.9
	C6	27.8	51.1	27.8	51.1	27.8	27.8
	D7	335.8	469.9	383.3	771.1	383.3	383.3
	F13	0.0	3.9	0	3.9	0	0
	F12	0.0	18.5	0	18.5	0	0
	I18	0.0	0	0	0	0	0
	G14	0.0	60.3	10.5	60.2	10.5	10.5
	G15	394.0	636.9	394	671.9	394	394
	Total	**776.6**	**1264.7**	**837.3**	**1601.1**	**837.3**	**837.3**
Total for WMA		**1334.8**	**2601.6**	**1674.1**	**3441.9**	**1674.1**	**1674.1**

5.8.2 Comparison of costs and benefits

Costs and benefits were compared over the period 2017 to 2040, based on estimated changes in 2040. The values of ecosystem services were assumed to grow over time in proportion to population and economic growth, at the same overall rate of growth as estimated for water demand under the high growth scenario. The changes in value in each time period were reduced to a net present value using a discount rate of 6% (the rate advocate by World Bank). Sensitivity analysis was performed using discount rates of 3% (social rate of discount) and 9%. The estimated changes in the value of ecosystem services relative to the Maintain PES scenario are summarised in Table 5-32.

The total infrastructure investments required to meet 2040 water demands under each scenario were costed using 2016 costs. It was assumed that the infrastructure investments would be spread over a 20-year period, starting in the first year. The annual values were then discounted to present value terms as described above. The estimated changes in the required cost of water supply infrastructure to the Maintain PES scenario are summarised in Table 5-32.

The overall economic impact of each scenario was expressed in terms of the direct gains and losses of ecosystem services and water supply costs, expressed in present value terms. The gain and losses for each scenario are given in Table 5-32 and shown graphically in Figure 5-9. The overall net gain is shown in the last column of Table 5-32, and illustrated graphically in Figure 5-10.

The results indicate that the risks of welfare losses under the ESBC scenario would be very high. A scenario in which demands are met without any environmental constraints would result in a small net welfare gain as the change in EGSA value is slightly less than the change in water supply infrastructure costs.. However the loss under the No EC (climate change) scenario would be significant. In fact, it should be borne in mind that the results of any classification scenario are likely to be negatively affected by climate change. Maintaining PES leads to the second-best outcome, but the best outcome from an economic perspective appears to be the allocation of the ecological REC. Figure 5-10 also show that the results are not sensitive to discount rate.

Table 5-32 Estimated differences in value of EGSA and in the costs of water supply infrastructure over the period 2017 to 2040 relative to maintain PES under the different scenarios.

	Change in EGSA value (R millions)		Change in water supply infrastructure costs (R millions)		Overall gain/loss (R millions, NPV @ 6%)
	Annual change in current terms	Overall change (PV)	Difference in value of infrastructure requirements (as if implemented in Year 1)	Difference in PV costs implemented over 20 years	
ESBC	-601	-8214	-928	532	-7682
REC	60	816	840	-482	334
NoEC	-32	-433	-928	532	99
No EC (CC)	-153	-2093	-928	532	-1561

Changes in EGSA and water supply values take economic and population growth into account using high-growth assumptions. All values in 2016 Rand. PV = present value (discounted at 6%).

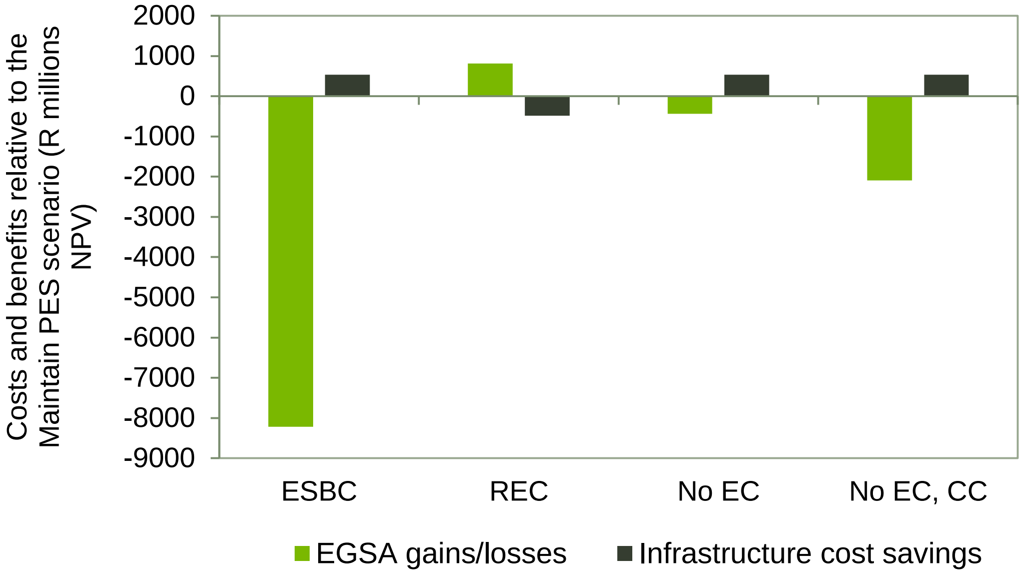


Figure 5-9 **Changes in the present value of EGSAs and water infrastructure under alternative scenarios, relative to the Maintain PES scenario, using a discount rate of 6%**

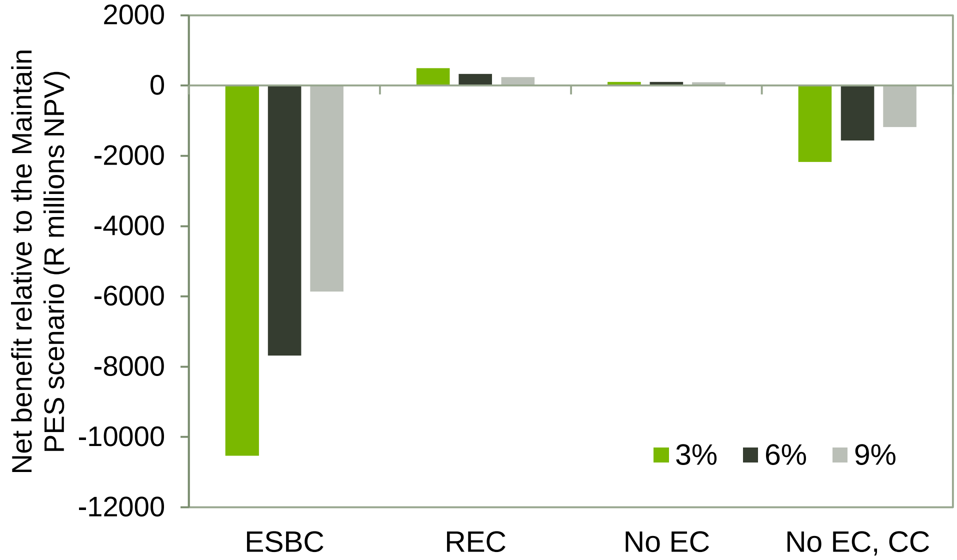


Figure 5-10 **Comparison of the net gains or losses under each scenario, relative to maintaining PES, using discount rates of 3%, 6% and 9%.**

This study has used the approach of costing the water deficit that arises from allocating water to the Ecological Reserve in terms of finding alternative means of supplying that water to meet demands. This is based on the assumption that it is either costlier or politically infeasible to make any significant reductions in water use through reduction of water use rights. To do otherwise also requires estimates of the marginal value of water in different uses. Such estimates do exist, but vary in magnitude and quality, since the type of data required to estimate this properly are simply not available. The existing estimates suggest that industry generates the greatest benefit from water use, followed by eco-tourism, mining and municipal use, with agriculture generating the lowest value (Muller 2017). In comparison, Louw (2002) estimated that the value of irrigation water in the Breede-Gouritz WMA ranged between 0 to 5.99 R/m^3, with a median value of 0.48 R/m^3, at 2015 price levels, and Muller (2017) estimated marginal values of irrigation in the same WMA to range from R0.14 to R4.84 (2015 prices), depending on crops. Given that the values of all non-irrigation water uses and several of the higher value irrigation uses exceeds the cost of water supply options required under the different scenarios, our approach makes economic sense.

Table 5-33 Estimates of non-agricultural water values (source: Muller 2017)

Study	Sector	Method	Type of Estimate	Estimate (2015 Rand)
Conradie (2002)	Municipal	Demand Function	Marginal Value	5.71
Williams *et al.* (2008)	Municipal	Contingent Valuation	Willingness to Pay	3.29
Conningarth Consultants (2001)	Industrial	Input/Output	Average Value	340.57
	Mining	Input/Output	Average Value	85.25
	Eco-Tourism	Input/Output	Average Value	96.07

Table 5-34 Estimated marginal value of water in crop production in the Breede-Gouritz WMA

Crop	**Marginal Value ($\mathrm{R/m^3}$)**	**Crop**	**Marginal Value ($\mathrm{R/m^3}$)**
Peaches	4.84	Naartjies	1.92
Tomatoes	4.78	Oranges	1.90
Table Grapes	4.36	Onions	1.82
Potatoes	3.10	Carrots	1.74
Wine Grapes	2.99	Pears	1.45
Apples	2.69	Pumpkins	1.10
Cabbage	2.27	Lucerne	0.64
Lemons	2.20	Wheat	0.14

Furthermore, the costs of alternative water supply options such as recycling and desalination are decreasing and will soon provide a more viable alternative for urban water supply in the study area.

In addition it should be noted that we have not assumed any changes in the efficiency of water use. The costs of water supply could potentially be reduced through pricing incentives that increase efficiency, and given the low cost of water this is a very feasible option. Ultimately, the least cost option for society (between augmented water supply and water demand management) would be favoured.

5.8.3 Social Impacts and Implications

Implementation of the ecological Reserve does not have major social implications in terms of meeting basic human needs for households in the form of water for domestic use or access to resources harvested for subsistence uses in the study area. This is because only a very small percentage of household in the study area fall into this category, and the number of these households is decreasing through improvements in service provision. This is a significant difference from other parts of the country with a more rural population.

The main social impacts of the scenarios are likely to be in the form of changes in the recreational usage and spiritual values of aquatic ecosystems to households. These values are very difficult to quantify, but can make a major difference to household wellbeing. The relative impacts of the different scenarios on these types of values is likely to follow the same pattern as for the tourism values described above. Thus, social values are maximised where the condition of ecosystems is closest to natural.

In the economic analysis, it is assumed that allocating more water to the Reserve is balanced by investing in measures to increase the supply of water in order to meet demands. The marginal costs of these measures increase with increasing supply. In the analysis, it is assumed that these costs are largely borne by the state (at the expense of some other public service), and would not incur significant additional costs to the users.

The above analysis does not take into account potential public willingness to pay for maintaining aquatic ecosystems in a good condition, whether the REC or a better level of health that supports more biodiversity, and has a more secure conservation outcome. This existence value has a bearing on the welfare of current and future generations. Existence value and other unquantified social costs and benefits will be evaluated in non-monetary terms in terms of the overall evaluation of the final recommended classification scenario.

6 Spatially Targeted Classification Scenario, Recommended ECs and Proposed Water Resource Classes

The Chapter 5 summary of results for the Ecology-driven Scenarios (Scenario 1-3), the Demand-driven Unconstrained (No EC) Scenario (Scenario 4) and the Demand-driven, Unconstrained Climate Change Scenario (Scenario 5) indicated that there is a need to find a balance between demand for water and improved ecological condition. This was also highlighted as an important consideration during the visioning exercise conducted with stakeholders (Chapter 2). Stakeholders mentioned that there is a need to meet agricultural needs for a growing population in certain IUAs, whilst there is a parallel need to meet the high ecological conditions required for important conservation areas. A spatially targeted scenario was considered to address these comments and to provide a more balanced scenario in terms of socio-economics and ecological requirements.

6.1 Spatially Targeted Classification Scenario

6.1.1 Guiding considerations

In order to give appropriate recognition to spatial variations of priority objectives inside individual IUAs, a spatially-targeted scenario needs to be formulated, resulting in a blend of targeted ECs for all nodes ranging between REC and ESBC. The following considerations guide the derivation of this scenario:

- There is a need to seek a balance of competing ecological requirements, conservation priorities, projected future demands and development opportunities inside individual IUAs.
- REC water requirements at all the nodes are the logical starting points for the derivation of the scenario.
- In search of the abovementioned balance of priorities, REC water requirements would need to be "relaxed" to the ESBC level for certain individual nodes or clusters of nodes.
- EC downgrades to the ESBC level will not be considered for nodes or clusters of nodes associated with special conservation areas, such as Strategic Water Source Areas, NFEPAs and Fish conservation areas, as well as for estuaries.
- The logical focus points across the WMA for such potential EC downgrades relative to REC are those IUAs with the highest total infrastructure costs to meet the environmental water requirements of the RECs of the nodes inside those IUAs.
- Stakeholder inputs are a prerequisite for the appropriate selection of nodes for potential EC downgrades below the REC level in each IUA.

6.1.2 A "pilot" spatially-targeted scenario

In order to demonstrate that the above approach towards derivation of a spatially-targeted scenario would be practicable, a "pilot" exercise was implemented. The process and outcome of this pilot exercise is described in the paragraphs below.

The IUAs with the highest infrastructure costs to implement the REC under 2040 water demands are, for the Breede - H16, H17, A1, A2+A3, B4 - and for the Gouritz - D7, G15 (Table 6-1 and Figure 6-1). For every node in each of these eight IUAs the water requirements for the ESBC replaced the relatively higher water requirements for the REC, unless that node was associated with special conservation areas, in which case the REC water requirement values were retained.

Table 6-1 The estimated total infrastructure costs to meet future demands and EWR requirements under the ESBC and REC scenarios

IUA Name	IUA	Estimated total infrastructure costs to meet future demands and EWR requirements	
		ESBC	REC
Overberg West Coastal	H16	R 306 million	R 300 million
Overberg East Fynbos	H17	R 103 million	R 308 million
Upper Breede Tributaries	A1	R 75 million	R 303 million
Breede Working Tributaries & Middle Breede	A2 + A3	R 296 million	R 550 million
Riviersonderend Theewaters	B4	R 3 million	R 197 million
Gouritz-Olifants	D7	R 383 million	R 771 million
Coastal	G15	R 394 million	R 672 million

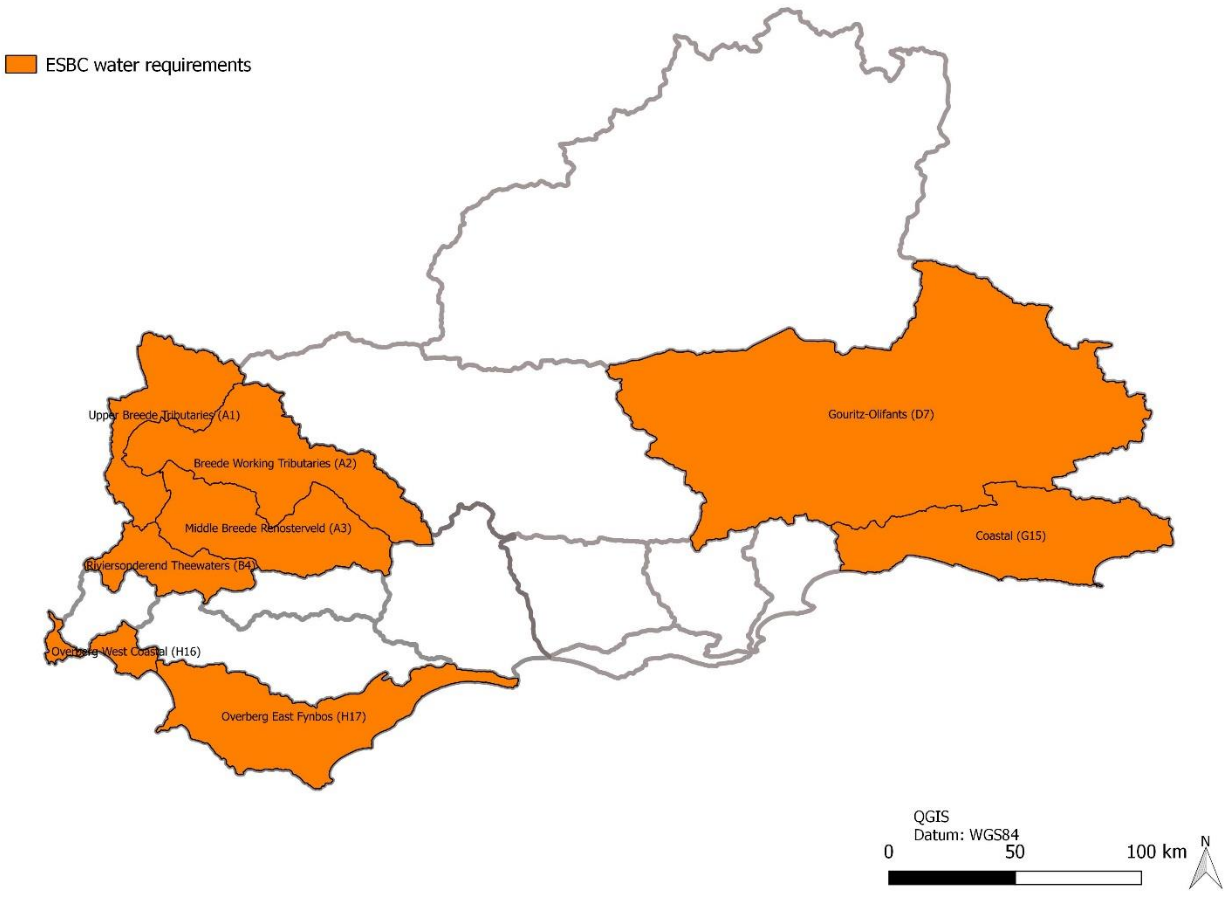


Figure 6-1 The eight IUAs identified where the water requirements for the ESBC scenario replaced the water requirements for the REC in the study area

In addition to this it was noted that there is variation within an IUA, in terms of ecological conditions, which may not be represented effectively given the large spatial scale of the IUA. In certain cases where important conservation areas (i.e. Strategic Water Source Areas or protected areas) “split” an IUA these were considered to be important to represent as separate areas in the classification summary (“management considerations”). These areas may be considered to be the more “pristine” tributaries which should be maintained at a higher class than “working rivers” which are more degraded. The IUAs considered for this “split are indicated in Table 6-2 and Figure 6-2.

Table 6-2 The IUAs considered which have important conservation areas in the study area

IUA Name	IUA	Conservation priority
Upper Breede Tributaries	A1	SWSA, Protected area
Breede Working Tributaries	A2	SWSA, Protected area
Middle Breede Renosterveld	A3	SWSA, Protected area
Riviersonderend Theewaters	B4	SWSA, Protected area
Overberg West	B5	SWSA, Protected area
Lower Breede Renosterveld	F11	SWSA, Protected area
Duiwenhoks	F12	SWSA, Protected area
Gouritz Olifants	D7	SWSA, Protected area
Gamka-Buffels	C6	Groundwater use
Coastal	G15	SWSA, Protected area

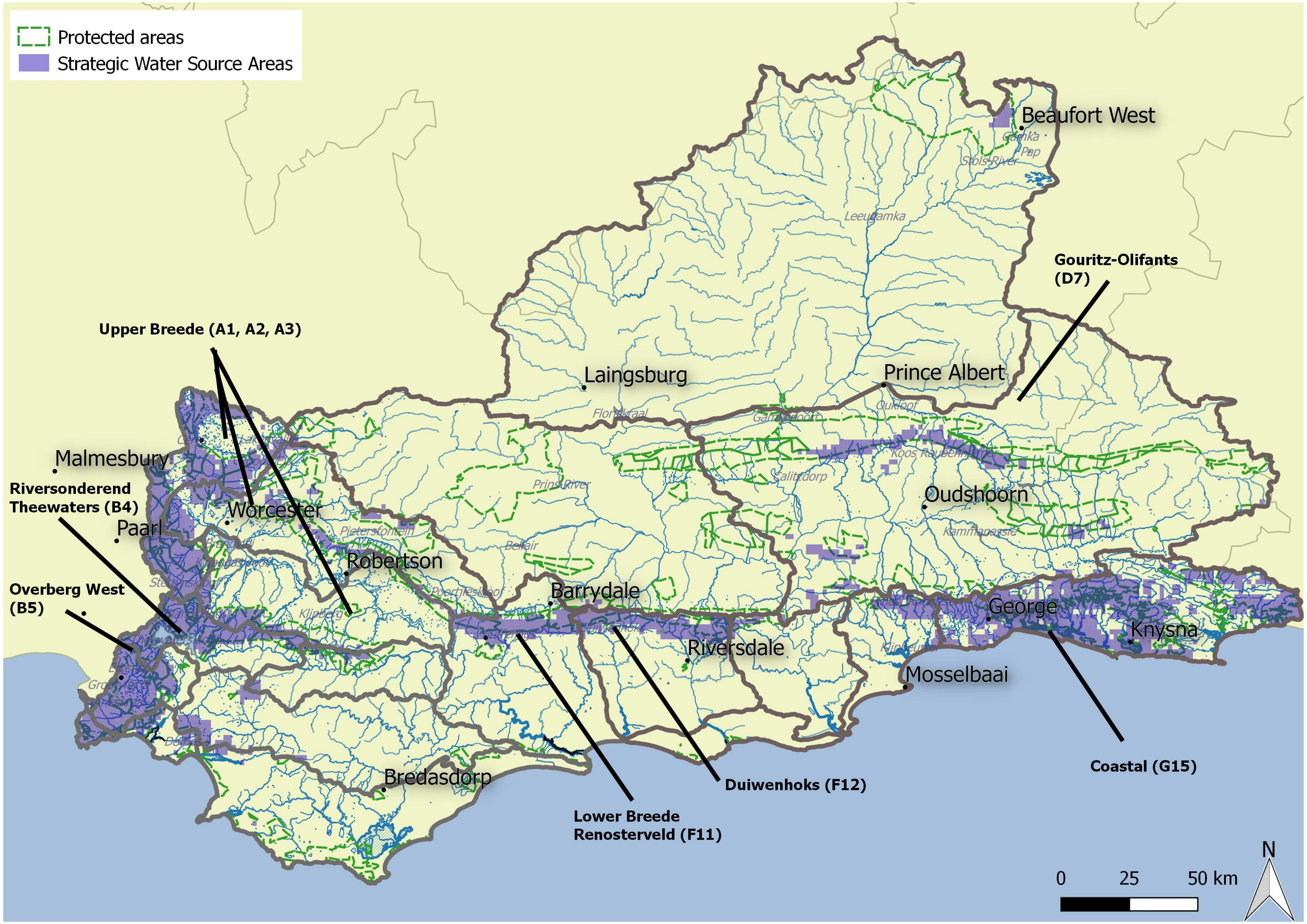


Figure 6-2 The IUAs in the study area which are considered to be "split" to allow for variation in working rivers versus pristine tributaries

6.2 Final Recommended Targeted Ecological Categories

The final recommended target ECs for all river and estuary nodes are presented in Table 6-3 and Figure 6-3 for the Breede-Overberg region and In the Gouritz-Coastal region, both the PES and the STS meet 32 of the 47 RECs (rivers and estuaries). Of the 23 estuaries, 13 RECs are met by the STS. With a few exceptions (Gouritz, Groot-Brak, and Hartenbos), the estuaries have flows at more than 70% of natural, and increasing flows alone will not improve their conditions. Of the 22 river nodes, only five do not meet the REC under the STS scenario, *viz*.: the Varing at gviii3, the Gwaing at gviii6, the Karatara at gvii13, the Noetzie at gviii10, and Keurbooms at giv6,

Table 6-4 and Figure 6-4 for the Gouritz-Coastal region. Also presented are whether the Spatially Targeted Scenario (STS) improves on conditions relative to PES both in terms of resulting Ecological Category and in terms of flow as a percentage of nMAR.

In the Breede-Overberg region, the PES meets 14 of the 24 RECs (rivers and estuaries), while the STS meets or exceeds at 15 of the 24. Of these, five are estuaries. An additional two estuaries (Uilkraal and Heuningnes) improve on the PES, although the REC is not met.

Table 6-3 Annual flow as % nMAR, and river condition (A to F) at each node for the Breede-Overberg IUAs for the Present Ecological Status (PES) and Spatially Targeted Scenario (STS)

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
B5-OverbergWest	**Piii1**	**G40C**	**Palmiet**	**B**	C	95.19	C	95.19	Not met	Not met		
	Piv10	G40C	Witklippieskloof		D	58.93	D	58.93				
	Piv9	G40C	Palmiet		D	42.96	D	42.96				
	Pvi1	G40C	Palmiet		D	60.68	D	60.68				
	Piv8	G40C	Klipdrif		D	93.39	D	93.39				
	Piv4	G40D	Klein-Palmiet		D	80.71	D	80.71				
	Piv7	G40D	Krom/Ribbok		D	34.85	D	34.85				
	Piii2	**G40D**	**Palmiet**	**B/C**	B/C	63.71	B/C	63.71	Met	Met		
	Piv12	G40D	Dwars/Louws		C	98.81	C	98.81				
	Piii3	**G40D**	**Palmiet**	**B**	B	69.83	B	69.83	Met	Met		
	Pxi1	**G40D**	**Palmiet estuary**	**B**	C	70.13	C	70.13	Not met	Not met		
H16- Overberg West Coastal	**Bxi1**	**G40B**	**Buffels**	**B**	B	81.86	B	81.86	Met	Met		
	Bxi2	**G40B**	**Rooiels**	**B**	B	98.63	B	98.63	Met	Met		
	Niv43	G40F	Swart		E	88.83	E	88.83				
	Niii5	G40E	Bot		C	84.20	C	84.20				
	Nxi6	**G40G**	**Bot**	**B**	C	81.78	C	81.78	Not met	Not met		
	Nxi8	**G40H**	**Onrus**	**D**	D	51.77	D	51.77	Met	Met		
F10-Overberg East Renosterveld	Nii4	G40J	Hartbees		D	87.08	D	55.69				Down
	Niv45	G40K	Steenbok		E	93.40	E	93.40				
	Nv23	**G40K**	**Klein**	**C**	C/D	89.23	C/D	79.11	Not met	Not met		Down
H17-Overberg East Fynbos	**Nxi7**	**G40L**	**Klein**	**B**	C	80.33	C	85.58	Not met	Not met		Up
	Nx8	G40M	Uilkraal		C	62.95	C	92.00				Up
	Nxi5	G40M	Uilkraal	C	E	43.93	C/D	58.79	Not met	Not met	Up	Up
	Nxi3	G50A	Ratel	C	C	90.02	C	90.02	Met	Met		
	Ni4	G50B	Nuwejaar	D	D	49.65	C/D	71.67	Met	Exceeds	Up	Up
	Nvii15	G50C	Heuningnes		D	50.14	C/D	71.67			Up	Up
	Niv44	G50C	Heuningnes		D	50.20	C/D	71.67			Up	Up
F10-Overberg East Renosterveld	Nv24	G50D	Kars	B	B/C	89.99	B/C	89.99	Not met	Not met		
H17-Overberg East Fynbos	Nii5	G50E	Kars		E	85.84	E	85.84				
	Nxi1	G50F	Heuningnes	A	C	68.78	A/B	78.17	Not met	Not met	Up	Up
F10-Overberg East Renosterveld	Nii6	G50G	Sout		D	73.69	D	73.69				
	Nii7	G50H	DeHoopVlei		B	91.96	B	91.96				
H17-Overberg East Fynbos	Bxi3	G50K	Klipdrifsfontein	A	A	64.77	A	64.77	Met	Met		

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
A1-UppBreedeTribs	Niv3	H10B	Titus		C	82.03	C	82.03				
	Niv1	H10C	Koekedou		D	96.32	D	96.32				
	Niv2	H10C	Dwars		C	62.47	C	52.94				Down
	nvi4	H10C	Breede		C	70.43	C	64.81				Down
	Niv4	H10D	Witels		A	100.00	A	100.00				
	Nvi3	H10D	Breede		C	75.09	C	72.88				Down
	Nvii16	H10E	Witte		A	92.04	A	92.04				
	Niv5	H10F	Witte		A	88.40	A	88.40				
	Niv6	H10F	Wabooms		D	64.05	D	37.75				Down
	Nviii1	H10F	Breede	D	D/E	77.18	D	75.82	Not met	Met	Up	Down
	Niv40	H10J	Elands		B	92.20	B	92.20				
	Niv41	H10J	Krom		B	92.21	B	92.21				
	Nvii2	H10J	Molenaars	B	B	92.20	B	92.20	Met	Met		
A2-BreedeWorkTribs	Niv7	H10G	Slanghoek		D	70.95	D	47.73				Down
	Niii1	H10G	Breede		D	77.70	D	74.99				Down
	Niv42	H10J	Smalblaar		E	92.20	E	92.20				
	Niv8	H10H	Jan du Toit		D	81.32	D	47.53				Down
	Nvii6	H10H	Hartbees		D	77.96	D	77.96				
	Niv9	H10H	Hartbees		D	80.09	D	58.41				Down
	Niv12	H10K	Holsloot		C	81.68	C	81.68				
	Nv3	H10H	Breede		C	62.39	C	59.83				Down
	Nv18	H20F	Hex		D	50.77	D	50.77				
	Nvii7	H20G	Hex	C	C	80.73	C	80.73	Met	Met		
	Niv10	H20H	Hex		D	58.69	D	58.69				
	Nii1	H40C	Breede		C	61.98	C	59.70				Down
	Nvii5	H40B	Koo		D	69.20	D	41.86				Down
	Niv11	H40C	Nuy		E	29.69	D/E	38.24			Up	Up
	Niv18	H30B	Kingna		D	58.05	D	42.98				Down
	Niv20	H30C	Pietersfontein		D	83.82	D	83.82				
	Nvii9	H30D	Keisie		D	84.80	D	73.21				Down
A3-MidBreede-Renoster	Niv13	H40D	Doring		E	77.78	E	77.78				
	Nvii8	H40F	Breede	C/D	C/D	61.10	C/D	59.76	Met	Met		Down
	Ni1	H40F	Breede		B	60.78	A/B	59.45			Up	Down
	Nvii11	H40G	Poesjenels		D	50.90	D	43.90				Down
	Niv15	H40H	Vink		D	83.93	D/E	45.45			Down	Down
	Nviii2	H40J	Willem Nels		D	84.78	D/E	44.77			Down	Down
	Nvii19	H40J	Breede		B	61.12	A/B	58.97			Up	Down
	Nvii12	H40K	Keisers		D	56.39	D	56.39				
	Niv14	H40K	Keisers		D	53.97	D	53.97				
	Nvi1	H40L	Breede		D	61.04	D	58.82				Down
	Nii2	H30E	Kogmanskloof		D	69.40	D	53.92				Down
	Niii3	H50A	Breede		D	61.08	D	58.26				Down
	Ni2	H50B	Breede		D	61.01	D	58.23				Down
B4-UpperRiviersonderend	Nvii10	H60B	Du Toits		B	90.87	B	90.87				
	Nv7	H60D	Riviersonderend		C	49.49	C	52.12				Up
	Niv28	H60E	Baviaans	B	B	88.72	B	88.72	Met	Met		
	Niv29	H60E	Sersants		D	88.72	D	54.44				Down
	Niv30	H60F	Gobos		C	87.77	C	62.36				Down
	Nv9	H60F	Riviersonderend	D	D	53.57	D	52.44	Met	Met		Down
F9-LowerRiviersonderend	Niv31	H60G	Kwartel		D	90.70	D	53.38				Down
	Niv33	H60H	Soetmelksvlei		D	67.84	D	47.90				Down
	Niv34	H60H	Slang		D	67.89	D	47.90				Down
	Nv10	H60H	Riviersonderend		D	55.01	D	51.95				Down
	Nv11	H60J	Riviersonderend		D	56.34	D	53.42				Down
	Niv35	H60K	Kwassadie		E	84.68	E	84.68				
	Nv12	H60K	Riviersonderend		D	56.82	D	53.96				Down
	Ni3	H60L	Riviersonderend		D	56.12	D	53.31				Down

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
F11-LowBreede-Renoster	Niv24	H70A	Leeu		E	85.44	E	85.44				
	Niv24a	H70B	Klip		E	92.40	E	92.40				
	Nv2	H70B	Breede		C	60.15	C	57.48				Down
	Nvii14	H70C	Huis		C	75.01	C	75.01				
	Nii3	H70C	Tradouw		B	75.21	B	75.21				
	Niv25	H70F	Buffeljags		E	73.18	E	73.18				
	Niii4	H70G	Breede	B/C	C	60.99	C	58.52	Not met	Not met		Down
	Nviii3	H70H	Breede		B	61.13	B	58.41				Down
	Niv26	H70J	Slang		E	89.07	E	51.86				Down
	Nxi2	H70K	Bree	B	B	49.53	B	47.19	Met	Met		Down

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 5.

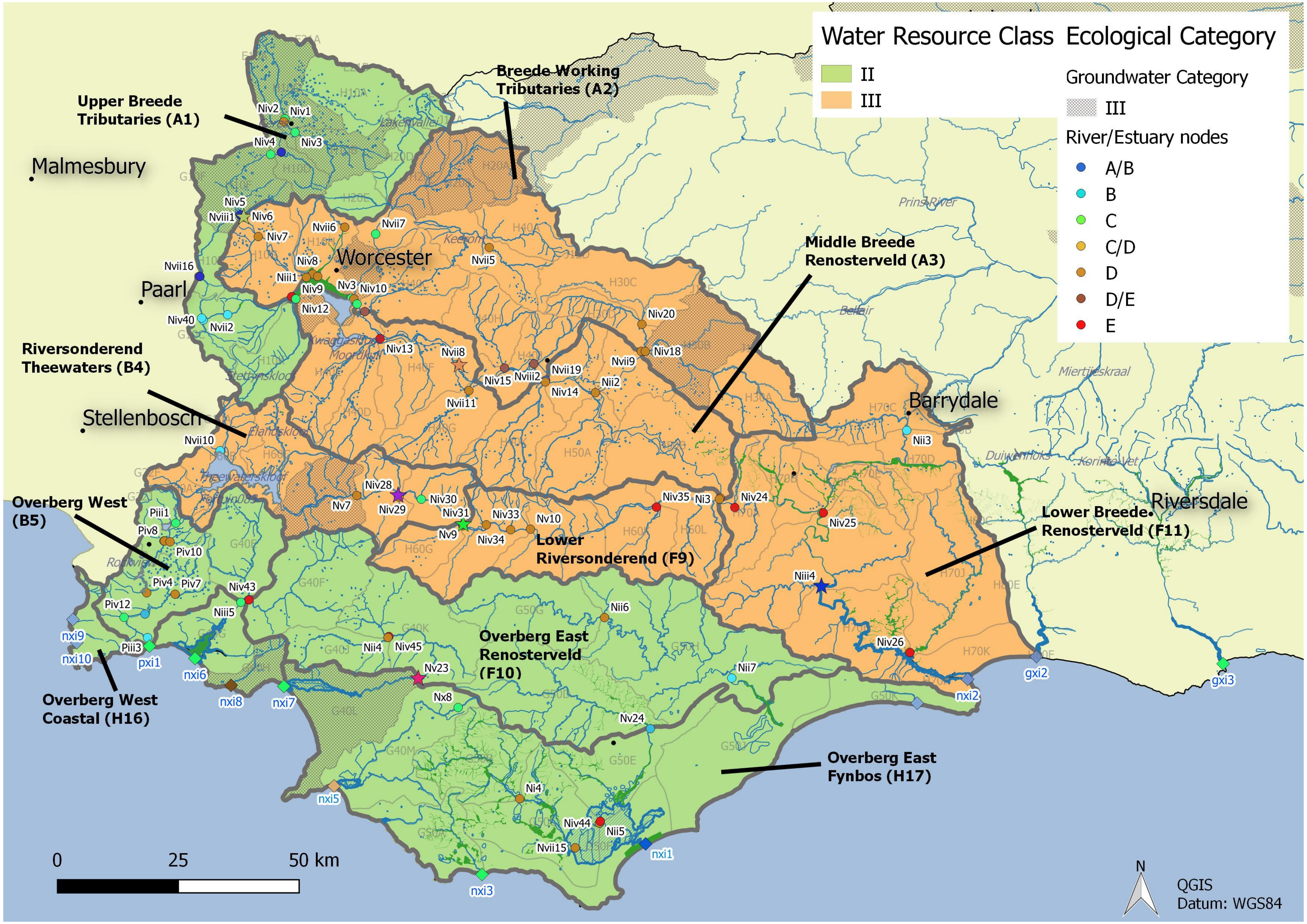


Figure 6-3 The water resource class and ecological category for the IUAs under the Spatially Targeted Scenario in the Breede-Overberg region of the study area

In the Gouritz-Coastal region, both the PES and the STS meet 32 of the 47 RECs (rivers and estuaries). Of the 23 estuaries, 13 RECs are met by the STS. With a few exceptions (Gouritz, Groot-Brak, and Hartenbos), the estuaries have flows at more than 70% of natural, and increasing flows alone will not improve their conditions. Of the 22 river nodes, only five do not meet the REC under the STS scenario, *viz*.: the Varing at gviii3, the Gwaing at gviii6, the Karatara at gvii13, the Noetzie at gviii10, and Keurbooms at giv6,

Table 6-4 Average monthly flows as % nMAR, and river condition (A to F) for the Gouritz-Coastal IUAs at each node for the Present Ecological Status (PES) and Spatially Targeted Scenario (STS)

IUA	Node	Quat	River	ER-REC	PES		STS		PES Meets REC?	STS Meets REC?	STS	
					EC	%nMAR	EC	%nMAR			EC Ch from PES	%nMAR Ch from PES
E8-Touws	giv30	J12C	Ysterdams		D	50.87	D	50.87				
	giv31	J12B	Donkies		D	55.52	D	55.52				
	giv28	J12D	Touws		D	54.57	D	54.57				
	giv27	J12H	Touws		B	50.24	B	50.24				
	giv26	J12K	Brak		C	14.46	C	14.46				
	gviii1	**J12L**	**Doring**	**C/D**	C/D	43.39	C/D	43.39	Met	Met		
	gv5	**J12L**	**Touws**	**B/C**	B/C	46.37	B/C	46.37	Met	Met		
	gv4	**J11H**	**Buffels**	**C**	C	60.32	C	60.32	Met	Met		
	gv6	J11J	Groot		D	42.70	D	42.70				
	giv32	J11K	Groot		D	38.59	D	38.59				
	gv7	J13A	Groot		C	41.06	C	41.06				
	gii3	J13C	Groot		B	42.79	B	42.79				
C6-Gamka-Buffels	giv34	J11C	Buffels		A	97.25	A	97.25				
	gv25	J11F	Buffels		C	93.27	C	93.27				
	gv18	J21A	Gamka		B	77.34	B	77.34				
	giv3	J21D	Gamka		B	77.81	B	77.81				
	giv1	J22F	Koekemoers		C	87.87	C	87.87				
	giv2	J22K	Leeu		C	44.14	C	44.14				
	gv17	J23C	Gamka		B	68.99	B	68.99				
	giv21	J23F	Gamka		B	62.35	B	62.35				
	gv27	J23J	Gamka		C	61.87	C	61.87				
	gv14	J24D	Dwyka		A	85.15	A	85.15				
D7-Gouritz-Olifants; Lower Gouritz	**giv20**	**J25A**	**Gamka**	**C**	C/D	55.79	C	66.02	Not met	Met	Up	Up
	giv18	J25D	Nels		D	55.82	E	42.22			Down	Down
	gii2	J25E	Gamka		C	48.82	C	59.98				Up
	giii2	**J31C**	**Olifants**	**C**	C	85.27	C	54.74	Met	Met		Down
	giv15	J32E	Traka		C	81.11	C/D	47.89			Down	Down
	gv33	J33B	Olifants		D	79.46	D	57.22				Down
	gv21	J33D	Meirings		C	90.58	C	90.58				
	giv11	J33F	Olifants		E	47.00	E	40.04				Down
	gv36	**J34C**	**Kammanassie**	**C/D**	C/D	75.67	C/D	75.67	Met	Met		
	giv10	J34F	Kammanassie		E	41.26	D	60.46			Up	Up
	gvii2	J35A	Grobbelaars		C	82.76	C	82.76				
	giv9	J35A	Grobbelaars		E	65.75	E	65.75				
	gv19	J35D	Olifants		E	51.60	E	50.63				Down
	giv17	J35F	Olifants		D	53.21	D	50.15				Down
	giv16	J40A	Gouritz		C	55.30	C	51.97				Down
	gi4	**J40B**	**Gouritz**	**C**	C	54.34	C	51.65	Met	Met		Down
	gv28	J40C	Gouritz		D	56.22	D	53.69				Down
	gv9	J40D	Gouritz		C	59.81	C	57.51				Down
	Gxi1	**J40E**	**Gouritz estuary**	**B**	C	61.88	C	59.73	Not met	Not met		Down
F12-Duiwenhoks-Hessequa	giii5	H80B	Duiwenhoks		E	94.05	E	94.05				
	gv11	H80C	Duiwenhoks		D	94.05	D	94.05				
	giii8	**H80D**	**Duiwenhoks**	**D**	D	94.35	D	94.35	Met	Met		
	Gxi2	**H80E**	**Duiwenhoks estuary**	**A**	B	91.89	B	91.89	Not met	Not met		

I18-Duiwenhoks-Hessequa	giii6	H90B	Korinte		D	89.02	D	89.02				
	giii7	**H90A**	**Goukou**	**C/D**	C/D	87.67	C/D	87.67	Met	Met		
	gv10	H90C	Goukou		D	84.73	D	84.73				
	gv41	H90D	Goukou		C	83.50	C	83.50				
	Gxi3	**H90E**	**Goukou estuary**	**B**	C	81.41	C	81.41	Not met	Not met		
G14-Groot Brak	giv25	K10D	Brandwag		D	73.80	D	73.80				
	gv39	**K10E**	**Moordkuil**	**D**	D	41.78	D	41.78	Met	Met		
	Gxi4	**K10F**	**Klein-Brak estuary**	**C**	C	77.05	C	77.05	Met	Met		
	gviii2	**K20A**	**Groot-Brak**	**B/C**	B/C	93.79	B/C	93.79	Met	Met		
	gviii12	**K20A**	**Varing**	**C/D**	C/D	97.27	C/D	97.27	Met	Met		
	gviii3	**K20A**	**Varing**	**C/D**	D	74.73	D	74.73	Not met	Not met		
	gvii7	K20A	Groot-Brak		B/C	45.89	B/C	45.89				
	Gxi5	**K20A**	**Groot-Brak estuary**	**C**	E	56.20	E	56.20	Not met	Not met		
	Gxi19	**K10A**	**Blinde estuary**	**B**	B	69.23	B	69.23	Met	Met		
	Gxi20	**K10A**	**Tweekuilen estuary**	**D**	D	96.73	D	72.31	Met	Met		Down
	Gxi21	**K10A**	**Gericke estuary**	**D**	D	96.80	D	72.31	Met	Met		Down
	Gxi22	**K10B**	**Hartenbos estuary**	**C**	D	65.01	D	65.01	Not met	Not met		
G15-Coastal	gviii4	K30A	Maalgate		D	75.80	D	75.80				
	gvii8	**K30A**	**Maalgate**	**D**	D	75.80	D	75.80	Met	Met		
	Gxi6	**K30A**	**Maalgate estuary**	**B**	B	79.32	B	79.32	Met	Met		
	gvii9	**K30B**	**Malgas**	**C**	C	95.00	C	95.00	Met	Met		
	gviii6	**K30B**	**Gwaing**	**D**	E	82.30	E	82.30	Not met	Not met		
	Gxi7	**K30B**	**Gwaing estuary**	**B**	B	85.00	B	85.00	Met	Met		
	gviii7	K30C	Swart		D	25.28	D	25.28				
	gvii11	**K30C**	**Kaaimans**	**B**	B	94.07	B	94.07	Met	Met		
	gviii8	K30C	Silver		B	94.07	B	94.07				
	Gxi8	**K30C**	**Kaaimans estuary**	**B**	B	72.45	B	72.45	Met	Met		
	gvii12	K30D	Touws		B	93.75	B	93.75				
	gx8	K30D	Klein		D	93.75	D	93.75				
	Gxi9	**K30D**	**Wilderness estuary**	**A**	B	88.59	B	88.59	Not met	Not met		
	giii10	**K40A**	**Diep**	**B**	B	96.53	B	96.53	Met	Met		
	giii13	K40B	Hoekraal		B	92.49	B	92.49				
	gvii13	**K40C**	**Karatara**	**A/B**	B	92.99	B	92.99	Not met	Not met		
	giii11	K40C	Karatara		B	92.99	B	92.99				
	Gxi10	**K40D**	**Swartvlei estuary**	**B**	B	86.61	B	86.61	Met	Met		
	gviii9	**K40E**	**Goukamma**	**B/C**	B/C	87.46	B/C	87.46	Met	Met		
	Gxi11	**K40E**	**Goukamma estuary**	**A**	B	87.46	B	87.46	Not met	Not met		
	gvii14	**K50A**	**Knysna**	**B**	B	95.63	B	95.63	Met	Met		
	giii12	K50A	Knysna		B	94.74	B	87.20				Down
	gviii11	**K50B**	**Gouna**	**A/B**	A/B	92.21	A/B	92.21	Met	Met		
	Gxi12	**K50B**	**Knysna estuary**	**B**	B	90.63	B	86.75	Met	Met		Down
	gviii10	**K60G**	**Noetzie**	**A/B**	B	92.46	B	92.46	Not met	Not met		
	Gxi13	**K60G**	**Noetsie estuary**	**A**	B	92.45	B	92.45	Not met	Not met		
	gx3	K60G	Piesang		E	92.45	E	64.25				Down
	Gxi14	**K60G**	**Piesang estuary**	**B**	C	73.04	C	73.84	Not met	Not met		Up
	giv6	**K60C**	**Keurbooms**	**B/C**	C	93.22	C	93.22	Not met	Not met		
	giv5	K60D	Palmiet		A	93.24	A	93.24				
	gx9	K60E	Keurbooms		B	92.25	B	92.25				
	giv4	K60F	Bitou		C	97.47	C	92.10				Down
	Gxi15	**K60G**	**Keurbooms estuary**	**A**	A	91.17	A	90.04	Met	Met		Down
	gx4	K70A	Buffels		B	83.72	B/C	57.23			Down	Down
	Gxi16	**K70A**	**Matjies estuary**	**B**	B	83.73	C	70.47	Met	Not met	Down	Down
	gx5	K70A	Sout		B	85.58	B	85.58				
	Gxi17	**K70A**	**Sout(Oos) estuary**	**A**	A	85.58	A	85.58	Met	Met		
	Gxi23	**K70A**	**Groot(Wes) estuary**	**B**	B	86.73	B	86.73	Met	Met		
	gvii15	K70B	Bloukrans		B	82.69	B	82.69				
	Gxi18	**K70B**	**Bloukrans estuary**	**A**	A	98.00	A	98.00	Met	Met		

ER = Ecological Reserve. EWR sites are in **bold** with RECs from ER studies in column 5.

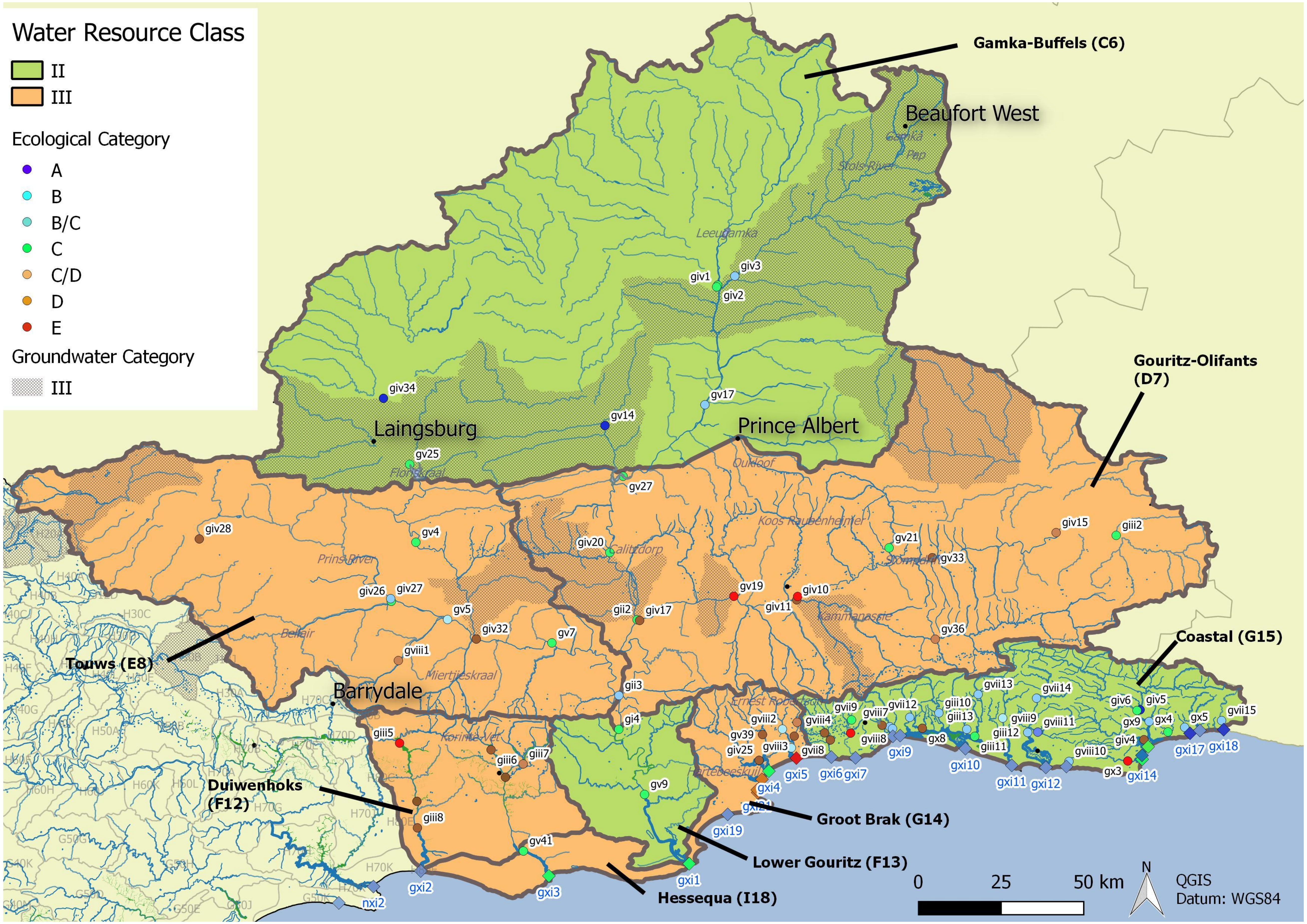


Figure 6-4 **The final water resource class and ecological category for the IUAs under the Spatially Targeted Scenario in the Gouritz-Coastal region of the study area**

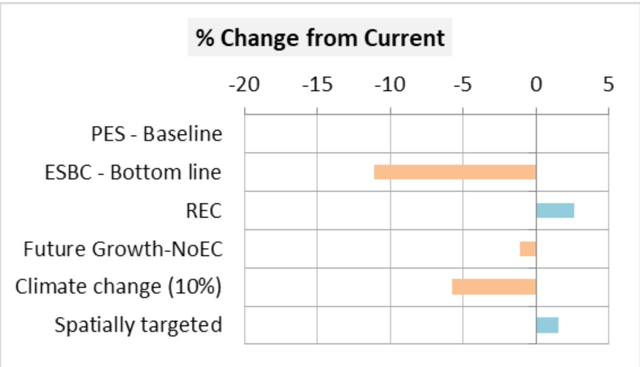
6.3 Summary of results

6.3.1 Rivers and Estuaries

In the spatially-targeted scenario the IUAs with the highest infrastructure costs to implement the REC under 2040 water demands are Overberg West Coastal (H16), Overberg East Fynbos (H17), Upper Breede Tributaries (A1), Breede Working Tributaries (A2), Middle Breede Renosterveld (A3), Riversonderend Theewaters (B4), Gouritz-Olifants (D7) and Coastal (G15) IUAs. The results in this regard were that in these IUAs a surplus of water is made available for development needs (unless a node is associated with a conservation site) by reducing the conditions of rivers. In all other IUAs the REC water requirements were retained.

This resulted in 76% of river EWR sites meeting or exceeding the EC required. At sites which did not meet the required EC additional interventions are often required, which are not related to flow. Of all the nodes most did not change from the current state (PES) with ~15% improving and ~8% declining from the current EC. In particular this decline is related to additional development needs in the Gouritz-Oifants IUA (D7) which pushes the Nels and Traka Rivers to below current, while the Kammanassie River improves from an E to a D category. In the Coastal IUA (G15) a decline from current EC is seen in the Buffels River, and the Matjies Estuary nodes. Developments in the Breede-Overberg reduce the ECs of the Vink (Niv15) and Willem Nels (Nviii2) rivers.

The overall changes in ecological condition for all scenarios are summarised in Figure 6-5, showing the compromise achieved between protection in the form of the REC scenario, and development, where in the Breede-Overberg, there is still some improvement relative to the PES scenario, and in the Gouritz-Coastal, there is a very slight reduction.



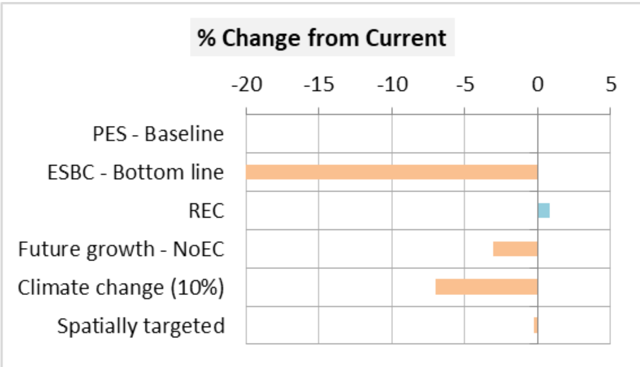


Figure 6-5 Breede-Overberg (left) and Gouritz-Coastal (right): Percentage change in ecosystem health / integrity from the current scenario (PES) for all scenarios

A note on the achievement of REC through flow for estuaries:

Ecological water requirements for estuaries are described in terms of the quantity and quality of flows required to meet defined health thresholds. Estuary Health or the Ecological condition of an estuary is therefore described through the Estuary Health Index (EHI) via assessment of abiotic (hydrology, hydrodynamics, physical habitat) and biotic (microalgae, invertebrates, fish, birds) health. This study assessed the relationship between freshwater inflows as a percentage of natural Mean Annual Runoff (%MAR) and estuary health. As the EHI is also influenced by anthropogenic factors other than changes in flow volumes (i.e. change in nutrient inputs, habitat reclamation, fishing), restoring flows to 100% of natural is often not sufficient to restore estuary condition to natural. Setting environmental flows requires consideration of both quantity and quality of flows, therefore if anthropogenic impacts on water quality were reduced, then EHI goes up.

The Ecological Water Requirements (EWRs) for estuaries (as defined in the EWR report) are determined using scenarios, representing future planning options. The threshold flow requirements for each Ecological Category (EC) for each estuary, based on current and improved water quality, were determined and assessed in terms of the likelihood of pollution problems being reduced in the future. In this way the future REC scenario provided a threshold flow requirement for the REC based on whether or not pollution impacts are likely to be reduced. This is the case for the following estuaries:

Figure 6-6 Estuaries where additional non-flow related interventions are required in order to meet REC

IUA	Node	Quat	River	ER-REC	Current		Spatially targeted	
					EC	%nMAR	EC	%nMAR
B5	Pxi1	G40D	Palmiet	B	C	70.13	C	70.13
H16	Nxi6	G40G	Bot	B	C	**81.78**	C	**81.78**
H17	Nxi7	G40L	Klein	B	C	80.33	C	85.58
	Nxi5	G40M	Uilkraal	C	E	43.93	C/D	58.79
	Nxi1	G50F	Heuningnes	A	C	68.78	A/B	78.17
D7	Gxi1	J40E	Gouritz	B	C	61.88	C	59.73
I18	Gxi2	H80E	Duiwenhoks	A	B	91.89	B	91.89
	Gxi3	H90E	Goukou	B	C	81.41	C	81.41
G14	Gxi5	K20A	Groot-Brak	C	E	56.20	E	56.20
G15	Gxi9	K30D	Wilderness	A	B	88.59	B	88.59
	Gxi13	K60G	Noetzie	A	B	92.45	B	92.45
	Gxi14	K60G	Piesang	B	C	73.04	C	73.84
	Gxi16	K70A	Matjies	B	B	83.73	C	70.47

6.3.2 Wetlands

The assessment for wetlands focused on the impacts of surface and groundwater use as well as the indirect impacts of future development scenarios. As the spatially-targeted scenario presents a balance between the development driven scenario (ESBC) and ecology driven scenario (REC), this means that indirect impacts of future development can be focused to particular IUAs considered above. Although wetlands occur throughout the study area, wetlands of particular ecological importance which supply important ecosystem services are considered most at risk to future development.

Under the PES and REC scenario most wetlands are in a good condition (i.e. AB or C), and the associated river nodes are similar. There are certain river nodes that are very poor in comparison to the condition of the associated wetlands, mainly due to the surrounding agricultural activities and transformation of the riverbanks. Most of the wetlands in the high-lying areas are within high yield Strategic Water Source Area (Breede), and within protected areas, where REC flows were maintained. Papenkuils floodplain wetland has a REC of C. Although the Smalblaar River node (Niv42) has a low ecological category (E), the Breede River nodes (Niii1 and Nv3) are in better condition (D and C, respectively), and are thus better able to support the preliminary Reserve determined for the Papenkuils (at an ecological condition of C). The node associated with De Hoop Vlei (Nii7) is maintained as a category B with near natural flows.

The Duiwenhoks wetland has a PES of D which needs to be maintained, although the PES of the associated river node is E. The Grootbosberg, Lower Tierkloof and Upper Gaffie wetlands on Goukou River are also at risk from erosion. The associated river node for these wetlands has a PES of C/D. The upper reaches of Donkies River in Touws IUA have FEPA channelled valley-bottom wetlands in a good condition, which are within the Bokkeriviere Nature Reserve and the Gouritz High Yield Strategic Water Source Area. This region requires natural flow and may be considered for conservation purposes. Channelled valley wetlands on the Brak and Touws tributaries are associated with nodes in a better condition, and this should be maintained. The poor condition of the Gouritz, Brandwag and Moordkuil Rivers impacts associated FEPA floodplain wetlands and valley bottom wetlands, which have a good condition.

The Wilderness Lakes is a Ramsar site and needs to be managed accordingly. Although currently the rivers in this area are in a good condition and the rivers flow is close to natural, future development means that in some cases flow has been reduced,

6.3.3 Water Quality

Water quality in the Upper Breede Tributaries will probably remain in the same state as present. With increased development the water quality in the Upper Breede Tributaries will probably remain ideal. Water quality in the Breede River downstream of Ceres would probably deteriorate more due to less dilution of irrigation return flows and WWTW discharges, and more poor quality (unacceptable category) irrigation return flows if the surplus water generated in this scenario is used locally to support expanded irrigation activities. Under this scenario wet season flows would probably decrease and the dry season flows would increase. The impacts on water quality is that the increase in flow during the dry season would dilute the poor quality in the lower reaches of the river impacted by large irrigation return flows. The reduction in flow during the wet season may not result in a major change in the water quality. Under this scenario lower volume freshening releases will probably be made from Brandvlei Dam during the summer months (dry season) which may result in elevated salinity in the river reach up to Sanddrift Canal. This may impact negatively on the irrigation farmers. The impacts of WWTW discharges on elevating nutrient concentrations and elevated bacterial counts from urban runoff in the middle Breede River will probably reduce during the dry season due to higher dilution as a result of the elevated flows. The poor quality in the Breede River at Swellendam could be slightly alleviated by the increase in dry season flows in the main stem river. Flow in the Klip River at Swellendam would be largely unchanged and it is therefore important that WWTW discharges from the Swellendam be controlled. The Overberg West IUA will probably remain in a good state provided point sources of pollution and urban runoff are controlled effectively. Water quality in the Overberg East Renosterveld IUA will continue to exhibit high salt concentrations which was largely ascribed to the geology of the region. In the Riviersonderend Theewaters IUA will probably remain in a good state provided the effluent discharges from WWTW and other pollution sources being controlled effectively. Water quality in the Lower Riviersonderend IUA will probably continue to exhibit elevated salt concentrations as a result of agricultural return flows and it might be higher due to reduced dry season flows in the main stem Riviersonderend River.

Water quality in the Gouritz-Olifants IUA will probably continue to exhibit elevated salt and nutrient concentrations, especially in river reaches receiving large volumes of treated wastewater effluents and/or irrigation return flows. High salinities that occur throughout the Touws IUA will probably continue. Water quality in the upper and middle reaches of the Duiwenhoks IUA will remain poor quality. Water quality in the Korentepoort Dam will probably remain ideal. The elevated salinities in the Groot Brak IUA, especially in the Hartebeestkuil Dam and the downstream Hartenbos River will remain. The same would probably apply to the moderately elevated salinities in Wolwedans Dam. The generally good water quality in the rivers of the Coastal IUA would probably be maintained or it might deteriorate slightly under this scenario.

6.3.4 Groundwater

The present groundwater status has a groundwater use of 215 million m^3/a. This increases in the spatially targeted scenario to 429 million m^3/a. This increase in groundwater use is 99% current, which is lower than the expected groundwater use for the REC scenario (124%). In the Upper Breede Tributaries IUA (A1) there is an increase in status of 4 quaternaries, 2 of which have a significant increase although none are high GWB/EWR. There is a moderate increase in status at 4 quaternaries in the Overberg West/Coastal IUAs, with one quaternary having a high GWBF/EWR (to be managed with RQOs). In the Gouritz-Olifants IUA (D7) there is a moderate increase in status at 7 quaternaries (4 of which change from status I to status III). None are high GWBF/EWR.

6.3.5 Ecosystem Goods, Services and Attributes

As described in Section 5, the assessment of the changes to Ecosystem Goods, Services and Attributes (ecosystem services) were modelled according to different flow scenarios for estuaries. The resulting changes that would be expected under the spatially targeted scenario are outlined below for the tourism, property value, subsistence fishing value and nursery value. The results of this analysis show that changes in ecosystem services are very specific to the location of any change in water flow. Some rivers and estuaries have much higher value than others due to the location of towns, amenities and infrastructure.

Under the spatially targeted (ST) scenario there is an overall gain of R15.4 million per year in the value of ecosystem goods and services compared to the current (PES). While this gain is not as high as the gains seen under the REC scenario, it is the second best scenario and higher than current EGSA values.

Table 6-5 Summary of changes to the aquatic ecosystem services under the different scenarios relative to PES for the Breede-Gouritz WMA, in Millions Rands per year. ST= spatially targeted.

Estuary Ecosystem Service	Scenario				
	ESBC	REC	No EC	CC	ST
Subsistence Fisheries Value	-1.15	+0.11	-0.41	-0.85	+0.10
Nursery Value	-105.68	+23.05	-3.71	-51.64	+11.79
Property Value	-39.15	+3.88	-14.51	-31.01	+3.28
Tourism Value	-455.18	+32.69	-13.07	-69.71	+0.21
Total (Rm/yr.)	**-601.16**	**+59.73**	**-31.70**	**-153.21**	**+15.38**

6.3.6 Water Supply Consequences

The average annual volume of surface water supplied to all user categories to meet current water requirements in the Breede-Overberg and Gouritz-Coastal regions of the WMA are 627.7 and 275.1 million m^3/a, respectively. The net surplus/deficit in supplying the current day water requirements under the spatially targeted scenario considers the ESBC water requirements in certain IUAs, and the REC requirements in all others. Under the ESBC scenario, in which less surface water is reserved for environmental flows, IUAs are in net surplus relative to the Ecological Reserve requirements. Under the REC scenario, in which more surface water is reserved for environmental flows, several IUAs are in net deficit relative to current-day flows.

For each node with a deficit, the availability of local groundwater to cover such a deficit was determined from the quaternary catchment groundwater availability information. In cases of inadequate local groundwater availability, additional sources of water indicated in Golder (2016) were accepted as suitable for the purposes of this exercise. Nodal deficits are indicated in only two IUAs, namely D7, which includes the town of Oudtshoorn, and for which adequate groundwater is available, and in the Middle Breede (IUA A2 and A3). In IUA A2 and A3 there is insufficient groundwater available and a new surface water scheme is needed. For the other IUAs nodal deficits are indicated in nine IUAs, of which six require additional water sources beyond groundwater: For H16 a new surface water scheme could serve the Greater Hermanus area, while for H17 a groundwater scheme targeting the TMG could serve the Greater Gansbaai area. Local groundwater as well as the TMG aquifer could also potentially supply the shortfall in D7.

6.3.7 Socio-Economic Consequences

6.3.7.1 Water supply infrastructure costs

Applying the ESBC water requirements for certain IUAs requires additional infrastructure, whilst implementing the REC across the rest of the IUAs would mean allocating more water to the ecological Reserve, making the provision of water more expensive in these IUAs. However, the results indicate that while the water supply infrastructure costs are higher for the spatially targeted scenario than the costs under the ESBC, No EC and CC scenarios, they are significantly lower than the costs needed to meet demands under the REC scenario.

Table 6-6 Infrastructure construction costs required to cover water supply deficits relative to current-day water requirements for different scenarios with current-day water supply infrastructure (R million)

WMA portion	IUA	Costs of planned infrastructure costs (R million)	Total infrastructure costs to meet both demands and EWR requirements under each scenario.					
			Maintain PES	ESBC	REC	No EC Constraints	No EC (CC)	Spatially-targeted
Breede	B5	29.6	52.1	30.5	52.1	30.5	30.5	52.1
	H16	189.2	253.1	306.5	299.4	306.5	306.5	299.4
	H17	100	102.7	102.7	308	102.7	102.7	250.8
	F10	11.2	11.2	11.2	26.6	11.2	11.2	11.2
	A1	42.7	283.8	75.2	303.4	75.2	75.2	268.3
	A2 + A3	172	526.5	296	550.5	296	296	393.3
	B4	2.7	3.9	2.7	197.3	2.7	2.7	2.7
	F9	2.8	4.8	2.8	4.8	2.8	2.8	2.8
	F11	8	98.8	9.2	98.8	9.2	9.2	8.0
	Total	**558.2**	**1336.9**	**836.8**	**1840.8**	**836.8**	**836.8**	**1288.6**
Gouritz	E8	19.1	24.4	21.9	24.4	21.9	21.9	24.4
	C6	27.8	51.1	27.8	51.1	27.8	27.8	51.1
	D7	335.8	469.9	383.3	771.1	383.3	383.3	367.3
	F13	0	3.9	0	3.9	0	0	3.9
	F12	0	18.5	0	18.5	0	0	18.5
	I18	0	0	0	0	0	0	0.0
	G14	0	60.3	10.5	60.2	10.5	10.5	53.7
	G15	394	636.9	394	671.9	394	394	627.7
	Total	**776.6**	**1264.7**	**837.3**	**1601.1**	**837.3**	**837.3**	**1146.6**
Total for WMA		**1334.8**	**2601.6**	**1674.1**	**3441.9**	**1674.1**	**1674.1**	**2435.2**

6.3.7.2 Comparison of costs and benefits

The same approach, as described in section 5.8.2 above, for comparing costs and benefits was used here to compare the results from the spatially targeted scenario. The overall economic impact of each scenario was expressed in terms of the direct gains and losses of ecosystem services and water supply costs, expressed in present value terms. The gain and losses for the spatially targeted scenario compared to the EC scenarios is given in Table 6-9 and shown graphically in Figure 6-7. The results show that there is an overall economic gain under the spatially targeted scenario. The overall gain is only slightly less than the overall gain under the REC scenario and while the REC results in a larger change in EGSA value from present, the infrastructure costs required to meet demands under the spatially targeted are significantly lower than under the REC scenario. Therefore, the best outcome from an economic perspective appears to still be the allocation of the ecological REC. However, the overall economic impact of the spatially targeted scenario is not much different and does result in a positive outcome when compared to the current PES scenario, with lower infrastructure costs.

Table 6-7 Estimated differences in value of EGSA and in the costs of water supply infrastructure over the period 2017 to 2040 relative to maintain PES under the different scenarios, including the spatially targeted (ST) scenario.

	Change in EGSA value (R millions) relative to maintaining PES		Change in water supply infrastructure costs (R millions) relative to maintaining PES		Overall gain/loss (R millions, NPV @ 6%)
	Annual change in current terms	Overall change (PV)	Difference in value of infrastructure requirements	Difference in PV costs over 20 years relative to Maintain PES	
ESBC	-601	-8214	-928	532	-7682
REC	60	816	840	-482	334
NoEC	-32	-433	-928	532	99
No EC (CC)	-153	-2093	-928	532	-1561
ST	15.4	210	-166.4	95	306

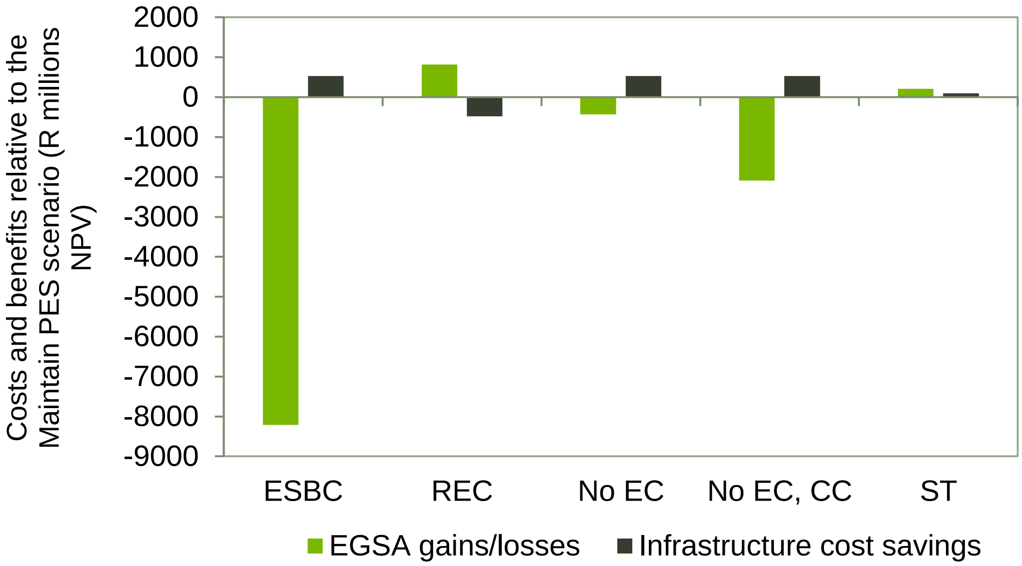


Figure 6-7 Changes in the present value of EGSAs and water infrastructure under alternative scenarios (including the spatially targeted scenario), relative to the Maintain PES scenario, using a discount rate of 6%.

6.3.7.3 Social impacts and Implications

The main social impacts of the scenarios are likely to be in the form of changes in the recreational usage and spiritual values of aquatic ecosystems to households. These values are very difficult to quantify, but can make a major difference to household wellbeing. The relative impacts of the different scenarios on these types of values is likely to follow the same pattern as for the tourism values. Thus, social values are maximised where the condition of ecosystems is closest to natural.

6.4 Final Proposed Water Resources Classes

The results of the final recommend classification scenario are used to determine the final proposed water resources class for each IUA based on the number of nodes of different EC in each IUA. The final proposed water resource class for each IUA in the Breede-Gouritz WMA are given in Table 6-8. In some cases, IUAs have been split to provide a clearer distinction between different water resources classes.

Table 6-8 Final proposed water resources classes for IUAs

Region	IUA		Spatially targeted	PES
Breede Overberg	Upper Breede Tributaries	A1	II	III
	Middle Breede Renosterveld	A2	III	III
	Breede Working Tributaries	A3	III	III
	Riviersonderend Theewaters	B4	III	III
	Lower Riviersonderend	F9	III	III
	Overberg West	B5	II	III
	Overberg West Coastal	H16	II	III
	Overberg East Renosterveld	F10	II	III
	Overberg East Fynbos	H17	II	III
	Lower Breede Renosterveld	F11	II	III
Gouritz Coastal	Gamka Buffels	C6	II	II
	Touws	E8	III	III
	Gouritz-Olifants	D7	III	III
	Lower Gouritz	F13	II	III
	Duiwenhoks	F12	III	III
	Hessequa	I18	III	III
	Groot Brak	G14	III	III
	Coastal	G15	II	II

6.5 Management considerations

A summary of the overall consequences of implementation of the proposed classification scenario for each IUA are given in Table 6-9 and Table 6-10.

Table 6-9 Summary of implications of the spatially targeted classification scenario for each IUA in the Breede-Overberg region of the WMA

IUA	Class	Description	Consequences of Implementation	Groundwater
A1	II	Upper Breede Tributaries (a)	• Upper Breede tributaries within the strategic water source area and Ceres Mountain Fynbos Nature Reserve/Hawequas Nature Reserve need to be maintained in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in four quaternary catchments (i.e. increases from category I to II or I to III). These four catchments are all in the H10 catchments of the Upper Breede Tributaries IUA. The increase in groundwater stress in two of the four is moderate, and the increase is fairly significant in the remaining two. This increase in stress relates to a change in groundwater category from I to II in two catchments; I to III in one catchment, and II to III in one catchment. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Upper Breede Tributaries (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Upper Breede tributaries outside of important conservation areas will be in a less natural state.	
A2	III	Breede Working Tributaries (a)	• Tributaries within Matroosberg MCA/Fonteintjiesberg Nature Reserve/Langeberg-Wes MCA/Dassieshoek Local NR need to be maintained in a good condition.	
		Breede Working Tributaries (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Although some river nodes are within strategic water source areas, these are not in a natural state and most will have a fair to poor condition. • Nuy River improves to a better condition, but is still in a poor condition.	
A3	III	Middle Breede Renosterveld (a)	• Tributaries within Brandvlei NR/Riviersonderend MCA/Vrolijkheid NR/Langberg Wes MCA/Marloth NR need to be maintained in a good condition.	
		Middle Breede Renosterveld (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Rivers are not in a natural state and most will have a poor condition.	
B4	III	Riviersonderend Theewaters (a)	• Upper tributaries within the strategic water source area and Hottentots-Holland NR/Theewaters NR//Hawequas NR/Riviersonderend NR need to be maintained in a good condition.	To achieve REC into the future, the groundwater status increases compared to PES in three quaternary catchments (i.e. increases from category I to II or I to III). These three catchments are all in the H60 catchments of the Riviersonderend Theewaters IUA. The increase in groundwater stress in these three catchments is moderate at two catchments, and significant at one catchment with an increase in the use/ recharge ratio ('stress') is from 0 to 66% at the H60D quaternary catchment. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Riviersonderend Theewaters (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Most river nodes will be in a poor condition.	
F9	III	Lower Riviersonderend (a)	• Upper tributaries in the Riviersonderend NR should be maintained in a good condition.	
		Lower Riviersonderend (b)	• Most river nodes will be in a poor condition.	
F11	II	Lower Breede Renosterveld (a)	• River nodes in the upper tributaries will be in a good condition (i.e. A to B Ecological Category).	Although there is an increase in total groundwater use for this scenario, the groundwater status

IUA	Class	Description	Consequences of Implementation	Groundwater
		Lower Breede Renosterveld (b)	• Certain river nodes (Leeu, Klip, Buffeljags and Slang) will be in an unacceptable condition.	does not change in any quaternary catchment.
H16	II	Overberg West Coastal	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Swart river node will be in an unacceptable condition, and Onrus river node improved from baseline but will still be in a poor condition (i.e. C to below D Ecological Category). • Buffels and Rooiels will be in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in four (of six) quaternary catchments. These four catchments include all those of the Overberg West Coastal, plus G40C of the Overberg West IUA. The increase in groundwater stress in these four catchments is moderate, with each catchment increasing its status by one equivalent category (i.e. increases from category I to II or II to III). One of the quaternary catchments impacted by a change in category (G40H) has been identified as having a high GWBF/EWR ratio, indicating groundwater contribution to baseflow has the potential to sustain the EWR. Abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.
B5	II	Overberg West (a)	• The nodes at the bottom of the catchment should be maintained in a good condition (i.e. B to C Ecological Category).	
		Overberg West (b)	• Although there are regions within the Overberg West IUA that are of conservation importance, the surrounding land use in most cases has led to degraded systems.	
F10	II	Overberg East Renosterveld	• Hartbees and Steenbok will be in a poor condition.	To achieve this scenario, the groundwater status increases compared to PES in one quaternary catchment (G40L, located in Overberg East Fynbos IUA). The increase in groundwater stress in this catchment is fairly significant, with the catchment increasing its use/ recharge ratio ('stress') from 19 to 88%. The quaternary catchment impacted by a change in category has not been identified as having a high GWBF/EWR ratio.
H17	II	Overberg East Fynbos (a)	• Kleinmond/Heuningnes/De Hoopvlei Ramsar wetlands need to be maintained in a good condition. • Upper tributaries in Walker Bay NR/Salmonsdam NR/Uitkraalsmond NR/Pearly beach NR/Algulhas NP/Quion Point NR/Algulhas NP/Soetendalsvlei NR/Heuningberg NR/Waenhuiskrans NR/De Hoop NR are to be maintained in a good condition.	
		Overberg East Fynbos (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Limited change from baseline condition. Conditions of river nodes are fair to poor. • De Hoop Vlei and Klipdrifsfontein will be maintained in a good condition.	

Table 6-10 Summary of implications of the spatially targeted classification scenario for each IUA in the Breede-Coastal region of the WMA

IUA	Class	Description	Consequences of Implementation	Groundwater
F12	III	Duiwenhoks (a)	• Upper tributaries in the Langeberg-Oos MCA/Boosmansbos/Garcia NR should be maintained in a good condition.	Although there is an increase in total groundwater use for this scenario, the groundwater status does not change in any quaternary catchment.
		Duiwenhoks (b)	• This flow regime meets the REC of D for giii8 (Duiwenhoks River). • The river node associated with Duiwenhoks wetland remains in an unacceptable condition. • Despite flowing relatively naturally, a range of agricultural impacts such as clearing of riparian vegetation for cultivation and infilling in cultivated areas have meant that the rivers of the Duiwenhoks and Hessequa are in moderate to poor condition. • Flow requirements are met for the REC of C/D at giii7 (Goukou River) with 80% of natural flows.	
I18	III	Hessequa	• The ecological condition of the Duiwenhoks and the Goukou estuaries will be B and C, respectively, which is lower than the Recommended Ecological Condition of A and B, respectively.	
E8	III	Touws (a)	• Tributaries within Bokkeriviere NR/Touw Local Authority NR/Anysberg NR/Warmwaterberg NR/Klein Swartberg MCA/Towerkop NR/Ladismith Klein Karoo/Rooiberg MCA/Wolwekop NR/Langeberg East MCA are to be maintained in a good condition.	To achieve this scenario into the future, the groundwater status increases compared to PES in two quaternary catchments. These two catchments are J12B and J13C; located at the northwest (upstream) and southeast (downstream) extremities of the catchment respectively. The increase in groundwater stress in J12B is significant, with an increase in its use/ recharge ratio ('stress') from 2 to 100%, corresponding for a change in status category from I to III. The change at J13C is moderate. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Touws (b)	• Ysterdams, Donkies and upper Touws rivers at the upper reaches of this region and the upper Groot River will remain in poorer condition.	
C6	II	Gamka-Buffels (a)	• Most river nodes will be in a good condition.	No increase in groundwater use.
		Gamka-Buffels (b)		There is a minor increase in groundwater use in this scenario (compared to PES), however there is no change in groundwater status category for any quaternary catchments within the IUA.
D7	III	Gouritz-Olifants (a)	• Tributaries within Klein Swartberg MCA/Grootswartberg MCA/Swartberg East NR/Kammanassie MCA/Rooiberg MCA/Gamkaberg NR/Doringrivier Wilderness area are to be maintained in a good condition.	

IUA	Class	Description	Consequences of Implementation	Groundwater
		Gouritz-Olifants (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Olifants, Grobbelaars and Kammanassie river nodes will be in a very poor condition. Other nodes are in a fair to poor condition.	To maintain PES into the future, the groundwater status increases compared to PES in seven quaternary catchments. These catchments are in the J25 (west of the IUA, west of Gamka River) and J33 and J35 catchments (centre of IUA) of the Gouritz-Olifants IUA. The increase in groundwater stress in these catchments is moderate to significant, and the increase in the use/ recharge ratio ('stress') ranges from 0 to 20% under current PES, to 26 to 97% at the quaternary catchments. Four of the seven change from a groundwater status of I to III. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
F13	II	Lower Gouritz	• The river and estuary nodes will remain in a baseline condition.	
G14	III	Groot Brak	• Groot Brak estuary will remain in an unacceptable condition.	To achieve this scenario, the groundwater status increases compared to PES in one quaternary catchment (K20A in the east of the IUA). The increase in groundwater stress in these catchments is low, with the catchment increasing in use/recharge ratio ('stress') from 1% to 24%, corresponding to a change in category from I to II. The catchment K20A has a high GWBF/EWR ratio, and abstraction would need to be carefully managed to ensure impacts on GWBF do not impact on the flow required for the associated EC.
G15	II	Coastal (a)	• Rivers and estuaries need to be maintained in a good condition.	To maintain PES into the future, the groundwater status increases compared to PES in two quaternary catchments. These catchments are K30C and K30B around George. The increase in groundwater stress is moderate, with an increase in its use/ recharge ratio ('stress') from between 2 and 5% under current PES, to between 39 and 40% in future respectively, corresponding for a change in status category from I to II. None of the quaternary catchments impacted by a change in category have been identified as having a high GWBF/EWR ratio.
		Coastal (b)	• High infrastructure costs to implement REC therefore water requirements for the ESBC used. • Most river and estuary nodes will be maintained in a good condition.	

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Appendix A: Detailed modelling results for the Spatially Targeted scenario

Appendix B: Groundwater tables