






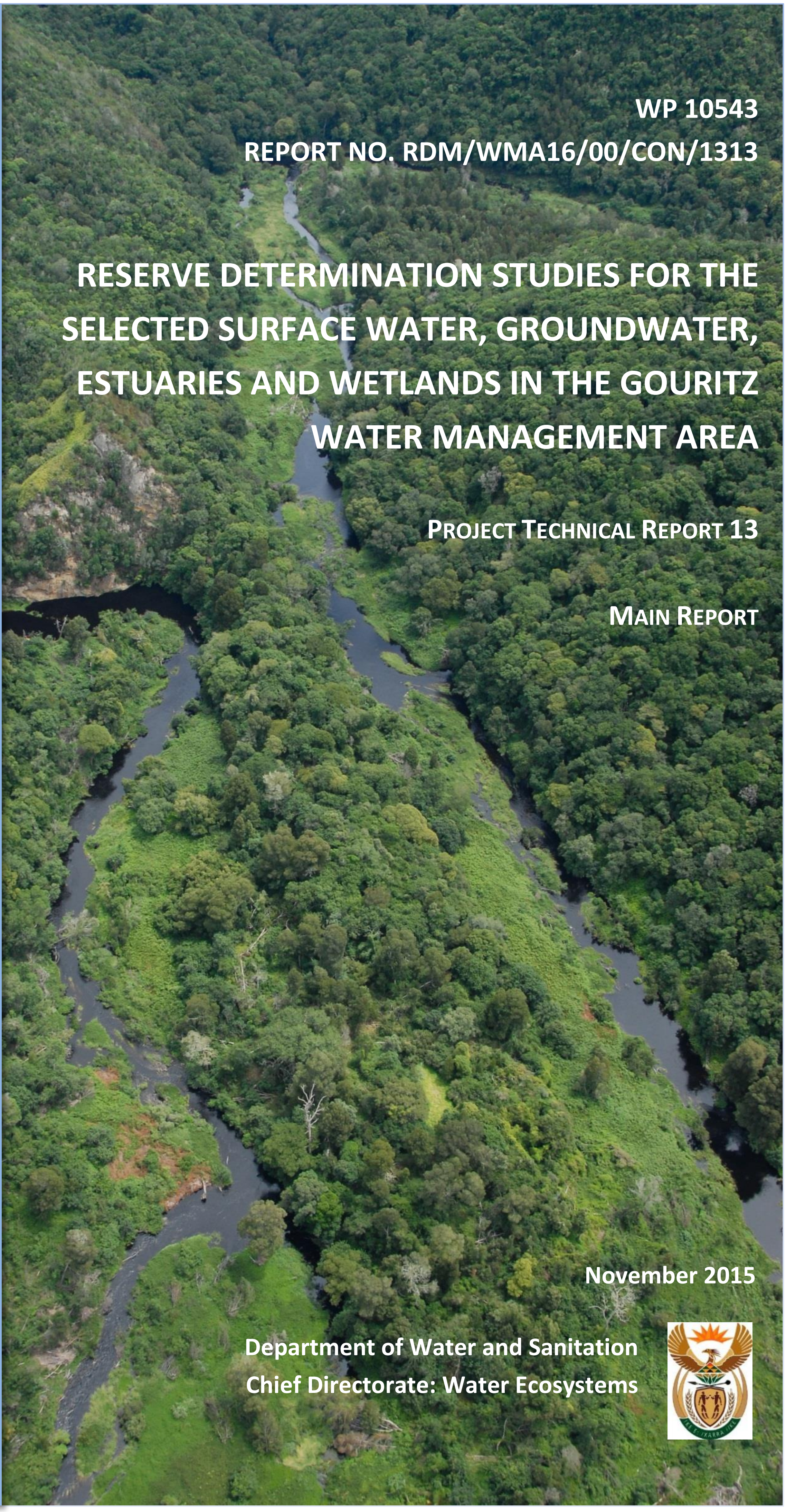

WP 10543

REPORT NO. RDM/WMA16/00/CON/1313

RESERVE DETERMINATION STUDIES FOR THE SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE GOURITZ WATER MANAGEMENT AREA

PROJECT TECHNICAL REPORT 13

MAIN REPORT

November 2015

Department of Water and Sanitation

Chief Directorate: Water Ecosystems

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DOCUMENT INDEX

Reports as part of this project:

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Report Number 03, Volume 2	RDM/WMA16/00/CON/0313, Volume 2	Delineation Report, Volume 2 (Rivers)
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Bold indicates this report.

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DATE:	November 2015
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REPORT SCHEDULE

Version	Date
First draft and final report	November 2015

EXECUTIVE SUMMARY

BACKGROUND

The requirement for detailed Reserve studies in the Gouritz Water Management Area (WMA) became apparent for the following reasons:

- *Various licence applications in the area.*
- *Gaps that had been identified as part of the Outeniqua Reserve Determination Study (ORDS) completed in 2010.*
- *The conservation status of various priority water resources in the catchment and existing and proposed impacts on them.*
- *Increasing development pressures and secondary impacts related from the aforementioned and the subsequent impact on the availability of water.*

Although it is acknowledged that the Breede and Gouritz WMAs have been consolidated, the focus of this study is the Gouritz River and its associated catchments. Therefore the study area was described in terms of the original WMA; the Gouritz WMA – WMA 16.

All information presented in this report is taken from the relevant documents produced during the Gouritz Reserve Determination Study (GRDS). The purpose of this document is to provide a summarised overview of the main results of the GRDS. Sub-sections below refer to the objectives for each component of the Reserve study, and the relevant section where results can be found in the Main Report.

ECONOMIC OVERVIEW

The table below presents the status quo results of the five identified economic regions (ERs) in the WMA as represented by the water dependent activities expressed in macro–economic parameters.

- *ER 1: Coastal (Tertiary catchments K10, K20, K30, K40, K50, K60 and K70).*
- *ER 2: Olifants (Tertiary catchments J31, J32, J33, J34 and J35).*
- *ER 3: Gamka (Tertiary catchments J21, J22, J23, J24 and J25).*
- *ER 4: Goukou, including Gouritz/Duiwenhoks (Tertiary catchments J40D, H80 and H90).*
- *ER 5: Touws, including Buffels/Groot (Tertiary catchments J11, J12 and J13).*

Economic Sector	GDP[1] (R million)			Employment (Numbers)			Household Income (R million)		
	Direct	Indirect	Total	Direct	Indirect	Total	Total	Medium	Low
Agriculture	1 483.26	1 519.66	3 002.92	17 559	14 875	32 434	3 071.00	2 251.54	819.46
Commercial	294.76	193.61	488.38	3 266	1 697	4 963	350.47	226.97	123.50
Saw Mills	-	-	-	-	-	-	-	-	-
Mining	-	-	-	-	-	-	-	-	-
Electricity	-	-	-	-	-	-	-	-	-
Industry	13 386.63	9 220.76	22 607.38	5 007	34 174	39 181	15 392.76	9 038.98	6 50.82
Tourism	3 225.14	2 840.76	6 065.90	28 722	9 896	38 618	4 970.51	3 663.03	130 748
Total	**18 389.79**	**13 774.79**	**32 164.58**	**54 554**	**60 643**	**11 517**	**23 784.74**	**15180.52**	**860 126**

1 Gross Domestic Product

The contribution by water to economic growth in the WMA as represented by direct GDP is over R18 000 million per annum, mainly driven by Mossgas in the industry sector (Table above). Overall in the Gouritz WMA tourism is the major direct employment creator with 28 700, followed by agriculture with 17 500, industry with 5 000 and commercial forestry, lagging far behind, with 3 200 employment opportunities. The table below shows the most dominant sector per ER.

ER1	ER2	ER3	ER4	ER5
Tourism by far followed by forestry and industry (saw mills, dairy factories and Mossgas)	*Agriculture leads by far followed by tourism*	*Tourism and agriculture virtually share the honour*	*Agriculture leads by far followed by limited tourism*	*Agriculture leads by far followed by tourism*

AIMS, OBJECTIVES AND OUTCOMES OF THE STUDY

Objectives

The summarised aims, objectives and proposed outcomes of the Reserve study were as follows:

- *Conduct a desktop EcoClassification (rivers) on a sub-quaternary (SQ) scale to determine the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), Recommended Ecological Category (REC), causes and sources and identify hotspots.*
- *Conduct a reconnaissance survey and together with the output of the desktop EcoClassification, select Ecological Water Requirement (EWR) sites in selected rivers.*
- *Determine the Reference Condition (RC), PES and RECs for each relevant section of the rivers, estuaries, wetlands and groundwater components.*
- *Determine and recommend Ecological Categories (ECs) for each relevant section of the rivers, estuaries, wetlands and groundwater components.*
- *Determine EWR for the selected resources at the EWR sites.*
- *Evaluate and select water resource operational scenarios for consideration during the study.*
- *Determine the impact of scenarios on systems in question where information regarding the scenarios was available.*
- *Determine the ecological consequences of these scenarios.*
- *Provide the DWS with all information relevant to the RECs and Alternative ECs (where conducted) to enable DWS to recommend an Ecological Reserve Category at the relevant EWR site for the protection and management of the water resources in the study area. The latter will be captured in the legal template to be approved and to be included in future water allocation and operating rules from infrastructure.*
- *Provide the ecological specifications associated with the selected EC, and provide vital information as input into the development of monitoring programmes for water resources.*
- *Provide the DWS with all relavent data (raw data, populated models and shape files used in the generation of maps) in electronic format.*
- *Prepare the surface and groundwater Basic Human Needs Reserve (BHNR) for water use directly from rivers and boreholes.*
- *Provide CD: WE with the information required to prepare the Reserve templates, including draft templates, for authorization.*
- *Train selected DWS Directorate: Reserve Requirements (D:RR) staff in specific tasks relating to Reserve determinations.*

Rivers

Ten EWR sites were selected in the study area. These EWR sites are listed below.

EWR site name	SQ reach	River	MRU[1]	Latitude	Longitude	Eco-Region (Level II)	Geo[2] Zone	Alt[3] (m)	Quat[4]
H8DUIW-EWR1	H80E-09314	Duiwen-hoks	MRU Duiwenhoks C	S34.25167	E20.99194	22.02	E Lower Foothills	15	H80E
H9GOUK-EWR2	H90C-09229	Goukou	MRU Goukou A	S34.09324	E21.29300	22.02	E Lower Foothills	87	H90C
J1TOUW-EWR3	J12M-08904	Touws	MRU Touws B	S33.72707	E21.16507	19.07	E Lower Foothills	271	J12M
J2GAMK-EWR4	J25A-08567	Gamka	MRU Gamka B	S33.36472	E21.63051	19.09	E Lower Foothills	375	J25A
J1BUFF-EWR5	J11H-08557	Buffels	MRU Buffels B	S33.38452	E20.94169	19.09	E Lower Foothills	499	J11H
J4GOUR-EWR6	J40B-09106	Gouritz	MRU Gouritz A	S33.90982	E21.65233	19.08	E Lower Foothills	121	J40B
J1DORI-EWR7	J12L-09895	Doring		S33.79137	E20.92699	19.07	E Lower Foothills	370	J12L
K6KEUR-EWR8	K60C-09882	Keur-booms	MRU Keurbooms B	S33.88955	E23.24392	20.02	D Upper Foothills	161	K60C
J3OLIF-EWR9	J31D-08592	Olifants	MRU Olifants A	S33.43813	E23.20587	19.01	E Lower Foothills	621	J31D
J3KAMM-EWR10	J34C-8869	Kamma-nassie	MRU Kammanassie A	S33.73286	E22.69740	19.01	E Lower Foothills	445	J34C

1 Management Resource Unit　　2 Geomorphic　　3 Altitude　　4 Quaternary catchment

Estuaries

The Gouritz WMA includes 21 estuaries stretching from the Duiwenhoks Estuary in the west to the Bloukrans Estuary in the east. Within this WMA, 11 estuaries have been assessed a part of previous EWR studies and the GRDS therefore focused on the remaining 10 estuaries (listed below). Of the 11 estuaries that was assessed previously, EWR assessments on eight of those did not define Ecological specifications (referred to in this document as EcoSpecs) and Thresholds of Potential Concern (TPCs), nor were monitoring programmes provided. Therefore, the GRDS also defined such parameters and programmes for those eight estuaries (see below).

Estuary	EWR level	EcoSpecs/TPCs	Monitoring programme
Duiwenhoks	*Intermediate (GRDS study)*	✓	✓
Goukou	*Intermediate (GRDS study)*	✓	✓
Gourits	*Intermediate (GRDS study)*	✓	✓
Blinde	*Desktop (GRDS study)*	✓	✓
Hartenbos	*Desktop (GRDS study)*	✓	✓
Klein Brak	*Rapid (GRDS study)*	✓	✓
Maalgate	*Desktop (previous EWR) (DWA, 2009a)*	✓	✓
Gwaing	*Desktop (previous EWR) (DWA, 2009a)*	✓	✓
Kaaimans	*Desktop (previous EWR) (DWA, 2009a)*	✓	✓
Wilderness	*Rapid (GRDS study)*	✓	✓
Goukamma	*Rapid (previous EWR) (DWA, 2009b)*	✓	✓
Noetsie	*Desktop (previous EWR) (DWA, 2009a)*	✓	✓
Piesang	*Desktop (GRDS study)*	✓	✓
Keurbooms	*Rapid (previous EWR) (CSIR, 2008)*	✓	✓
Matjies	*Intermediate (previous EWR) (Bornman, 2007a)*	✓	✓
Sout (Oos)	*Intermediate (previous EWR) (Bornman, 2007b)*	✓	✓
Groot (Wes)	*Desktop (GRDS study)*	✓	✓
Bloukrans	*Desktop (GRDS study)*	✓	✓

Results

*Results are shown in **Chapters 5 – 7** for rivers and estuaries where information on delineation, EcoClassification and EWRs is provided.*

BASIC HUMAN NEEDS RESERVE

*The prescribed minimum standard of water supply services necessary for the reliable supply of a sufficient quantity and quality of water to households not supplied directly from a formal water service delivery system and thus directly dependent on the resource for support life and personal hygiene is provided in **Chapter 8**.*

WETLANDS

*Results can be found in **Chapter 9.** Two high priority wetlands, the Duiwenhoks unchannelled valley bottom, a large palmiet-dominated wetland, and the Bitou floodplain, were assessed in the field. Both wetlands had a moderate importance. The Duiwenhoks was in a D EC, largely due to extensive erosion of the palmiet wetland. The Bitou wetland was in a C EC, largely attributable to landuse conversion. Like many wetlands across the WMA, the impacts of invasive alien vegetation were ubiquitous and the removal and control of woody alien trees could greatly reduce or even reverse some of the wetland degradation in the region.*

GROUNDWATER

*Results of the groundwater study can be found in **Chapter 10** of this report. The objectives of the study were as follows:*

- *Perform a Desktop-Rapid level groundwater Reserve determination for the entire Gouritz WMA to identify hotspots/areas of water resource concern and areas in the WMA where limited groundwater is available after the Reserve is allocated;*
- *Perform Intermediate groundwater Reserve determinations for selected catchments/ Groundwater Resource Units (GRUs) that are classified as stressed based on the classification of the desktop Reserve; and*
- *Report on groundwater Reserve figures and findings for the WMA and selected GRUs and make recommendations on where more detailed future studies should be performed.*

CONCLUSIONS: PRELIMINARY ECOLOGICAL RESERVE CATEGORIES

*The Ecological Reserve Categories associated with the Preliminary Reserve provided in **Chapter 12** were arrived at through consideration of driving ecological considerations in the study area, an evaluation of future developments and associated scenarios where available, and discussions with the DWS in September 2015, and stakeholders at two meetings in October 2013 and October 2015. Final recommendations are presented per river and estuary system, and for priority wetlands in the study area.*

CAPACITY BUILDING

Appendix A presents and discusses capacity building opportunities offered during the study for DWS staff, as well as feedback from departmental staff regarding training.

TRAINING WORKSHOP AGENDAS

Appendix B presents agendas for the three training workshops presented during 2014 and 2015.

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ACRONYMS

Alt	Altitude
BAS	Best Attainable State
BHNR	Basic Human Needs Reserve
BPD	Barrels Per Day
CD: WE	Chief Directorate: Water Ecosystems
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMA	Catchment Management Agency
CSIR	Council for Scientific and Industrial Research
CWAC	Coordinated Waterbird Counts
D: RQIS	Directorate: Resource Quality Information Services
D:RR	Directorate: Reserve Requirements
DAFF	Department of Agriculture, Forestry and Fisheries
DAGEOS	Deep Artesian Groundwater Exploration for Oudtshoorn Supply
DAWC	Department of Agriculture Western Cape
DEA	Department of Environmental Affairs
DO	Dissolved Oxygen
DSS	Decision Support System
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EcoSpecs	Ecological Specifications
EFZ	Estuarine Functional Zone
EHI	Estuarine Health Index
EI	Ecological Importance
EIS	Ecological Importance and Sensitivity (Applicable to sections pertaining to Rivers and Wetlands)
EIS	Estuarine Importance Score (Applicable to sections pertaining to Estuaries)
ER	Economic Region
ES	Ecological Sensitivity
EWR	Ecological Water Requirement
EWRM	Ecological Water Resources Monitoring
FEFLOW	Finite Element subsurface FLOW system
GDP	Gross Domestic Product
Geo	Geomorphic
GIS	Geographic Information System
GRAII	Groundwater Resource Assessment Phase II
GRDM	Groundwater Reserve Determination Methodology
GRDS	Gouritz Reserve Determination Study
GRUs	Groundwater Resource Units
GTL	Gas To Liquids
GYMR	Groundwater Yield Model for the Reserve
HDI	Historically Disadvantaged Individuals
HFSR	Habitat Flow Stressor Response method
HGM	Hydrogeomorphic

IEI	Integrated Environmental Importance
IERM	Intermediate Ecological Reserve Methodology
IHI	Instream Habitat Integrity
KKRWSS	Klein Karoo Rural Water Supply Scheme
magl	metres above ground level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	metres below ground level
MPA	Marine Protected Area
MRU	Management Resource Unit
MSL	Mean Sea Level
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Area
nMAR	natural Mean Annual Runoff
NMMU	Nelson Mandela Metropolitan University
NRU	Natural Resource Unit
NWA	National Water Act (1998)
NWRCS	National Water Resource Classification System
OCWSS	Outeniqua Coast Water Situation Study
ORDS	Outeniqua Reserve Determination Study
PES	Present Ecological State
pMAR	Present Day Mean Annual Runoff
PSP	Professional Service Provider
Quat	Quaternary catchment
RAU	Reserve Assessment Unit
RC	Reference Condition
RDRM	Revised Desktop Reserve Model
REC	Recommended Ecological Category
REI	River Estuary Interface
RHAM	Rapid Habitat Assessment Method
RO	Regional office
RQO	Resource Quality Objectives
RU	Resource Unit
SAFCOL	South African Forestry Company Limited
SASS5	South African Scoring System version 5
SCI	Socio-Cultural Importance
SQ	Sub Quaternary
TMG	Table Mountain Group
TOR	Terms of Reference
TPC	Threshold of Potential Concern
VEGRAI	Vegetation Response Assessment Index
WfWetlands	Working for Wetlands
WMA	Water Management Area
WRC	Water Resource Classification
WRU	Wetland Resource Unit
WRUI	Water Resource Use Importance
WRYM	Water Resources Yield Model
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The National Water Act (Act No. 36 of 1998) (NWA), Section 3 requires that the Reserve be determined for water resources, i.e. the quantity, quality and reliability of water needed to sustain both human use and aquatic ecosystems, so as to meet the requirements for economic development without seriously impacting on the long-term integrity of ecosystems. The Reserve is one of a range of measures aimed at the ecological protection of water resources and the provision of basic human needs (i.e. in areas where people are not supplied directly from a formal water service delivery system and thus directly dependent on the resource according to Schedule 1 of the NWA). Chief Directorate: Water Ecosystems (CD: WE) within Department Water and Sanitation (DWS) is tasked with the responsibility of ensuring that the Reserve is considered before water allocation and licensing can proceed.

The requirement for detailed Reserve studies in the Gouritz Water Management Area (WMA) became apparent for the following reasons:

- Various licence applications in the area.
- Gaps that had been identified as part of the Outeniqua Reserve Determination Study (ORDS) completed in 2010.
- The conservation status of various priority water resources in the catchment and existing and proposed impacts on them.
- Increasing development pressures and secondary impacts related from the aforementioned and the subsequent impact on the availability of water.

For management and improved governance reasons, South Africa's 19 WMAs have been consolidated into nine (9) WMAs. The Gouritz WMA (previously WMA 16) now forms part of the previous Breede WMA (WMA 8) which now is known as the Breede-Gouritz WMA. It will be governed by the Breede-Gouritz Catchment Management Agency (CMA).

1.2 STUDY AREA OVERVIEW

Although it is acknowledged that the Breede and Gouritz WMA have been consolidated into WMA 8, the focus of this study is the Gouritz River and its associated catchments. The study is therefore described in terms of the original WMA; the Gouritz WMA – WMA 16.

The Gouritz WMA (WMA16) is situated on the south coast of the Western Cape, largely falling within the Western Cape Province, and with a surface area of approximately 53 000 km^2. It consists of primary drainage region J (approximately 90 quaternary catchments), and part of primary drainage regions K (K1 to K7) and H (H8 to H9). The WMA therefore consists of approximately 100 - 105 quaternary catchments. It consists of the large dry inland area that is comprised of the Karoo and Little Karoo, and the smaller humid strip of land along the coastal belt. The main rivers are the Gouritz and its major tributaries, the Buffels, Touws, Groot, Gamka, Olifants and Kammanassie rivers, with smaller coastal rivers draining the coastal belt. All the inland rivers drain via the Gouritz into the Indian Ocean. The Mean Annual Precipitation (MAP) varies from as high as 865 mm in the coastal areas, which experience all year round rainfall, to as little as 160 mm in the drier areas inland to the north, which experience late summer rainfall.

The Gouritz River is controlled by several dams in its tributaries, including Kammanassie, Stompdrift, Koos Raubenheimer, Leeu-Gamka, Gamkapoort and Floriskraal dams. Several dams have been constructed on the coastal rivers, the largest of which being the Wolwedans Dam. About 41 % of the total surface runoff from the WMA comes from the catchment of the Gouritz River, which covers the bulk of the land in the WMA. A further 46% flows from the Coastal sub-area, while the remaining 13% is contributed by the rivers west of the Gouritz River (CMA proposal; DWAF, 2005).

Forestry and agriculture are the two primary activities in the WMA. Most of the afforestation on the coastal belt, primarily in the Plettenberg Bay / Knysna area (K1 – 7) is indigenous forestry. Most irrigation (as at 2005) is opportunistic and lucerne is predominantly grown. Grapes and apples are also grown in the Langkloof area and there is significant ostrich farming near Oudtshoorn.

The coastal belt boasts extensive eco-tourism, with the WMA also having several areas that are ecologically sensitive and important. These include the upper river reaches of the Dwyka, Leeuw and Gamka rivers in the interior; and the Keurbooms, Knysna and South Cape Coastal system rivers, along the coast. Many of the wetland and estuary systems in the area have not been studied in detail. A map of the study area is provided below (**Figure 1.1**).

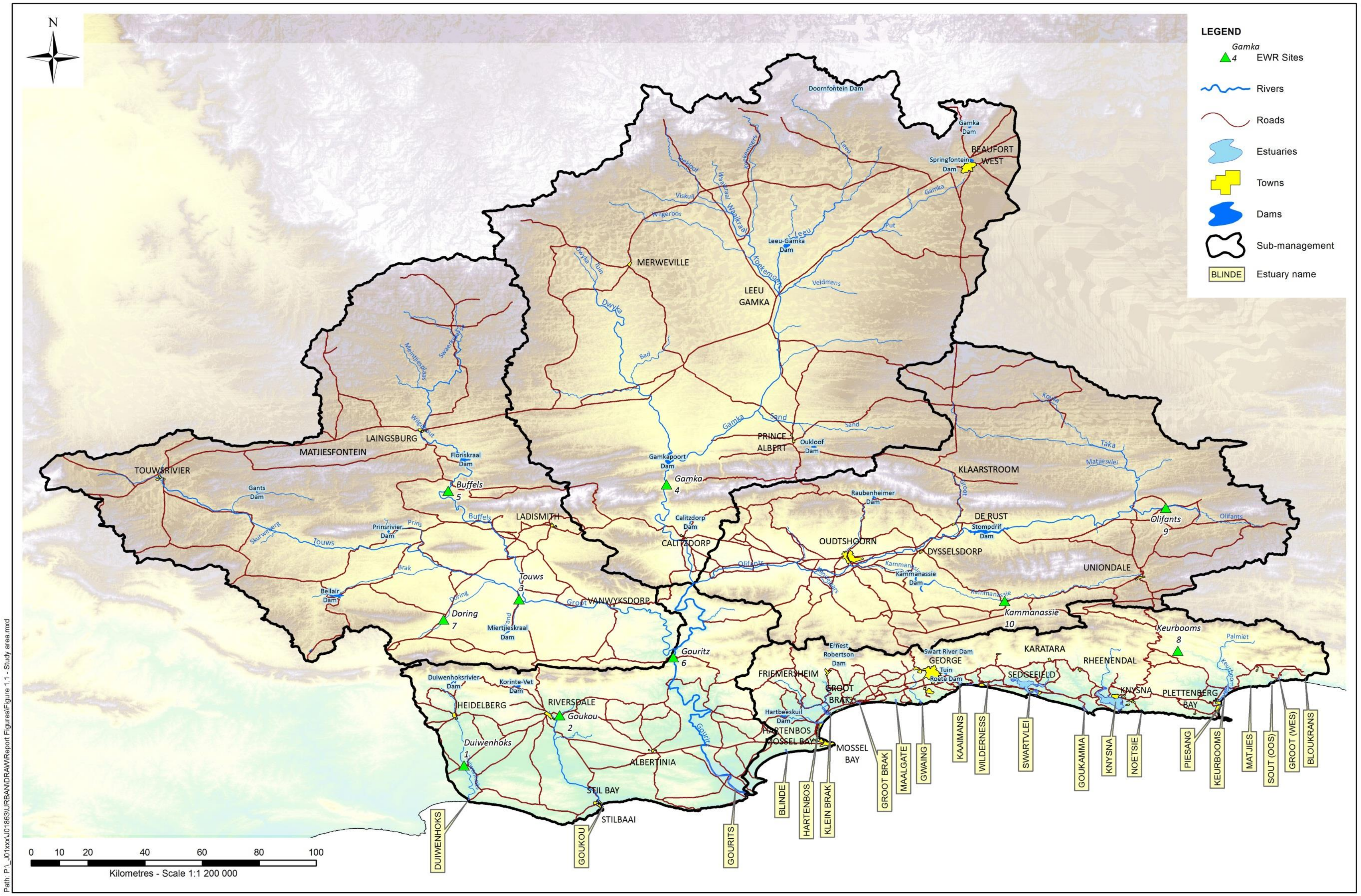

Figure 1.1 Study area

1.3 PROJECT PLAN AND APPROACH

1.3.1 Aims, objectives and outcomes of the study

The Gouritz Reserve Determination Study (GRDS) is an integrated study to determine the Preliminary Reserves of selected surface and groundwater resources, estuaries and wetlands was undertaken for the Gouritz part of WMA 8. The focus of the study was on providing detailed ecological information as input to Water Resource Classifcation (WRC), which will be initiated for the Breede-Gouritz WMA during 2016.

The specific objectives and outcomes of the Reserve determination for the different aquatic ecosystems were to:

- Conduct a desktop EcoClassification (rivers) on a Sub Quaternary (SQ) scale to determine the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), Recommended Ecological Category (REC), causes and sources and identify hotspots.
- Conduct a reconnaissance survey and together with the output of the desktop EcoClassification, select Ecological Water Requirement (EWR) sites in selected rivers.
- Determine the Reference Condition (RC), PES and RECs for each relevant section of the rivers, estuaries, wetlands and groundwater components.
- Determine and recommend Ecological Categories (ECs) for each relevant section of of the rivers, estuaries, wetlands and groundwater components.
- Determine EWR for the selected resources at the EWR sites.
- Evaluate and select water resource operational scenarios for consideration during the study.
- Determine the impact of scenarios on systems in question where information regarding the scenarios was available.
- Determine the ecological consequences of these scenarios.
- Provide DWS with all information relevant to the RECs and Alternative ECs (where available) to enable DWS to recommend an Ecological Reserve Category at the relevant EWR site for the protection and management of the water resources in the study area. The latter will be captured in the legal template to be approved and to be included in future water allocation and operating rules from infrastructure.
- Provide the ecological specifications associated with the selected EC, and provide vital information as input into the development of monitoring programmes for water resources.
- Prepare the surface and groundwater Basic Human Needs Reserve (BHNR) for water use directly from rivers and boreholes.
- Provide DWS with all relavent data (raw data, populated models and shape files used in the generation of maps) in electronic format.
- Provide CD: WE with the information required to prepare the Reserve templates, including draft templates, for authorization.
- Train selected DWS Directorate: Reserve Requirements (D:RR) staff in specific tasks relating to Reserve determinations.

1.3.2 Project plan

The GRDS was structured into two main components, namely:

- Project Management Component, led by Dr Aldu Le Grange of AECOM SA (Pty) Ltd. (AECOM), and
- Technical Component (Reserve determination studies), led by Dr Patsy Scherman of Scherman Colloty and Associates cc.

Technical project-related activities were grouped into study tasks provided in **Table 1.1** and adopted for the Technical Component of the GRDS:

Table 1.1 GRDS Technical Component task structure

Task A: Project Management
Task B: Project Inception
Task C: Desktop Ecoclassification and Hotspot Identification: Rivers
Task C1: EcoSystem services component (i.e. socio-economics)
Task C2: Rivers ecological and water quality components
Task C3: Water Resource Use Importance
Task C4: Desktop EcoClassification Report
Task D: Reconnaissance and Cross-sectional Surveys: Rivers
Task D1: Survey 1
Task D2: Survey 2
Task E: Delineate Resource Units and Delineation Report
Task E1: Rivers
Task E2: Estuaries
Task E3: Wetlands
Task E4: Groundwater
Task E5: Delineation Report
Task F: Field Surveys
Task F1: Estuarine summer surveys
Task F2: River biophysical survey 1
Task F3: River biophysical survey 2
Task F4: High flow surveys
Task F5: Groundwater field survey (hydrocensus and groundwater sampling)
Task F6: Wetlands field survey: Rapid assessment
Task F7: Wetlands field survey: Priority wetlands
Task G: Data Analysis - Estuaries
Task G1: Desktop Assessment - Hartenbos, Blinde, Piesang, Groot (Wes), Bloukrans estuaries
Task G2: Rapid Level - Duiwenhoks, Klein Brak and Touw/Wilderness estuaries
Task G3: Rapid/Intermediate Level - Goukou and Gouritz estuaries
Task H: Data Analysis - Rivers
Task H1: Analysis of data: EcoClassification for rivers
Task H2: Hydraulic data analysis and hydraulic modelling
Task I: Data Analysis - Wetlands
Task I1: Identification of priority wetlands
Task I2: Determining RC, PES, EIS
Task I3: Provide management recommendations and produce Wetland Report
Task J: Rapid Reserve - Groundwater
Task J1: Data collection and analysis

Task J2: Develop a conceptual groundwater model
Task J3: Short report on data gaps, groundwater sources, sinks and Basic Human Needs Reserve (groundwater)
Task K: Reserve Determination of the Groundwater Component (Qualitative and Quantitative) - Groundwater Reserve Determination Methodology
Task K1: Update groundwater conceptual model
Task K2: Conduct Reserve assessment
Task K3: Produce Groundwater Report
Task L: Hydrology, Yield Modelling and Operational Scenarios
Task L1: Evaluation of hydrology and compilation of flow records at all points of interests
Task L2: System modelling and yield analysis
Task L3: Water balances
Task L4: Liaison regarding scenarios and defining scenarios
Task L5: Running scenarios
Task M: Estuary EWR Assessments (Workshops), including EcoSpes and Monitoring Plans
Task M1: EWR workshop on the Hartenbos, Blinde, Piesang, Groot (Wes), Bloukrans, Duiwenshok, Klein Brak and Touw/Wilderness
Task M2: EWR workshop on Goukou and Gouritz estuaries
Task N: River EWR Determination (Workshops), including Consequences to Operational Scenarios and Reports
Task N1: Intermediate specialist meeting
Task N2: Rapid assessment
Task N3: Reports
Task O: Basic Human Needs Reserve (surface water)
Task P: Consequences to Operational Scenarios – Rivers and Estuaries
Task P1: Rivers / Wetlands
Task P2: Estuaries
Task P3: Economics
Task P4: Ecological Services
Task Q: Estuary Reports
Task Q1: Desktop Assessment Report - Hartenbos, Blinde, Piesang, Groot (Wes) and Bloukrans estuaries
Task Q2: Rapid Level EWR Report - Duiwenhoks, Klein Brak and Touw/Wilderness estuaries
Task Q3: Rapid/intermediate Level EWR Report - Goukou and Gouritz estuaries
Task R: Ecological and Other Objectives
Task R1 Ecological Specifications and Thresholds of Potential Concern: Rivers
Task R2: Wetland objectives
Task R3: Groundwater objectives and monitoring programme
Task S: Stakeholder Engagement
Task S1: Input to advertisements, Background Information Document, etc.
Task S2: Public meeting at start of study, October 2013
Task S3: Public meeting at end of study
STUDY TERMINATION PHASE
Task T: Integrated Main Report
Task U: Training Workshops
Task U1: Training Workshop 1 – Introduction and Rivers (East London)
Task U2: Training Workshop 2 – Estuaries and Wetlands (Cape Town)
Task U3: Training Workshop 3 – Modelling, Groundwater and Economics (Cape Town)
Task U4: Training Report – Appendix to the Main Report

1.4 OUTLINE OF THIS REPORT

The report outline is as follows:

- **Chapter 1** provides general background to the GRDS.
- **Chapter 2** represents and Economic Overview of the study area.
- **Chapters 3 to 6** summarises the river results for the study, as follows:
    - The desktop ecological classification process for the rivers in the study area and the identification of river hotspots are shown in **Chapter 3**.
    - **Chapter 4** summarises the selected Management Resource Units (MRUs) for rivers and provides a summary of the EWR sites that were selected in WMA 16.
    - **Chapter 5** provides the EcoClassification results for rivers.
    - **Chapter 6** summarises the EWR assessment undertaken for the River EWR sites.
- **Chapter 7** provides an overview of the Estuaries assessed during the study and includes information on the PES, EIS, REC and EWR (were applicable) per estuary.
- **Chapter 8** describes the surface water Basic Human Needs Reserve (BHNR).
- **Chapter 9** summarises the findings of the wetlands assessment.
- **Chapter 10** provides the findings of the groundwater assessments and Reserve component
- **Chapter 11** provides more information on the monitoring requirements of the Study Area.
- **Chapter 12** reports on the conclusions of the study in terms of the final Ecological Reserve Categories selected after consultion with DWS and stakeholders for future management of the water resources in the study area.
- **Chapter 13** list the references.
- **Appendix A** discusses training opportunities presented during the GRDS and **Appendix B** provides the agendas associated with the training workshops.
- **Appendix C** provides the comments received from various reviewers.

Note that the study report from which information has been extracted or author(s) that prepared the section is indicated at the start of each Chapter.

2 ECONOMIC OVERVIEW OF STUDY AREA

This section of the report is authored by David Mosaka and William Mullins.

The economic analysis reflects the status quo of the current (as at September 2014) economic activities as well as the situational analysis of the current prevailing social economic position in the Gouritz WMA concerning the large water users such as irrigation agriculture, commercial forestry, industry (Mossgas, saw mills, dairy and food processing) and tourism, as well as the other dependents. The purpose for determining the status quo at current water provision volume is to eventually measure any possible deviations that alternative water provision allocations may have on the overall economic situation in the Gouritz WMA.

The Gouritz WMA has distinct socio-economic characteristics and covers several small but important economic hubs such as George, Knysna, Mossel Bay along the coast and Oudtshoorn, Beaufort West, Prince Albert and Laingsburg in the Karoo.

The economic significance of water uses is dominated by primary sectors such as irrigated agriculture and commercial forestry along the coastal region, and subsequently by secondary industries in particular saw mills and furniture production with the petrochemical industry at Mossel Bay. Tertiary flow of the economy represents the tourism sector.

It is an important agricultural region hosting large wool and mutton producing areas in the Great Karoo, vegetable seed production and ostrich farming in the Little Karoo and a large variety of other agricultural products such as wine grapes, fruit, fodder, vegetables, grains, hops, dairy, timber, tobacco and goat farming. In the coastal areas the agricultural production varies from beef and dairy to crop and horticulture. The Southern Cape area is the only region in South Africa suitable for the production of hops. Approximately half of the hops required by the South Africa brewing industry are cultivated in the George district. The fish and shellfish industry also plays a role in the economy of the coastal region. In the Little Karoo area, particularly the Oudtshoorn area, the ostrich industry plays an important function in the region's economy.

Most irrigators utilise sprinkler irrigation systems, but there are several centre pivots along the coastline with a few in the Oudtshoorn area.

This area includes a number of tourist attractions such as the Garden Route, also inland tourist destinations such as the Oudtshoorn ostrich industry, the Cango Caves and some nature reserves like Anysberg Nature Reserve and Groot Swartberg Nature Reserve in the Karoo and on the coast the Goukamma Nature Reserve, the Concordia Forest Reserve, the Tsitsikama National Park as part of the Garden Route National Park and the Keurbooms Rivier Nature Reserve and the Karoo National Park.

Forestry, and its associated processing and manufacturing activities, is one of the strongest components of agricultural production, particularly in the coastal region. Wooden furniture made from high quality indigenous wood is one of the most important export articles of the Southern Cape region. The commercial forestry operator South African Forestry Company Limited (SAFCOL) is in the process of reducing its activity in the Western and Southern Cape and as such the future of the commercial forestry industry in the Gouritz WMA is uncertain.

The financial sector is also focussed on supporting the agricultural and trade sectors in the financing of machinery and equipment. Manufacturing occurs to the greatest extent in Mossel Bay and George, and to a lesser extent, in Oudtshoorn. At Mossel Bay the Mossgas natural gas extraction and refinery project plays a large role in the manufacturing industry, but with a limited lifetime. The manufacturing and transport sectors in Mosselbay are also supported by the harbour, which is important to the region as the only major harbour in the Gouritz WMA.

2.1 DELINEATION OF ECONOMIC REGIONS

The WMA is divided into regions of economic activity which take into consideration the prevailing climatic and topographic conditions, and are designated Economic Regions (ERs). The delineation process of the ERs consisted of the criteria of the different irrigation requirements, rainfall patterns and allocation between dams and identified drainage regions during the GRDS study. As macro-economic impacts cannot necessarily be identified at a specific geographical point, it requires a number of quaternaries to form an ER.

The Gouritz WMA Economic Regions determined include the following (**Figure 2.1**):

- ER 1: Coastal (Tertiary catchments J40 excluding J40D, K10, K20, K30, K40, K50, K60 and K70).
- ER 2: Olifants (Tertiary catchments J31, J32, J33, J34 and J35).
- ER 3: Gamka (Tertiary catchments J21, J22, J23, J24 and J25).
- ER 4: Goukou/Gouritz/Duiwenhoks and labled as Goukou in **Figure 2.1** (Tertiary catchments J40D, H80 and H90).
- ER 5: Touws/Buffels/Groot and labelled as Touws in **Figure 2.1** (Tertiary catchments J11, J12 and J13).

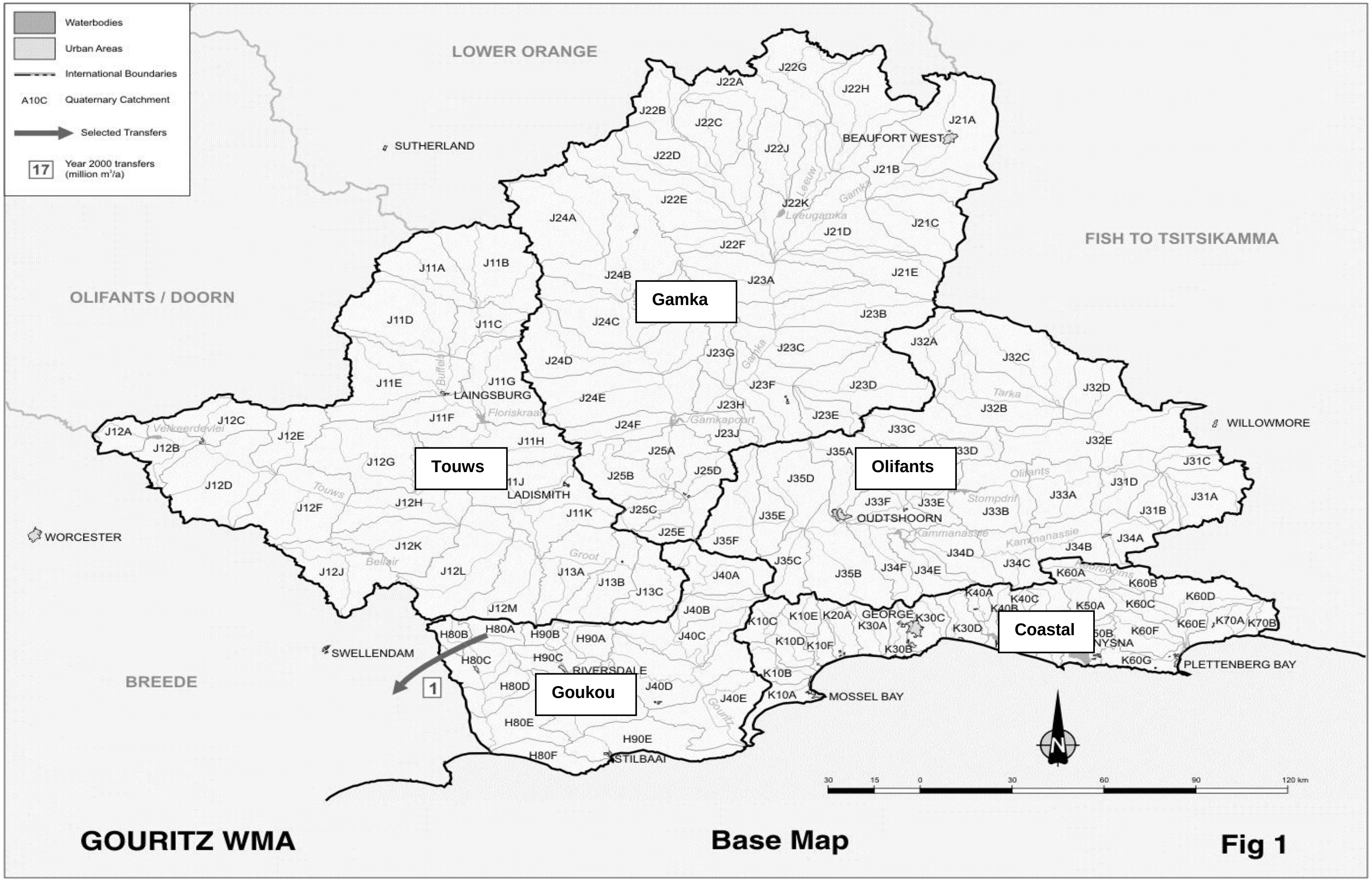

Figure 2.1 Base map of the Gouritz WMA ERs

The economic value of water use for each economic region was determined. This provided a tool to create an appropriate economic baseline, against which to measure the possible impact of changes in water availability and therefore macro-economic impact by means of scenarios, should they be available for consideration.

2.2 ASSUMPTIONS

The following assumptions were made in calculating or defining the economic baseline for the study area.

2.2.1 Irrigation agriculture

It is assumed that the maximum irrigation capacity of the available agricultural land has been reached. No additional water allocations will be made for irrigation agriculture in future. The irrigation agriculture area is therefore proposed to remain constant over the study period. The only change in irrigation agriculture would be the production level depending on the water available for irrigation after the EWRs have been satisfied.

2.2.2 Carrying capacity of the land

It is assumed that the maximum carrying capacity of the agricultural land has been reached in the Gouritz WMA. It is assumed that if farmers were to increase their livestock farming activities, it would only be possible through the acquisition of additional land. The livestock numbers are therefore proposed to remain constant over the study period horizon.

2.2.3 Commercial forestry

One of the assumptions made in the development of the scenarios is that the current commercial forestry may be reduced to improve the yield of the system. For the baseline it is assumed that the area under commercial forestry as determined in the Outeniqua Coast Water Situation Study (OCWSS) (DWAF, 2007) has been maintained. Furthermore the economic valuation of forestry has been restricted to the values from the figures based only on timber production, and has not taken into account the much broader assessment which values biodiversity, landscape, cultural heritage and other environmental assets of forestry in general.

2.3 ECONOMIC STATUS QUO

The economic baseline for the Gouritz WMA is defined as the economic contribution of the available and "out-of-river use" of surface and groundwater to the total water dependent economic activities in the region, without any water restrictions. It will therefore necessitate the identification and quantification of the direct economic contribution of each user and then in turn use this to calculate the indirect and induced impacts.

As an example, the production of vegetables is directly dependant on the availability of irrigation water which has a backward linkage to the suppliers of required production commodities, and forward linkages to the processing plants. All of these in turn again have backward linkages. The land use of the different sectors to be assessed is discussed below.

2.3.1 Irrigation area

The irrigation data used was obtained from a number of sources. The total irrigated hectares were sourced from Water Resources of South Africa[1], and the economic contribution was calculated using the Mosaka Economists internal database (2005 figures) and production budgets updated to 2013 prices. The final areas were brought in line with data received from Water User Associations.

As irrigation agriculture is very dynamic and the crop composition differs from year to year it was necessary to group some of the crops together and reduce the number of crops to ten crop types. Depending on the importance of the specification of crops, twenty different crop types can be presented and individual results produced. In **Table 2.1** the total irrigation hectares, as used per ER in the analysis for the Gouritz WMA are presented.

Table 2.1 Summarised crop areas under irrigation in the WMA

Crop	ER 1 Coastal	ER 2 Olifants	ER 3 Gamka	ER 4 Goukou	ER 5 Touws	Total
	Number of hectares (ha)					
Deciduous fruit	40.57	1 617.92	705.36	179.43	552.30	**3 096**
Alfalfa (lucerne) and pastures	4 576.18	37 152.37	3 820.70	1 973.73	3 645.18	**51 168**
Macadamia	28.27	122.15	82.29	956.96	1 546.44	**2 736**
Maize	543.98	-	587.80	299.05	552.30	**1 983**
Onions	-	584.76	-	-	-	**585**
Onion seed	-	1 328.19	-	-	-	**1 328**
Potatoes	-	205.10	-	-	-	**205**
Table grapes	118.63	-	-	-	-	**119**
Vegetables - Summer	126.01	206.73	146.95	299.05	552.30	**1 331**
Vegetables - Winter	126.01	206.73	146.95	299.05	552.30	**1 331**
Wheat	157.35	-	235.12	1 824.21	3 369.03	**5 586**
White and Red wine grapes	-	429.05	152.83	149.53	276.15	**1 008**
Total	**5 717**	**41 853**	**5 878**	**5 981**	**11 046**	**70 475**

Overview of irrigation per ER in the WMA:

- ER 1 (Coastal): An estimated 5 700 ha of irrigated land is found which in an average year is fully harvested. The more reliable rainfall within the coastal strip ensures a greater reliability and

[1] Water Resources of South Africa, 2012 Study (WR2012) (WRC, 2015). Available at: http://waterresourceswr2012.co.za/about/.

assurances of supply are higher if compared to the inland Karoo catchments. Of the total irrigated area, 3 300 ha occurs in the Knysna to Bloukrans area.

- ER 2 (Olifants): An estimated 41 800 ha of irrigated land is found within this sub-area. Of this, it is estimated that an average of only 8 800 ha is harvested annually. This suggests that the assurance of supply to irrigators in this sub-area is extremely low, aggravated by the losses experienced in the conveyance of water in unlined canals within the Olifants River Government Water Scheme and most tributaries.
- ER 3 (Gamka): Only 5 800 ha of irrigated land is found within this sub-area. Of this, more than 50% lies downstream of Gamkapoort Dam. Alfalfa and pasture is the dominant crop type upstream of the Gamkapoort Dam whilst stone fruits and vineyards are the main crops downstream of the dam, reflecting differences in assurance of supply.
- ER 4 (Goukou): An estimated 5 900 ha of irrigated land is found within this sub-area. The assurance of supply is much higher than that of the inland catchments of the Karoo and it is estimated that all land under irrigation is harvested annually. Opportunistic irrigation is therefore less prevalent here. Vineyards, alfalfa and pasture are also the dominant crop types under irrigation.
- ER 5 (Touws): An estimated 11 000 ha of irrigated land is found within this sub-area. Of this, it is estimated that an average of only 4 300 ha is harvested annually. Crops such as alfalfa can lie dormant in certain years when water is not available. The assurance of supply to irrigators in this sub-area is low and as such, much of the irrigation is opportunistic, taking place as and when water is available.

The most dominant crop is alfalfa with a total of approximately 51 000 ha. Dry land agriculture constitutes almost 65% of the crops in ER 1 (Coastal), while nearly 100% of the crops in ERs 2, 3 and 5 are under irrigation. The most hectares identified were in the Olifants (ER 2) with about 37 000 ha.

2.3.2 Commercial forestry

Different sources show different areas being under commercial plantation in the Gouritz WMA as areas are harvested and replanted. In **Table 2.2** the commercial forestry areas are presented per ER. Commercial forestry is present along the southern foothills of the Outeniqua Mountains and excludes the Knysna natural forest.

The two main role players in the area, totalling 48 496 ha, are:

- MTO Forestry (Pty) Ltd., trading as Cape Pine: Manage the Jonkersberg, Woodville, Buffelsnek, Garcia and Kruisfontein (which includes the Bergplaas, and Hontini Plantations) plantations; and
- Steinhoff Southern Cape (Pty) Ltd.: Manage the Ruigtevlei and Brackenhill (including the Elandskraal 203/7 lease area of 14 ha) plantations.

These are the two main role players in the area and manage a total of 48 496 ha.

The designated forestry land in the WMA comprises of approximately 71% pine followed by 2% gum (Eucalyptus) and the remainder other are unplanted. The major percentage of commercial forestry is situated in the Coastal ERs. After trees are refined to saw logs, the logs are transported to saw and/or paper mills for further synthesising to the wood and paper products which are exported in certain instances and furniture.

Table 2.2 Commercial forestry areas

Tree Species	ER 1 Coastal	ER 2 Olifants	ER 3 Gamka	ER 4 Goukou	ER 5 Touws	Total
	Number of ha					
Pine	47 278	1 218	0	2 700	0	**51 196**
Gum/Eucalyptus	0	0	0	0	0	**0**
Other	0	0	0	0	0	**0**
Total	**47 278**	**1 218**	**0**	**2 700**	**0**	**51 196**

Overview of commercial forestry per ER in the WMA:

- ER 1 (Coastal): It is estimated that 47 278 ha of commercial afforestation and 1 700 ha of indigenous forest is found in this sub-area. The indigenous component occurs only in the Knysna to Bloukrans area. Of the 47 278 ha of commercial forest, 18 689 ha occurs between Knysna and the Bloukrans River, 16 861 ha in the Wilderness catchments and the remaining 11 737 ha between George and Mossel Bay.
- ER 2 (Olifants): Only 1 218 ha of afforestation is found in this sub-area.
- ER 4 (Goukou): Approximately 2 700 ha of afforestation is found in this sub-area, all of which is located in the Duiwenhoks and Goukou River catchments.

2.3.3 Possible future Southern Cape forestry developments

Possible Cape Pine Outeniqua exit areas are:

- The Jonkershoek Plantations stretching along the southern foothills of the Outeniqua Mountains to the east of George.
- The Woodville Plantations and adjoining Buffelsnek Plantations stretching from the west of George along the southern foothills of the Outeniqua Mountains to the east of Plettenberg Bay.

Cape Pine sustainable areas are:

- The Garcia Plantation north of Riversdale along the Outeniqua Mountains (Langeberg).
- The Kruisfontein Plantation (which includes the Bergplaas, and Hontini Plantations) stretching from the west of Knysna along the coastal plains to Plettenberg Bay.

2.3.4 Sawmills

Several sawmills operate in the Gouritz WMA, the largest being that of Steinhoff Southern Cape (Pty) Ltd. and the SA Pine George Sawmill. Sawmills in the Western and Southern Cape are under threat of closing down as the timber source they are dependent upon is in danger of ceasing production in 2020. At stake is the backbone of the southern Cape economy, local primary and secondary timber processing industries, capital infrastructure investments, and the livelihoods of a few thousand employees and contractors.

With the exception of the two largest role players in the Cape timber industry, i.e. the State lessee MTO Forestry (also known under its trading name Cape Pine) and, the private firm PG Bison (part of the KAP group), and a few smaller sawmills with access to their own sustainable timber supplies, all sawmills in the region are threatened with extinction. Even these two major firms will have to downsize/adapt their operations considerably from 2020.

Causes of down-sizing are both the economic recession and, primarily, steadily dwindling timber supplies despite rising domestic demand. At the core of the local timber supply problem is the State's exit from much of its commercial saw-timber plantations in the Western Cape, and its lack of decisive action to re-commission half of this area following Cabinet's decision in 2008 to partially reverse its plantation exit strategy. This strategy was put in place in June 2001 when Cabinet approved the de-commissioning of 45 000 ha of State commercial timber plantation areas in the Western Cape (Boland and Southern Cape) as they were uneconomical and negatively affected the profitability of SAFCOL. The affected State plantations are located along the coastal mountain belt between Wolseley in the Boland and Plettenberg Bay in the Southern Cape.

2.3.5 Dairy factories

There are a number of dairy factories in the Gouritz WMA representing large water users producing cheese, long life milk and condensed milk. They include factories such as Parmalat in George and Ladismith, Lancewood in George, Nestlé in Mossel Bay and Towerkop in Ladismith. There is also a smaller private cheese factory on a farm outside of Stilbaai marketing their Kasselshoop cheese.

2.3.6 Petro SA

Petro SA's main activities are the extraction of natural gas from offshore fields about 89 km from Mossel Bay, the production of synthetic fuels from this gas through a Gas To Liquids (GTL) process, and the extraction of oil from oil fields off the Southern Coast of South Africa. The GTL Refinery is located at Mossel Bay. Its capacity is about 45 000 Barrels Per Day (BPD) and processes both the gas and condensate to produce liquid fuels and chemicals.

2.3.7 Tourism

Tourism data was collected with the help of tourism accommodation internet sites as well as information received from Domestic Tourism Survey 2012 – Reference period January – December 2011 (Stats SA, 2013), Western Cape Annual Tourism Trends 2012[2] and Mossel Bay Tourism: Annual Report 2013 - 2014[3]. Note that the GRDS is not a tourism verification study but a study to allocate available data to specific ERs.

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[2] http://wesgro.co.za/publications/publications/2012-annual-western-cape-tourism-trends.
[3] http://www.visitmosselbay.co.za/membership/mossel-bay-tourism-2013-14.

The term tourism in the GRDS refers to the travel for recreation, leisure, religious, family business purposes, usually of a limited duration. Tourism is commonly associated with trans-national travel, but in this study includes travelling to another location within the same country.

In ER 1 tourism, mostly holiday tourists visiting the coastal towns, is the most dominant economic sector, with ER 3 trailing far behind as these tourists are mainly holiday travellers passing through the ER on their way to the main holiday destinations such as Cape Town, the Southern Cape and surrounding venues and to ER 1. **Table 2.3** shows estimated bed nights per ER, using the input data as described.

Table 2.3 Estimated bed nights per ER

Economic Region	Number of Bed Nights
ER 1 - Coastal	6 870 306
ER 2 - Olifants	955 060
ER 3 - Gamka	1 066 106
ER 4 - Goukou	960 923
ER 5 - Touws	236 083
Total	**10 088 477**

2.4 ECONOMIC VALUE PER ER

The economic results of the different regions are discussed below. In certain instances the data of prominent sectors were included for background information. The results are presented using the following macro-economic parameters:

- Gross Domestic Product (GDP).
- Payments to households.
- Employment creation.

Another variable that provides an indication of the number of people in the region, the "Employment" created, i.e. those who are dependent on employment created and sustained by water, is also presented. As the direct employment is in the region, the dependency on the water-based activities is at four dependents per employee. Direct employment was therefore multiplied by four to provide a figure. This is obviously an undercount as a certain percentage of the indirect and induced jobs will also be within the region. This will specifically apply to the large urban areas of George and Knysna.

2.4.1 ER 1: Coastal

The most dominant sector that influences the economic outcome in the Coastal catchment is tourism in terms of bed nights (occupancy) or tourists visiting the area. This also affects the secondary sector, namely the saw mill industry which forms part of it. Tourism contributes a very substantial part in the ER with more than 6 870 306 bed nights sold (**Table 2.3**). **Table 2.4** presents the macro-economic parameters which represents the water-based activities in the region.

Table 2.4 Economic activities in ER 1 expressed as macro-economic parameters

Economic Sector	GDP (R million)			Employment (Numbers)			Household Income R million)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	90.76	102.94	163.69	805	1 001	1 807	201.99	41.18	53.11
Commercial Forestry	287.36	188.75	476.11	3 184	1 655	4 839	341.66	221.27	120.39
Industry	12 920.20	8 796.66	21 716.85	4 382	31 038	35 419	14 662.39	8 505.05	6 157.34
Tourism	2 460.54	2 167.28	4 627.82	17 037	4 628	21 665	3 792.12	2 824.83	967.30
Total	**15 728.85**	**11 255.63**	**26 984.48**	**25 408**	**38 321**	**63 729**	**18 998.16**	**11 592.33**	**7 298.13**

In total 25 408 direct employment opportunities are provided in the region by the water dependent economic activities, and the total employment opportunities comes to 63 729. At four dependents per employee at least 101 634 (25 408 x 4) individuals benefit. As stated above it is found that tourism is the largest employment provider with 17 037 direct opportunities in the ER, with another 4 628 indirect and induced opportunities. The industry sector is the second largest direct employment creator followed by commercial forestry. The indirect and induced employment of the industry sector is at 31 038 opportunities - the largest mainly because of the indirect and induced impacts of the Mossgas operation.

2.4.2 ER 2: Olifants

The Olifants ER, located in the Little Karoo, is characterized by mostly arid mountainous areas with secluded fertile valleys where disease free vegetable seed is cultivated on about 5 717 ha. Export disease free onion seed earns up to R 1 000 per kilogram with approximately 585 ha cultivated. Tourism contributes a major part in this ER as well with in the region of 955 060 bed nights sold. T**able 2.5** presents the macro-economic parameters which represents the water-based activities in the region.

Table 2.5 Economic activities in ER 2 expressed as macro-economic parameters

Economic Sector	GDP (R million)			Employment (Numbers)			Household Income (R million)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	894.31	883.37	1 777.68	7 851	8 510	16 362	1 751.25	1 290.69	460.56
Commercial Forestry	7.40	4.86	12.27	82	43	125	8.80	5.70	3.10
Industry	416.67	379.30	795.97	427	2 808	3 235	661.90	493.75	168.15
Tourism	217.64	191.70	409.34	1 507	1 499	3 006	335.42	249.86	85.56
Total	**1 536.02**	**1 459.24**	**2 995.26**	**9 867**	**12 861**	**22 727**	**2 757.37**	**2 040.00**	**717.37**

The analysis shows the large overall dependency in the area on the wellbeing of irrigation agriculture, mainly seed production. In the case of direct employment creation 7 851 opportunities are created by agriculture and at an average dependency of four people per employment opportunity, it is estimated that over 31 404 people in the region depend on agriculture. For the water based activities in total, the dependency is over 88 000 people.

2.4.3 ER 3: Gamka

The Gamka ER, located in the Great Karoo, is characterized by its low rainfall, arid air, cloudless skies, and extremes of heat and cold. The main economic activities are agriculture in the form of sheep farming and tourism due to holiday makers passing through the region on their way to Cape Town and surrounding areas or the holiday facilities along the coast to the south. Economic activities are mainly divided between tourism and agriculture. The macro-economic parameters representing the water-based activities in the region are presented in **Table 2.6**.

Table 2.6 Economic activities in ER 3 expressed as macro-economic parameters

Economic Sector	GDP (R million)			Employment (Numbers)			Household Income (R million)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	105.83	133.01	238.85	1 589	1 284	2 873	289.44	212.25	77.19
Commercial Forestry	-	-	-	-	-	-	-	-	-
Industry	-	-	-	-	-	-	-	-	-
Tourism	262.27	231.01	493.27	1 816	1 807	3 623	404.20	301.09	103.10
Total	**368.10**	**364.02**	**732.12**	**3 405**	**3 091**	**6 495**	**693.64**	**513.35**	**180.29**

In terms of dependency about 3 405 direct employment opportunities are created by the two different sectors. About 6 495 individuals are dependent on the continuation of the activities. Again tourism is considered as the largest water use economic sector in this ER creating the most direct, indirect and induced employment opportunities, with agriculture following close behind.

2.4.4 ER 4: Goukou

The Goukou ER direct employment opportunities are provided by agriculture creating 1 168 direct employment opportunities. A small contribution to employment is made by tourism and industry. **Table 2.7** presents the macro-economic parameters which represents the water based activities in the region.

Table 2.7 Economic activities in ER 4 expressed as macro-economic parameters

Economic Sector	GDP (R million)			Employment (Numbers)			Household Income (R million)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	90.76	100.39	191.15	1 169	900	2 068	152.54	104.98	47.56
Commercial Forestry	16.41	10.78	27.19	182	94	276	19.51	12.64	6.88
Industry	27.79	32.19	59.99	250	279	530	37.76	23.00	14.76
Tourism	22.43	19.76	42.19	155	155	310	34.57	25.75	8.82
Total	**145.28**	**159.82**	**305.10**	**1 785**	**1 437**	**3 222**	**229.74**	**140.61**	**77.00**

In terms of direct dependency there are 1 169 employees in agriculture with a further 900 individuals indirectly depending on the continuation of the activity. The tourism sector is the second largest employment creator of the sector. Adding the other economic activities the number increases to about 5 560 (1 390 x 4 dependants per household) as far as dependency on water is involved. This is only taking into consideration the direct employment and immediate dependants and not calculating the indirect and induced numbers. The total number of employment opportunities created is estimated at 3 222.

2.4.5 ER 5: Touws

The Touws ER is also located in the Great Karoo and similarly characterized by its low rainfall, arid air, cloudless skies, and extremes of heat and cold. The main economic activities are agriculture in the form of sheep farming and tourism due to holiday makers passing through the region on their way to Cape Town and surrounding areas or the holiday facilities along the coast to the south. The macro-economic parameters representing the water-based activities in the region are presented in **Table 2.8**.

Table 2.8 Economic activities in ER 5 expressed as macro-economic parameters

	GDP (R million)			Employment (Numbers)			Household Income (R million)		
Economic Sector	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	331.59	299.95	631.54	6 146	3 180	9 325	675.78	494.74	181.04
Commercial Forestry	-	-	-	-	-	-	-	-	-
Mining	-	-	-	-	-	-	-	-	-
Industry	32.28	29.06	61.35	132	213	345	50.64	32.27	18.37
Tourism	262.27	231.01	493.27	8 207	1 807	10 014	404.20	261.49	142.71
Total	**626.14**	**560.02**	**1 186.16**	**14 485**	**5 200**	**19 685**	**1 130.62**	**788.50**	**342.12**

The results for this ER indicate that tourism activities has the highest direct employment, namely 8 207 individuals with 1 807 indirect and induced opportunities. Tourism is followed by agriculture with 6 146 direct opportunities and 3 180 indirect and induced opportunities. If the 6 146 direct employment in agriculture is used to estimate dependency at four per employee, the total comes to 24 584 dependents being supported.

2.5 CONCLUSIONS

Table 2.9 presents the status quo results of the five identified economic regions in the WMA as represented by the water dependent activities expressed in macro-economic parameters.

Table 2.9 Total for the WMA per economic sector

Economic Sector	GDP (R million)			Employment (Numbers)			Household Income (R million)		
	Direct	Indirect and Induced	Total	Direct	Indirect and Induced	Total	Total	Medium	Low
Agriculture	1 483.26	1 519.66	3 002.92	17 559	14 875	32 434	3 071.00	2 251.54	819.46
Commercial Forestry	294.76	193.61	488.38	3 266	1 697	4 963	350.47	226.97	123.50
Saw Mills	-	-	-	-	-	-	-	-	-
Mining	-	-	-	-	-	-	-	-	-
Electricity	-	-	-	-	-	-	-	-	-
Industry	13 386.63	9 220.76	22 607.38	5 007	34 174	39 181	15 392.76	9 038.98	6 50.82
Tourism	3 225.14	2 840.76	6 065.90	28 722	9 896	38 618	4 970.51	3 663.03	130 748
Total	**18 389.79**	**13 774.79**	**32 164.58**	**54 554**	**60 643**	**11 517**	**23 784.74**	**15 180.52**	**860 126**

Table 2.9 shows that the contribution by water to economic growth in the WMA as represented by direct GDP is over R18 000 million per annum, mainly driven by Mossgas in the industry sector. Overall in the Gouritz WMA tourism is the major direct employment creator with 28 700, followed by agriculture with 17 500, industry with 5 000 and commercial forestry, lagging far behind, with 3 200 employment opportunities. **Table 2.10** shows the most dominant sector per ER.

Table 2.10 Dominant economic sectors per ER

ER 1 - Coastal	ER 2 - Olifants	ER 3 - Gamka	ER 4 - Goukou	ER 5 - Touws
Tourism by far followed by forestry and industry (saw mills, dairy factories and Mossgas)	Agriculture leads by far followed by tourism	Tourism and agriculture virtually share the honour	Agriculture leads by far followed by limited tourism	Agriculture leads by far followed by tourism

3 RIVER DESKTOP ECOCLASSIFICATION AND HOTSPOT IDENTIFICATION

Department of Water Affairs (DWA), 2014a. *Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Desktop EcoClassification Report. Prepared by Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/0213.

3.1 BACKGROUND

The objective of this task was to describe and document the status quo or the water resources that included various components such as water use, river ecology, water quality and Ecosystem Services. This task therefore described the physical template and information for decisionmaking regarding the different levels of investigation for Reserve determination. The process also guides the selection of rivers for which EWRs were provided, as well as preferred sections of river in which the EWR sites should have been placed.

3.2 WATER RESOURCES STATUS QUO ASSESSMENT

The Gouritz WMA was divided into water resource zones based on similar water resource operation, location of significant water resource infrastructure (including new proposed infrastructure) and distinctive functions of the catchments in context of the larger system. The significant resources of the proposed water resource areas are summarised in **Table 3.1**.

Table 3.1 Gouritz catchment water resource zones

Secondary catchment	Quaternary catchment	Description	Water resource areas	Major impoundments	Impoundment at outlet of	River
H8	H80 A to H80F	Duiwenhoks	H80	Duiwenhoks Dam	H80A	Duiwenhoks
H9	H90A to H90E	Goukou	H90	Korintepoort Dam	H90B	Korinte-Vet
J1	J11A to J11K, J12A to J12M, J13A to J13C	Groot (tributary of Gouritz)	J11J	Floriskraal Dam	J11G	Buffels
			J11G	Bellair Dam	J12J	Touws
			J12A	Verlorenvlei	J12A	Touws
			J12B	Verkeerdevlei Dam	J12B	Touws
			J12C	Tierkloof Dam	J12C	Touws
			J12C	Aartappel Dam	J12C	Touws
			J12D			
			J12E	Gant Dam	J12E	Touws
			J12F			
			J12G	Prins River Dam	J12G	Touws
			J12M	Miertjieskraal Dam	J12M	Touws
J2	J21A to J21E, J22A	Gamka	J21A	Stols River Dam	J21A	Gamka
			J21A	Gamka Dam	J21A	Gamka

Secondary catchment	Quaternary catchment	Description	Water resource areas	Major impoundments	Impoundment at outlet of	River
	to J22K, J23A to J23J, J24A to J24F, J25A to J25E		J21A	Stols River Dam	J21A	Stols
			J21A	Springfontein Dam	J21A	Kuils
			J22G	Doornfontein Dam	J22G	Leeu
			J22K	Ou Leeugamka Dam	J22K	Leeu
			J22K	Leeu Gamka Dam	J22K	Leeu
			J25D	Calitzdorp Dam	J25D	Tributary of Dwyka
			J23E	Oukloof Dam	J23E	Tributary of Swart
			J24F	Gamkapoort Dam	J24F	Tributary of Dwyka
J3	J31A to J31D	Olifants (tributary of Gouritz)				Upper Olifants (to Stompdrift)
	J32A to E					Traka
	J33A and J33B		J33B	Stompdrift Dam	J33B	Middle Olifants
	J33C to J33F					Middle Olifants
	J34A to J34E		J34E	Kammanassie Dam	J34E	Upstream of Kammanassie
			J34E	Ezeljacht Dam	J34E	Tributary of Kammanassie
	J34F					Downstream of Kammanassie tributary
	J35A to J35F		J35A	Koos Raubenheimer Dam	J35A	Grobbelaars
J4	J40A to J40E	Gouritz				Gouritz
K1	K10A to K10F	Klein Brak	K10B	Hartbeeskuil Dam	K10B	Hartenbos River
			K10F	Klipheuwel Dam	K10F	Klein Brak
K2	K20A	Groot Brak	K20A	Wolwedans Dam	K20A	Groot Brak
K3	K30A to K30D	Kaaimans/ Touws	K30C	Swartrivier Dam	K30C	Swart
			K30C	George (or Swart River) and Garden Route dams	K30C	Swart
			K30D	Rondevlei	K30D	Touws
			K30D	Bo-Lang Vlei	K30D	Touws
			K30D	Onder-Lang Vlei	K30D	Touws
			K30A	Geelhoutboom Dam	K30A	Maalgate
			K30A	Kruisrivier Dam	K30A	Maalgate
K4	K40A to K40E	Goukamma	K40D	Groenvlei Dam	K40D	Goukamma
K5	K50A to K50B	Knysna	K50B	Knysna Lagoon	K50B	Knysna
K6	K60A to K60G	Keurbooms	K60G	Roodefontein Dam	K60G	Keurbooms
K7	K70A to	Sout/Matjie				Sout/Matjie

Secondary catchment	Quaternary catchment	Description	Water resource areas	Major impoundments	Impoundment at outlet of	River
	K70B					

3.3 WATER QUALITY STATUS QUO ASSESSMENT

A water quality overview was undertaken per primary and secondary catchment and was based on an extensive literature review, including the DWA Green Drop Report for the Western Cape regarding the functionality of Wastewater Treatment Works (WWTWs) (DWA, 2012). The present water quality state was described based on the available literature, current water users/uses and landuse practices as the latter are closely linked to the water quality state.

3.4 ECOSYSTEM SERVICES STATUS QUO ASSESSMENT

The socio-economic profile was established based on the desktop review of existing studies and information for the applicable district and local municipalities. Specifically, this included a review of the latest versions of the district and local municipal Integrated Development Plans. These plans were further supplemented by the analysis of the 2011 Census, Community Survey 2007 data (as provided by Statistics SA) (Census, 2011) and other applicable sources. Land use was determined via existing GIS coverage and the Internal Strategic Perspectives (DWAF, 2004) developed for the Gouritz WMA.

The GRDS study identified areas and communities that are significantly dependent on Ecosystem Services provided by the natural resource. The level of dependence can be determined based on the general principle that vulnerable communities will have limited access to formal resources and thus are more likely to be dependent on local natural resources.

An index or set of criteria was established to determine which areas and communities may be considered vulnerable and dependant on Ecosystem Services and as such constitute “hot spots”. For each criterion, a number of variables or thresholds were determined to permit the identification of specific areas/communities via spatial mapping. The criteria were summarised in a single score entitled resource dependence and linked to the overall Socio-Cultural Importance (SCI) assessment of the SQ catchment. The score used was between 0 (no resource dependence significance) and 5 (extreme dependence of significant communities on riverine Ecosystem Services). **Table 3.2** sets out the SQs that have high (≥3) scores.

For the most part areas with high resource dependence and associated Ecosystem Services utilisation by communities are in areas that are rural and defined as underdeveloped. Given the nature of the population and the largely formal as opposed to subsistence rural setting, there are only few communities who are highly dependent on riverine linked Ecosystem Services.

Table 3.2 SQs with high Ecosystem Services dependence

SQ	River	High SCI score (≥3)	Comment
H90E-09383	Goukou	3.2	This river section extends into the Goukou estuarine system. The town of Stilbaai is located along much of the west bank of this river section. The east bank is comprised mostly of open terrain with some development. Moderate to high (in season) recreational use of the estuary.
J33D-08571	Meirings	3.1	River section extends through a gorge with aesthetic value. Limited farming noted on upper and middle reaches, but more extensive on the lower reaches. The town of De Rust is located to the west of the river. Guest houses and lodges noted.
J34A-08871	Holdrif	3.1	River section extends through a uniform open terrain. Greater presence of agriculture noted in proximity of the river. Grazing likely. The town of Uniondale noted on the extreme upper reaches. Presence of tourism resorts.
J40E-09359	Gouritz	3	Coastal plains with agricutlure. Estuary with Gouritzmond town on west bank and elevated aesthetic and recreational values.
K50B-09117	Knysna	4	The lower reaches of the river extends into the Knysna lagoon/estuarine system. The estuary is flanked on both banks by a number of up-market residential areas. Recreational and ritual use, as well as heritage and aesthetic value, is high. Indicate the conservation area on the other bank.
K60E-09097	Keurbooms	3.3	Located in the Keurboomsrivier Nature Reserve. The river extent is comprised of open/natural terrain. The river extends into a lagoon, and a number of resorts are located on both banks of the lagoon. Plettenberg Bay is located near the river mouth. The nature reserve, presence of upscale resorts at the estuary and Plettenberg Bay suggest high levels of tourism and recreational use, as well as elevated heritage and aesthetic value.
K20A-09083	Groot Brak	3.2	River headwaters located in the inland escarpment. The lower reaches of the river extends through the coastal plain and a mosaic of open/natural terrain, indigenous forests and commercial agriculture. The river drains through the Wolwedans Dam therefore recreational, ritual and aesthetic value is likely to be elevated. River extends towards the coast into the river estuary. The small towns of Groot Brakrivier, Bergsig, Southern Cross and The Island (formal, affluent) are located on the west and east banks of the river/estuary. Recreational, ritual and aesthetic value is likely to be elevated along the lower river reaches and the estuary.
K60F-09092	Bitou	3.2	Upper reaches of the river extends through the Knysna Forest, with the presence of plantation forestry on the east bank. Middle and lower reaches of the river comprise of a mosaic of open/natural terrain, small-holdings and commercial agriculture. A number of tourism facilities (lodges, hotels) noted along the river route suggesting elevated recreational use, as well as aesthetic value. The small town of Wittedrift (formal, affluent) is located within 1 km of the river. The river drains into the Keurbooms lagoon, and there are high levels of recreational use in this lagoon.
K60G-09188	Keurbooms	3.1	River section completely contained in the Keurbooms lagoon. A number of resorts are located on north bank of the lagoon. Plettenberg Bay is located near the river mouth. This town/estuary is also an international destination with Plettenberg bay as a neighbour. Thus, the presence of up scale resorts at the estuary and Plettenberg Bay suggest high levels of tourism and recreational use, as well as elevated heritage and aesthetic value.

SQ	River	High SCI score (≥3)	Comment
K30D-09173	Touws	3	Short river section extends through Wilderness Town into the Touws Estuary. Tourism and recreational facilities and resources noted, therefore recreational, aesthetic, ritual and heritage use is elevated.
K70B-09055	Bloukrans	3	River exclusively extends through indigenous forest (linked to a nature reserve). Some plantation forestry noted on the banks of the lower reaches of the river. River drains into an estuarine system used for recreation also the world renowned Bundgi destination. Has a high ethetic value.

3.5 DESKTOP ECOLOGICAL STATUS QUO ASSESSMENT OF THE RIVERS

Determination of the PES, which in essence represents the ecological status quo of the rivers, is undertaken as part of the EcoClassification process (Kleynhans and Louw, 2007). The EcoClassification process consists of four levels which refer increasing complexity and intensity of work ranging from Level I (Desktop) to Level IV. An additional level, also Desktop, was developed by Dr Neels Kleynhans with the specific purpose of building up a countrywide database of PES, Ecological Importance (EI) and Ecological Sensitivity (ES). This project is referred to as the national PES/EI/ES project and has been finalised in 2013. All the spreadsheets for the secondary catchments in South Africa have been completed and the information was used as the baseline for the status quo assessment. The work specifically for the Gouritz WMA was undertaken by Southern Waters (DWS, 2014a). The PES component was reviewed during the GRDS.

3.5.1 K1 (Hartenbos, and Klein Brak catchment)

K10A-9292 is in a PES of D, primarily related to water quality alterations (Mossdustria industrial area) and limited non-flow related impacts, such as agriculture. The entire Hartenbos River system (including Melkboom) (K10B) is in a PES of D. The primary impacts are non-flow related associated with agriculture (wheat) and livestock farming activities, while flow related impacts are associated with the Hartbeeskuil Dam and irrigation abstraction. The land use in quaternary catchments K10C and K10D is primarily agriculture (non-flow related), resulting in the PES of this entire area ranging between a C/D and D. The primary land use and impacts in quaternary catchment K10E is related to forestry, with the condition still being good (category B) in the Beneke River (K10E-9119) and moderate (Category C) in the upper Moordkuil River (K10E-9064). The lower Moordkuil River (K10F-9139) and unnamed tributary (K10F-9204) are impacted by flow and non-flow related impacts namely forestry and agriculture, as well as the Klipheuwel Dam, resulting in a PES of C/D.

3.5.2 K2 (Groot Brak catchment)

The Groot Brak River (K20A-9083) is impacted by non-flow related (forestry and agriculture) as well as flow related impacts (Wolwedans Dam in lower 20% of reach), resulting in a moderately modified PES of B/C on the river.

3.5.3 K3 (Maalgate, Malgas, Gwaing and Swart catchment)

The Maalgate River (K30A-9087) is primarily impacted by flow related activities namely abstraction for irrigation, while the non-flow related agricultural impacts also contribute to the largely modified PES of a D. The Malgas River (K30B-9082) and especially the upper reaches of this SQ is in a good condition (PES of B), while the lower reaches are impacted by a cement factory and golf estate (irrigation and return flows, as well vegetation removal). The remaining SQs of K30B have a PES of a D due to the non-flow related impacts (forestry and urban development) with some flow related (irrigation) impacts in the Rooi River (K30B-9115) and K30B-9100. While water quality impacts (cement factory and irrigation return flows) are the primary causes for deterioration in the Gwaing River (K30B-9158 and K30B9151). The Kaaimans River (K30C-9065) is still in a relatively good state with a PES of a B with the primary impacts being related to forestry. The Swart River (K30C9177) is, however, largely impacted by flow modification (George (or Swart River) and Garden Route dams), resulting in a PES of a D. The Touws River (K30D-9042) is also still in a relatively good state with a PES of a B and the primary impacts being related to forestry. The remainder of K30D (Klein Keurbooms and Duiwe rivers) is subjected to primarily flow related impacts (dams and irrigation abstraction), while non-flow related agriculture and forestry impacts contribute somewhat to the PES of C/D to D prevailing in this area.

3.5.4 K4 (Sedgefield, Diep, Hoëkraal and Karatara catchment)

Both the Hoëkraal and Karatara rivers are Category B rivers and have large portions with indigenous forest. The Huis River, which is a tributary of the Karatara River, is in a C Category and the main impacts are non-flow related, mainly commercial forestry and agriculture. The Diep River is also in a Category C, but the upper half of the SQ is likely a B with more impacts occurring in the lower half. Impacts are mainly related to forestry encroachment in the riparian zone and invasion by alien plant species.

The Homtini River is in a Category B/C with the majority of impacts occurring in the lower portions of the SQ. Impacts are mainly agriculture with associated vegetation clearing.

3.5.5 K5 (Knysna catchment)

The Knysna River system runs mostly through mountainous terrain with indigenous forests and encounters few impacts overall. Consequently the PES is high throughout the system, although commercial forestry and invasion by alien plant species does occur, especially towards the lower part of the catchment towards the estuary.

3.5.6 K6 (Keurbooms catchment)

Most rivers in the Keurbooms system are in a Category B or better, with the impacts that exist being non-flow related (i.e. vegetation removal or the presence of alien plant species). The important Bitou wetlands (high biodiversity) occur in the lower parts of the Keurbooms River adjacent to the Keurbooms estuary. The Bitou (B/C Category) also has both flow (small farm dams and irrigation) and non-flow related impacts (loss of riparian vegetation to agriculture), while the riparian zone of the upper portion of the Keurbooms (K60A-08947) is largely fragmented by agricultural activities.

The Piesang River on the other hand is the most impacted system in this secondary catchment with both flow (dams) and non-flow related (loss of riparian vegetation due to agriculture and urban development) impacts.

3.5.7 K7 (Bloukrans catchment)

All the rivers in catchment K7 are near natural (Category B) with minimal removal of riparian vegetation in localised areas and some commercial forestry.

3.5.8 J1 (Groot catchment)

Buffels and tributaries up to Floriskraal Dam: Most of these streams occur in mountainous areas and have low impacts. Overall, the PES of this area is in a Category B or higher, with only four of the 32 SQs in a C Category (Roggeveld (J11D-08162), Buffels (J11F-08427; J11F-08460) and Baviaans (J11E-08425)). Impacts are predominantly agriculture, irrigation and small farm dams. Some alien plant species also occur in the area.

Groot and tributaries downstream of Floriskraal Dam to Touws River confluence: Most of the streams in this portion are in C or D Categories with the exception of J11H-08584 and the Buffels (J11H-08647) which are a Category A and B, respectively. Other than the mainstream Buffels and Groot rivers being impacted by the Floriskraal Dam there is also extensive irrigation in the area and associated agriculture which fragments and deteriorates the riparian zone and associated floodplains. Alien plant species have invaded some areas.

Touws River and tributaries from source to confluence with Prins River: The rivers in this area are mixed in terms of their PES. About 50% of the SQs are in a Category B/C or better while the rest are in a Category C or D. There are no Category A or A/B SQs and only a single E Category (Unnamed stream in J12B-08656) reach are present. The main impacts in the area are both flow and non-flow related. Flow related impacts include multiple small farm dams in areas, irrigation (extensive in some areas), and a few large dams, e.g. Verkeerdevlei and Gants Dams. Non-flow related impacts are mainly related to agricultural encroachment or clearing of riparian zones and/or floodplains, overgrazing in areas and physical disturbance (manipulation) of morphological features (localised). Some canals exist for off-take to reservoirs and some artificial levees and river course manipulation is evident. Several of the upper SQs fall within the southern extreme of the critically endangered Riverine Rabbit distribution (*Bunolagus monticularis*).

Prins River to the confluence with the Touws River: Most of the SQs in this area traverse mountainous areas with few impacts and are predominantly B Category rivers. Prins River Dam (a large dam) occurs towards the lowest reach on the Prins River, and several small farm dams exist in some places. Where topography allows there is intense but localised agricultural activities with irrigation in places and some off-takes via canals. In these areas the PES has deteriorated to a Category B/C or C.

Brak River and tributaries to the confluence with the Touws River: Mostly Category B/C and C rivers with some of the mountainous tributaries in Category A or A/B (Wilgebos).

3.5.9 J2 (Gamka catchment)

Most of the upper reaches of catchment J2 (J21, J22, J23 and J24) are in a good PES ranging between Categories A, A/B and B. These areas are generally seasonal or ephemeral, and impacts are limited to livestock farming, some agriculture and dams as well as towns. Some of the reaches that are in a more deteriorated state (C to D) are due to primarily non-flow related farming impacts (livestock and agriculture) and limited flow modification associated with farm dams (i.e. Kuils (J21A-07211), Kwagga (21A-07499), Boeteka (J21B-07538), Plaatjies (J21C-07669), Koekemoers (J22F-07805) rivers).

The SQ reaches of the Leeu (J22F) and the Gamka rivers (J23A and J23B) in the vicinity and especially downstream of the town of Leeu Gamka are also in a deteriorated PES, ranging between a C and D due to flow modification (dams and abstraction for irrigation), water quality deterioration (Leeu Gamka town and irrigation return flows) as well as non-flow related impacts associated with farming (cultivated lands in riparian zone, over grazing by livestock).

The Cordier, Swart and Dorps rivers in the vicinity of Prince Albert are in a deteriorated PES ranging between C and D due to flow modification (Oukloof and farm dams and irrigation), non-flow related impacts (agriculture, towns developments) and water quality impacts (town and irrigation return flows).

The lower Gamka River (J23J, J25A, J25C, J25E) is also in a deteriorated state due to modified flows (Gamkapoort Dam, abstraction for irrigation and towns), as well as non-flow related impacts (extensive agricultural activities along river) as well as water quality deterioration (irrigation return flows and the town of Calitzdorp). The Kobus River (J25B-08591) is highly cultivated in some sections, resulting in a D PES, while the Nels River (J25D-08626) is impacted by flow modification (Calitzdorp Dam) as well as non-flow related and water quality impacts associated with the extensive agricultural areas in the vacinity.

3.5.10 J3 (Olifants catchment)

Upper Olifants: Of the 15 SQs, 11 fall in a B PES Category. Only three of these SQs are in the main Olifants River, the rest are situated in tributaries. The good condition is due to the dry (mostly ephemeral) nature of the rivers (minimising options of use) and the topography (lack of access). The remaining four SQs consist of three in the Olifants River (PES of a C and B/C) and one in the Hartbees River (PES of a C). The impacts are largely non flow-related and consist of overgrazing, erosion, bank disturbance due to agriculture, and removal of the riparian zone to make place for agricultural fields.

Traka: Of the 34 SQs, 24 fall in a B PES EC or higher. The good state is due to the ephemeral nature of many of the rivers which occur in mountanous areas and are inaccessible. Impacts are limited to localised agricultural activities and farm dams. The remaining ten SQs consist of five in the main Traka River, with the rest situated in the tributaries. Most of the impacts in the Traka River are dominated by non-flow related impacts due to grazing, agricultural practices and agricultural fields located within the riparian zone. In the lower Traka River, a railway line is situated in the river and marginal zone as it traverses through a kloof in the Swartberg Mountains. The impacts in the tributaries are similar to the Traka River, with farm dams also resulting in barrier and inundation impacts.

Middle Olifant and Groot rivers: This catchment consists of 31 SQs. Due to the extensive utilisation of water for irrigation in this dry area, the river states are displaying a negative trajectory leading to a progressive degradation in their respective ecological states. There are only five SQs which are in a B Category whilst 15 SQs are in a PES of a C and B/C (few) Category. The reasons for this are due to abstraction for irrigation (flow-related impacts) and non-flow related secondary impacts from irrigation activities (irrigation fields in the riparian zones, irrigation return flows, etc.). In the main Olifants River downstream of Stompdrif Dam, the Olifants River deteriorates significantly and ranges from a D, D/E to an E PES Category. These states relate to the minimal flow in the river, extensive reed growth in the channel, irrigation return flows and irrigation fields in the riparian zone.

Kammanassie River: Of the 17 SQs, only one SQ in the Klues River (J34C-08859) falls within a B PES. Three SQs fall in a B/C state – the Huis (J34D-08853) and the Kammanassie (J34D-08868 and 08899). Most of the rest of the SQs fall in a C and C/D state. Sections in the Potjies and Diep rivers fall in a D/E due to extensive alien vegetation and agricultural fields. The Kammanassie River downstream of Kammanassie Dam falls in an E and D/E PES due to flow modification, agricultural fields and return flows and extensive reed growth. Upstream of Kammanassie Dam the impacts are related to urban impacts, agricultural fields in the riparian zone, and alien vegetation. The areas that are in inaccessible, being in a deep river valley, are in the best condition.

Lower Olifants River: Ten of the 26 SQs fall in the main Olifants River catchment area. All of these SQs apart from the most downstream SQ have a PES of a D/E and E Categories. This is due to flow modifications, the excessive reed growth in the channel due to the irrigation return flows, alien vegetation and changes in the physical channel. Water quality impacts from the return flows will also be severe.

Three SQs lie within the Grobbelaars River and its tributary, the Klein-Leroux River. Some of the mountainous areas are in reasonable condition, but the lower Grobbelaars River is in an E PES due to flow changes (i.e. Koos Raubenheimer Dam) and extensive irrigation as well as the impacts resulting from Oudtshoorn town through which it flows.

Of the remaining 13 SQs in the tributaries, there are four SQs in a B Category PES; the Kansa, Droë and two unnamed rivers. The rest of the rivers are in lower categories and two SQs have deteriorated to a D/E PES (Moeras and Kandelaars rivers). All impacts are associated with alien vegetation and extensive agriculture and irrigation activities.

3.5.11 J4 (Gouritz catchment)

Main Gouritz, Slang and Kamma rivers: The main stem of the Gouritz River in J40A (8924 and 9020) is primarily impacted by flow related activities in the upper catchment (J2 and J3), with limited non-flow related activities (agriculture) within this reach, resulting in a C PES. The Slang River (J40A-8967, 8997, 8961) is ephemeral and primarily impacted by non-flow related impacts associated with dry land agriculture, resulting in a PES of a C. The Kamma River (J40B-9054) is mostly natural with limited farming activities (non-flow related) contributing to a B PES. The Gouritz

River in J40B remains primarily impacted by upstream flow and water quality alterations, with J40B-9106 also impacted by the activities in catchment J1, but still remaining in a Category C due to minimal localised impacts (agriculture).

Weyers, Langtou, Gouritz, Vals and Stink rivers: The Weyers River (J40C-09156) originates in the Paardeberg Nature Reserve, with the upper reaches therefore being in a close to natural state. The lower reaches of this river is impacted by mixed agriculture, grazing, dairy, irrigated (vineyards and vegetables) and dry land cultivation (wheat), resulting in an overall PES of C. The lower Langtou (J40C) is primarily impacted by agricultural activities while the upper reaches seem to be in a fairly good state with limited impacts. The Gouritz River in J40C remains primarily impacted by upstream flow and water quality alterations, but with the PES deteriorating to a Category C/D due to the inclusion of localised agricultural impacts (flow and non-flow related). This PES is also continued downstream into J40D where localised farming impacts increase and contribute to the deterioration. The upper reaches of J40D-9178 is in a relative undisturbed state, while the lower reaches is impacted by agricultural activities, with the overall reach estimated to be in a C/D PES. The Vals River (J40D-09185) is largely impacted by agricultural activities (non-flow related) resulting in an overall C PES. The Stink River (J40E-9273) is impacted by agricultural (seems to by mostly dry land) activities resulting in a C PES.

3.5.12 H8 (Duiwenhoks catchment)

The upper reaches of the Duiwenhoks River (H80A-09154 and H80B-09149) is subject to primarily non-flow related impacts (agriculture), with the Duiwenhoks Dam situated in the lower reaches of H80A-09154, resulting in an overall PES of C. The flow modification and water quality impacts of the Duiwenhoks Dam are more significant in the next downstream reach of the Duiwenhoks River (H80C-09208) and, together with the agricultural impacts (including irrigation) and Heidelberg town, result in a deteriorated D/E PES. The Hooikraal River (H80C-09290) is primarily impacted by non-flow related activities (farming) resulting in a D PES. Farming activities are the main non-flow related impacts on the Spieëls River (H80C-09209) resulting in a C/D PES for this reach. The Duiwenhoks River improves slightly in the lower reaches (H80D-9286 and H80D-9314) to a Category D but is still impacted notably by flow modification (Duiwenhoks Dam and abstraction for irrigation) as well as non-flow related activities (farming). The Pienaars River (H80D-09293) is primarily impacted by farming activities (crops and livestock) resulting in a D PES.

3.5.13 H9 (Goukou catchment)

The Kruis River (H90A-09165) is impacted by agricultural activities with the middle section being fairly natural, but overall classified in a D PES. The Goukou River originates in the Spioenkop Nature Reserve and later flows through the Broomvlei (Kruis River) Nature Reserve. Impacts that are affecting the health status of this river is mostly due to agricultural activities and alien vegetation invasion especially in the riparian areas and this results in a C PES. The primary impact in the Korinte River (H90B-09155) is associated with the Korintepoort Dam, together with agricultural activities resulting in a D PES. The Naroo River (H90C-09211) is seriously impacted by agricultural activities resulting in a D PES. After the confluence of these two rivers it becomes the Vet River (H90C-09220) which is in a deteriorated non-sustainable E PES due to mostly the upstream agricultural impacts and Riversdale urban impacts. The lower Goukou (H90D-09287, H90D-09316 and H90D-09318) downstream of Riversdale is impacted by the aggregate impact of the upstream reaches together with localised agriculture, Riversdale urban runoff and the WWTW, resulting in a D PES, with a slight improvement in the lower reach H90E-09343 to a C Category due to the reduced localised impacts. The Soetmelks River (H90D-09254 and H90D-09298) and SQ reaches H90D-09278 and H90E-09364 flows through agricultural areas resulting in a Category D.

3.6 IDENTIFICATION OF HOTSPOTS

A hotspot represents a river reach with a high Integrated Environmental Importance (IEI) which could be under threat due to its importance for water resource use. The hotspots are therefore an indication of areas where detailed investigations would be required if development was being considered. The hotspot identification therefore provides an indication of the level of EWR assessment required at the SQ catchment. In essence, this would be similar to a filtering process where the most detailed assessment is undertaken at hotspots, and less detailed assessments at the other areas. Nodes that are EWR sites represent the areas where most detailed EWR methods will be required.

The purpose of the identification of hotspots for the GRDS was the following:

- To select rivers and river reaches where new EWR sites should be selected.
- To provide guidance to levels of Reserve assessment that might be required for licensing purposes within the framework provided by the National Water Resource Classification System (NWRCS).
- To provide an indication where scenario development and testing would be important.

Hotspots (priority areas with overall importance) are identified by comparing (or overlaying) IEI with Water Resource Use Importance (WRUI). The hotspot represents a river reach with a high IEI which could be under threat due to its importance for water resource use.

The hotspots are an indication of areas where detailed investigations would be required if development was being considered. These hotspots usually represent areas which are already stressed or will be stressed in future. This assessment can therefore guide decision-making with regards to which areas are in need of detailed EWR and other studies (modified from Louw and Huggins, 2007). A matrix was designed (Louw and Huggins, 2007) and modified during this study to guide the consistent identification of hotspots (**Table 3.3**). The Y-axis is based on the IEI value and the X-axis depicts an estimate of water resource use, with 0 being of no importance and 4 being of very high importance. The information derived from the matrix provides an indication of the level of studies required. Although the terminology used is the same as that used for the different levels of EWR studies in South Africa, it is a descriptive term which is relevant for any environmental assessment required. As an example – an IEI of 2.5 and WRUI value of 3.5 would require a comprehensive EWR assessment and this specific SQ would represent a hotspot.

Table 3.3 Matrix used in determining hotspots

IEI	**Very high**	**4 - 5**	2	2	2	2	3	3	4	4	4
	High	**3 - 3.99**	1	2	2	2	2	3	3	4	4
	Moderate	**2 - 2.99**	1	1	1	2	2	2	3	3	3
	Low	**1 - 1.99**	1	1	1	1	1	2	2	2	3
	Very low	**0 - 0.99**	1	1	1	1	1	1	1	2	2
			0	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
			Very low	**Low**		**Moderate**		**High**		**Very high**	
			WRUI								

All hotspots, within the GRDS, with a 3 and 4 rating were identified as indicated in **Table 3.4** and mapped in **Figure 3.1** to **3.4**.

Table 3.4 Hotspot results

SQ	River	IEI	WRUI	Hotspot rating
H80A-09154	Duiwenhoks	3	3	3
H80C-09303	Duiwenhoks	2	3	3
H90B-09155	Korinte	2	3	3
H90C-09211	Naroo	2	3	3
H90C-09220	Vet	2	3	3
H90C-09229	Goukou	2	3	3
J11H-08543	Buffels	2	4	3
J11H-08557	Buffels	3	4	4
J11H-08647	Buffels	5	4	4
J11J-08686	Groot	2	4	3
J11K-08828	Groot	2	4	3
J11K-08860	Groot	2	4	3
J13A-08905	Groot	3	3	3
J13A-08933	Groot	3	3	3
J13A-08954	Groot	3	3	3
J13B-08923	Groot	3	3	3
J13B-08938	Groot	3	3	3
J13C-08915	Groot	5	3	4
J13C-09099	Groot	5	3	4
J12H-08790	Touws	5	2	3
J12L-08831	Touws	4	3	4
J12M-08904	Touws	2	3	3
J12L-08930	Doring	4	2	3
J12L-08985	Doring	2	3	3
J12L-09084	Doring	2	3	3
J23A-07922	Gamka	2	3	3
J23A-07962	Gamka	2	3	3
J23A-08007	Gamka	2	3	3
J23B-08017	Gamka	3	3	3

SQ	River	IEI	WRUI	Hotspot rating
J23B-08123	Gamka	3	3	3
J23C-08155	Gamka	4	3	4
J23C-08176	Gamka	5	3	4
J23C-08212	Gamka	5	3	4
J23C-08217	Gamka	5	3	4
J23F-08268	Gamka	5	3	4
J23F-08334	Gamka	5	3	4
J23F-08335	Gamka	5	3	4
J23H-08359	Gamka	5	3	4
J23H-08415	Gamka	5	3	4
J23J-08497	Gamka	3	3	3
J25A-08536	Gamka	3	3	3
J25A-08567	Gamka	4	3	4
J25C-08776	Gamka	5	3	4
J25C-08795	Gamka	2	3	3
J25E-08769	Gamka	2	3	3
J31D-08592	Olifants	4	2	3
J31D-08650	Olifants	4	2	3
J33B-08637	Olifants	2	3	3
J33B-08714	Olifants	2	3	3
J33B-08749	Olifants	3	3	3
J33E-08649	Olifants	2	4	3
J33E-08757	Olifants	2	4	3
J33E-08763	Olifants	2	4	3
J33E-08777	Olifants	2	4	3
J33F-08772	Olifants	2	4	3
J35B-08799	Olifants	2	4	3
J35B-08820	Olifants	2	4	3
J35B-08841	Olifants	1	4	3
J35C-08821	Olifants	2	4	3
J35C-08873	Olifants	1	4	3
J35D-08854	Olifants	2	4	3
J35E-08764	Olifants	2	4	3
J35E-08816	Olifants	2	4	3
J35F-08739	Olifants	2	4	3
J35F-08849	Olifants	1	4	3
J34D-08899	Kammanassie	4	2	3
J34F-08843	Kammanassie	2	4	3
J34F-08848	Kammanassie	2	4	3
J40A-08924	Gouritz	3	3	3
J40A-09020	Gouritz	3	3	3
J40B-09073	Gouritz	3	3	3
J40B-09106	Gouritz	3	3	3
J40C-09169	Gouritz	3	3	3
J40D-09236	Gouritz	3	3	3

SQ	River	IEI	WRUI	Hotspot rating
J40D-09250	Gouritz	3	3	3
J40E-09284	Gouritz	3	3	3
J40E-09323	Gouritz	5	3	4
J40E-09357	Gouritz	4	3	4
J40E-09359	Gouritz	5	3	4
K60C-08992	Keurbooms	5	3	4
K60E-09114	Keurbooms	5	3	4

The rivers where hotspots dominate are:

- Keurbooms (forestry).
- Buffels/Groot (Floriskraal Dam and irrigation).
- Gamka (various dams, irrigation, Nature Reserve and World Heritage site).
- Olifants (various dams and irrigation).
- Gouritz (extensive irrigation).

3.7 RIVERS WITH HOTSPOTS SELECTED FOR POTENTIAL EWR SITES

Rivers with hotspots are listed below:

- Duiwenhoks (two SQ hotspots).
- Goukou and tributaries (four SQ hotspots).
- Buffels/Groot (13 SQ hotspots).
- Touws (three SQ hotspots).
- Doring (three SQ hotspots).
- Gamka (20 SQ hotspots).
- Olifants (20 SQ hotspots) (upper section only).
- Kammanassie (three SQ hotspots).
- Gouritz (11 SQ hotspots).
- Keurbooms (two SQ hotspots).

Note that the Doring River (tributary of the Touws) was not delineated into MRUs. An EWR site in this river was only included in direct reaction to a current/future development in the Lemoenshoek Stream (not part of the 1:500 000 DWS river coverage), a tributary of the Doring River. The EWR site was therefore selected in the Doring River as close as possible to and downstream of the confluence of the Lemoenshoek confluence with the Doring River.

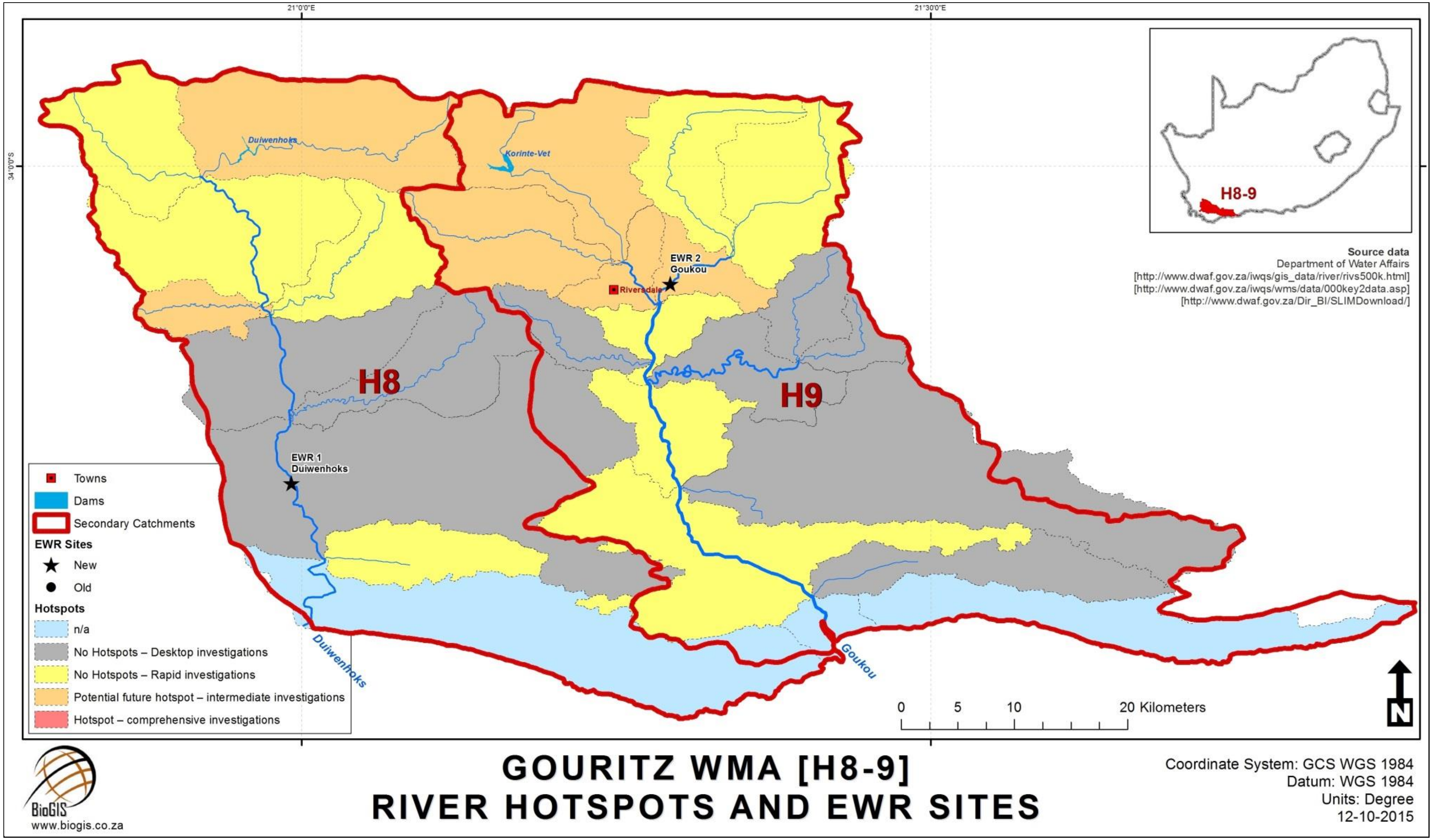


Figure 3.1 Catchment H8 and H9: Hotspots and location of EWR sites

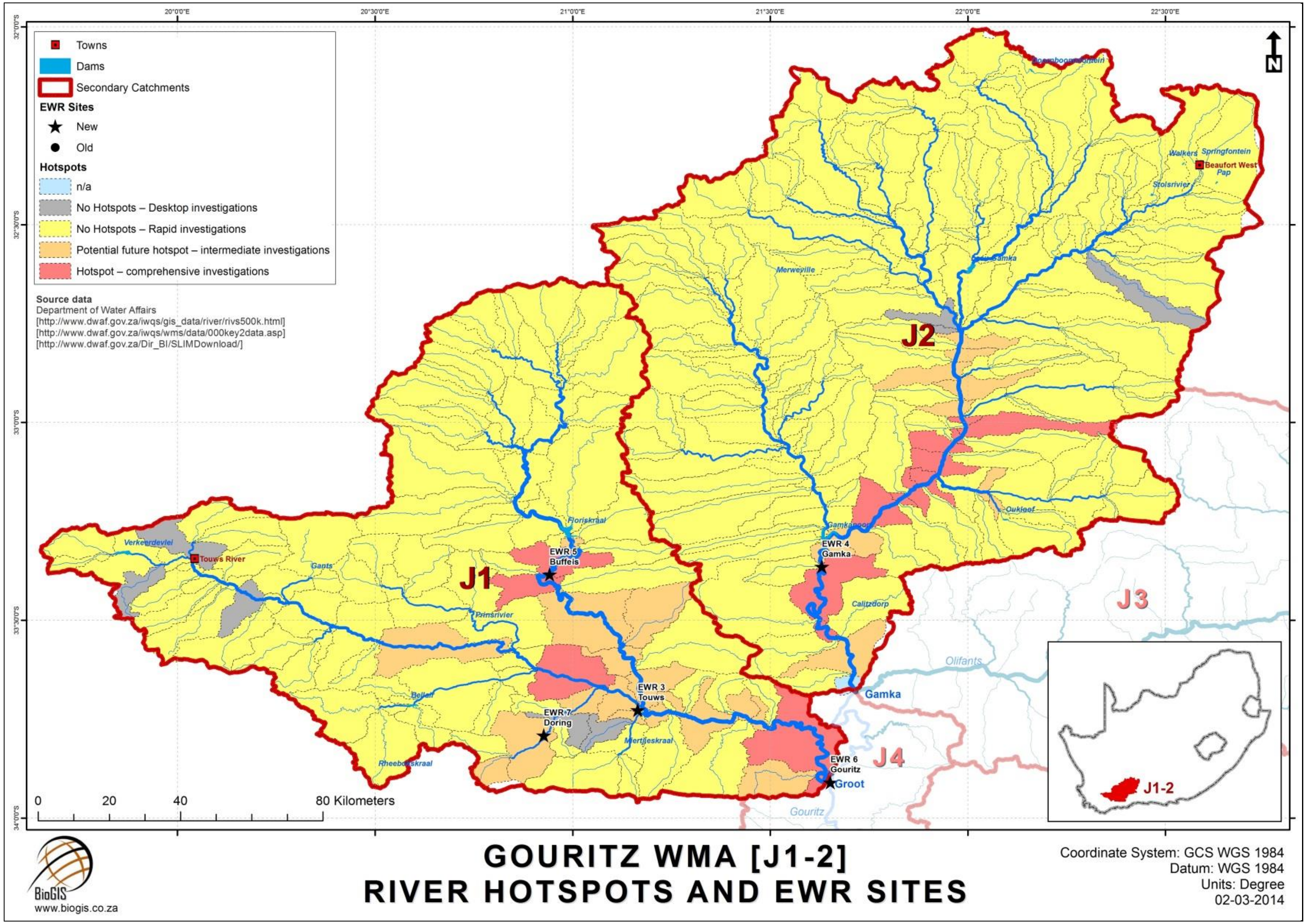


Figure 3.2 Catchment J1 and J2: Hotspots and location of new and existing EWR sites

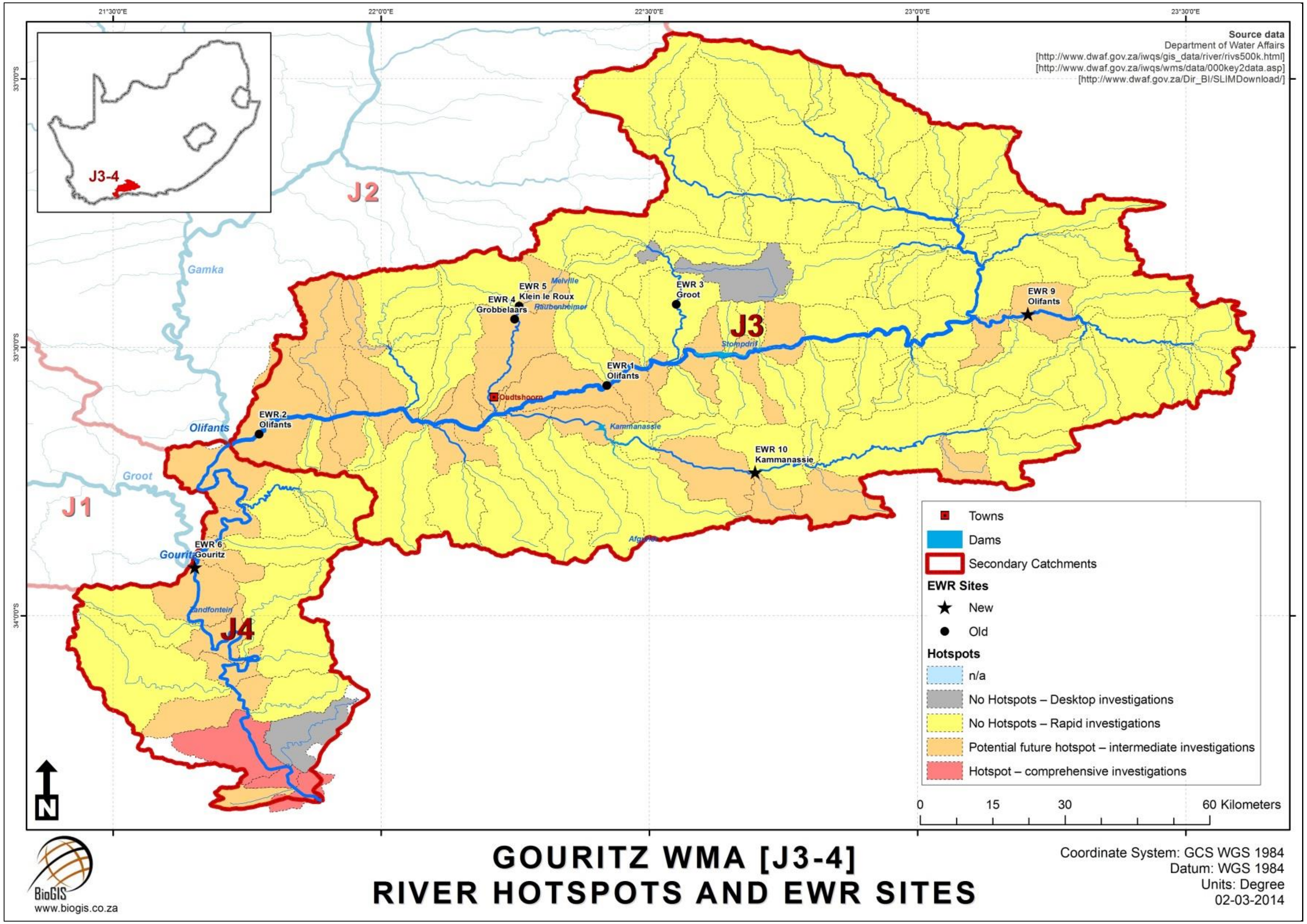


Figure 3.3 Catchment J3 and J4: Hotspots and location of new and existing EWR sites

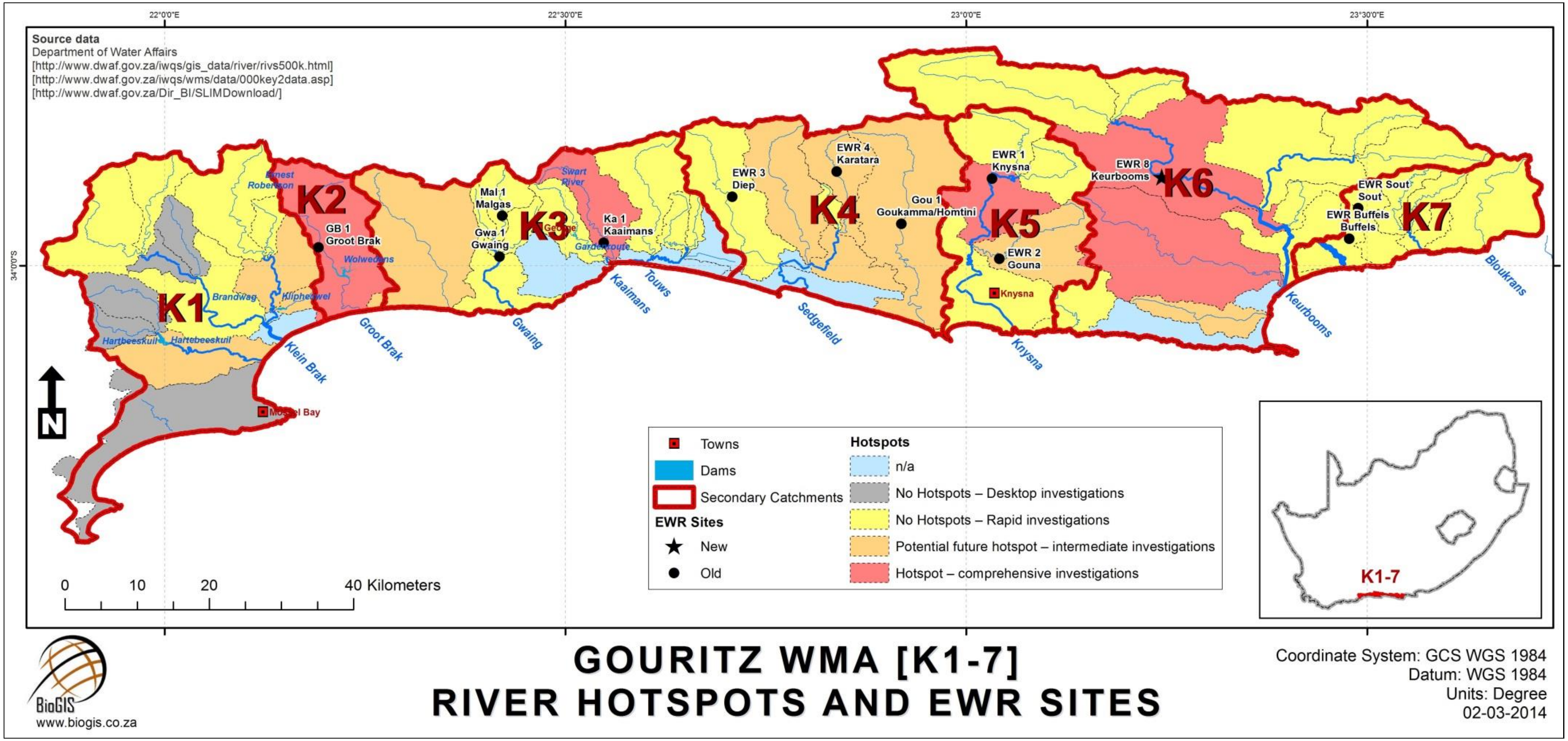


Figure 3.4 Catchment K1 - 7: Hotspots and location of new and existing EWR sites

4 RIVER DELINEATION

Department of Water Affairs (DWA), 2014b. *Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area*: Delineation Report, Volume 2. Prepared by Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/0313, Volume 2.

4.1 BACKGROUND

The objective of this task was to delineate the different river systems in the study area and select EWR sites which were assessed during the EcoClassification task of the project. During the Ecological Reserve determination process it is necessary to delineate the catchment into Resource Units (RUs). These are each significantly different to warrant their own specification of the Reserve, and the geographic boundaries of each must be clearly delineated (DWAF, 1999).

4.2 APPROACH

RUs are required as it may not be appropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches. Different sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach. The approach adopted was to consider:

- Natural Resource Units (NRUs) - based primarily on a biophysical characteristics within the catchment; and
- Management Resource Units (MRUs) - Management requirements (DWAF, 1999) that take the following aspects into account:
  - EcoRegion classification of the river system.
  - Geomorphological zonation in which channel gradient has been found to be a dominant factor.
  - Land cover.
  - Management and operation of the river system.
  - Water quality considerations.
  - Local knowledge.
  - Desktop PES.

4.3 RESULTS

Results on the NRU and MRU delineation are detailed in DWA (2014a) and shown in **Table 4.1.**

Table 4.1 MRU summary table

MRU	Rationale
Duiwenhoks River	
MRU Duiwenhoks A	The similar relief and land use with a distinct break at the Duiwenhoks Dam result in the selection of the MRU.
MRU Duiwenhoks B	The PES is a D/E due to the land use with the dominant impact being on the riparian zone. Heidelberg is at the end of the MRU with associated water quality problems. The end of MRU B is due to the change in relief with the river now in a steep valley (gorge) which results in a riparian buffer zone being present.
MRU Duiwenhoks C	Steep river valley with irrigation in the higher regions. End of MRU is at the estuary.
Goukou River	
MRU Goukou A	The mountainous area with limited use is included in the much more extensive irrigation area as the mountainous area cannot be operated differently from the downstream area. The break is at the Vet River tributary at Riversdalee. This tributary is in an E Category and this, with the Riversdalee water quality impact, changes the situation downstream.
MRU Goukou B	See above. The riparian buffer zone is in a marginally better condition than upstream, but extensive alien vegetation occurs. End of MRU is at the estuary.
Buffels River	
MRU Buffels A	The MRU represents the area that is very similar to NRU A and is dominated by the mountainous area in good ecological condition. The downstream end of the MRU is situated at Floriskraal Dam as a logical management break. The most downstream section includes Laingsburg and some irrigation down to the Floriskraal Dam.
MRU Buffels B	This area is different from upstream as it is dominated by irrigation.
Touws River	
MRU Touws A	The MRU A ends where the irrigation decreases and the river state improves. Most of the operational possibilities for managing the downstream MRU is situated in MRU A.
MRU Touws B	As there are no operational changes in this section and the land use is largely homogenous, this reach comprises the downstream MRU.
Gamka River	
MRU Gamka A	Similar land use with limited operational capability apart from Gamkapoort Dam which form the logical end point of the MRU.
MRU Gamka B	Releases from the dam for irrigation and extensive irrigation around Calitzdorp provide the rationale for delineating a MRU.
Olifants River	
MRU Olifants A	Unregulated and minimal use.
MRU Olifants B	Operation from Stompdrift Dam.
MRU Olifants C	Impacts from Oudtshoorn and the Grobbelaars and Kammanassie rivers.
Kammanassie River	
MRU Kammanassie A	Kammanassie Dam is the only operational breakpoint and was selected as the end of this MRU. PES is also better than the PES downstream of the Kammanasssie Dam.
MRU Kammanassie B	Downstream of Kammanassie Dam the geomorphic features change from Upper foothills to lower foothill, there is different system operation and land use. The PES also deteriorates downstream of the Kammanassie Dam.
Gouritz River	
MRU Gouritz A	Change from mountainous area to more open area (lowland), change in land use, change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.

MRU	Rationale
MRU Gouritz B	Lowland and one EcoRegion. Open area, irrigation, slightly worse PES.
Keurbooms River	
MRU Keurbooms A	Change from mountainous area to more open area (lowland), change in land use, change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.
MRU Keurbooms B	Delineation based mainly on change in land use. Open area, irrigation, slightly worse PES.

4.4 EWR SITES

Well established criteria and processes (Louw *et al*., 1999) were adopted to select EWR sites for further analysis. The key considerations were:

- The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows.
- Accessibility of the sites for sampling during the study and afterwards for monitoring purposes.
- An area or site that could be critical for ecosystem functioning. These are often represented by riffle units, where low flow conditions or the cessation of flow constitutes a break in the functioning of the river, and consequently, the biota dependant on this habitat and/or perennial flow are adversely affected. Pools are not considered critical habitats in perennial system since they are still able to function or at least maintain life during periods of no flow.

Recommendations regarding the number and locality of EWR sites were made as part of the MRU delineation. A total of ten EWR sites were selected in the GRDS study area. The locality and general description of the selected EWR sites are provided in **Table 4.2** to **Table 4.11**. The location of the EWR sites is provided in **Figure 3.1** to **3.4**.

Table 4.2 Locality and characteristics of H8DUIW-EWR1

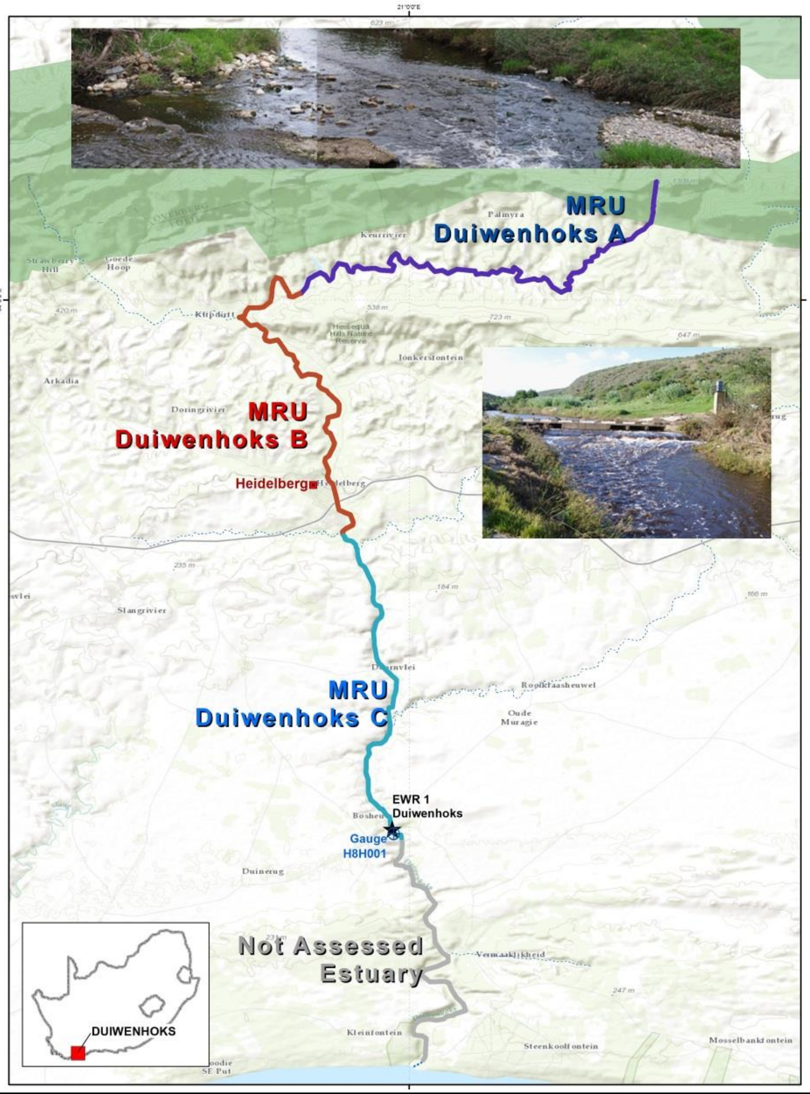
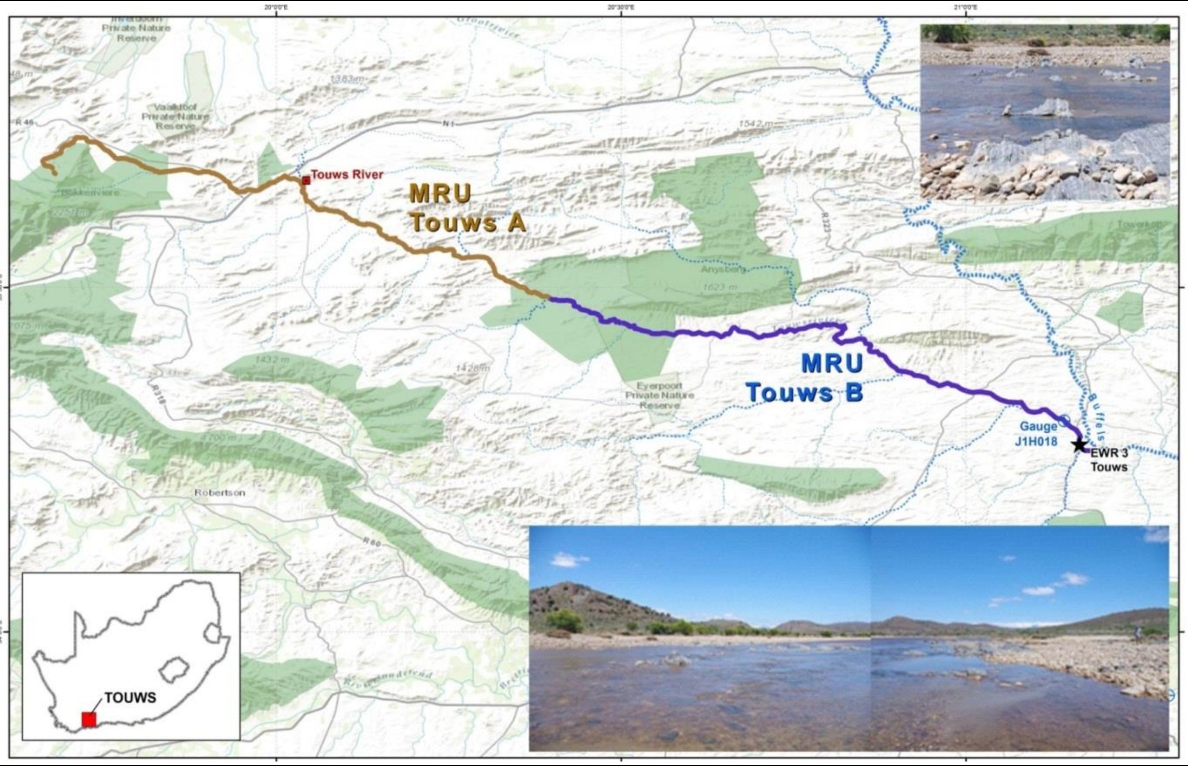
<table>
<tr><td>EWR and River name</td><td>H8DUIW-EWR1
Duiwenhoks River</td><td rowspan="8">
</td></tr>
<tr><td>Co-ordinates</td><td>S34.25167
E20.99194</td></tr>
<tr><td>EcoRegion (Level II)</td><td>22.02</td></tr>
<tr><td>Geomorphic Zone</td><td>E Lower Foothills</td></tr>
<tr><td>Altitude (m)</td><td>15</td></tr>
<tr><td>RU</td><td>MRU Duiwenhoks C</td></tr>
<tr><td>SQ</td><td>H80E-09314</td></tr>
<tr><td>Hydrological gauge</td><td>H8H001</td></tr>
<tr><td>Rationale</td><td colspan="2">An EWR site in MRU A would not have been of use in managing the river downstream of the Duiwenhoks Dam (the main operating system), and neither would it have been useful in providing scenarios for estuary EWR determination at the bottom of the system. MRU B was in a D/E condition (i.e. upstream of Heidelberg), and unsuitable for EWR site selection. An EWR site was selected in MRU C. Access was limited and the river was disturbed (locally) due to the low water crossing, local sand mining and extensive alien vegetation. Access limitations and the presence of a gauging weir necessitated EWR selection in this MRU.</td></tr>
</table>

Table 4.3 Locality and characteristics of H9GOUK-EWR2

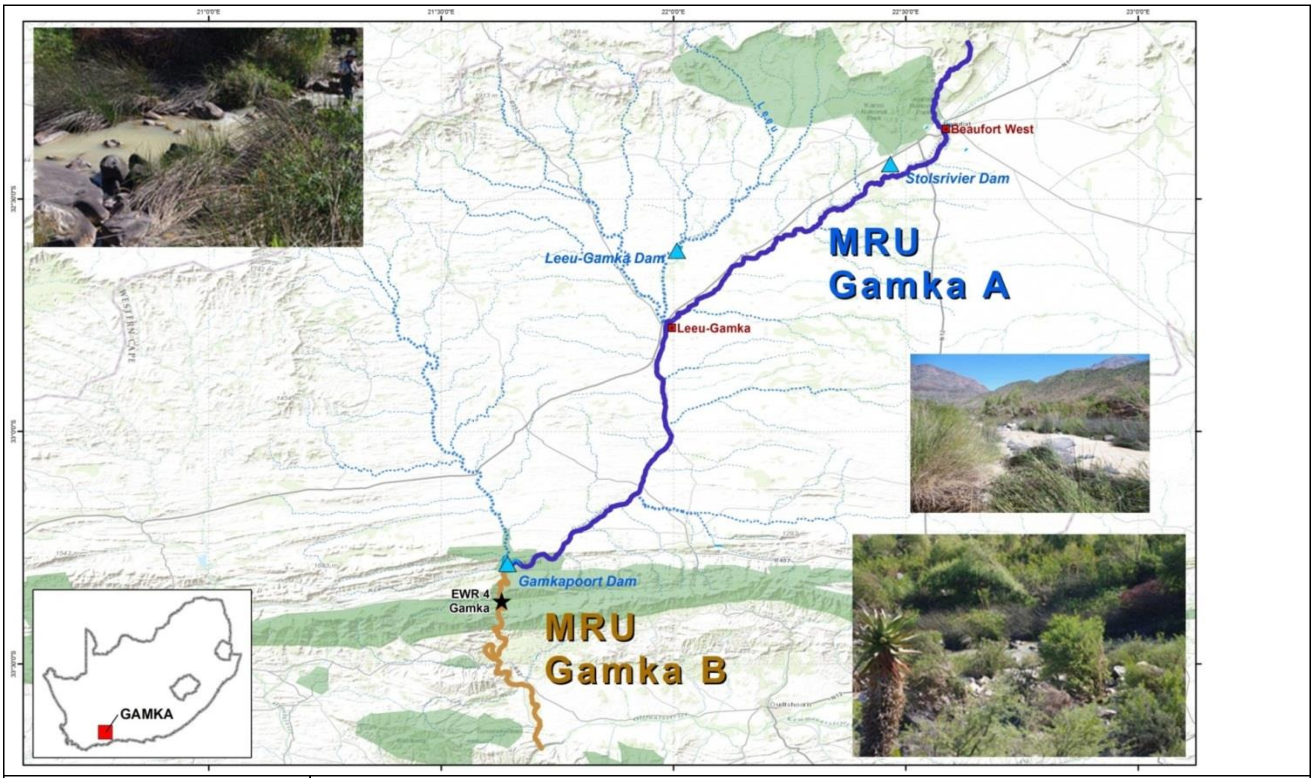
EWR and River name	H9GOUK-EWR2, Goukou River	
Co-ordinates	S34.09324; E21.29300	
EcoRegion (Level II)	22.02	
Geomorphic Zone	E Lower Foothills	
Altitude (m)	87	
RU	MRU Goukou A	
SQ	H90C-09229	
Hydrological gauge	H9H005	
Rationale	Based on the estuary requirements and system operation, an EWR site towards the downstream end of the system would have been preferable. However, this section was influenced by Riversdale impacts and impacts associated with the Vet Tributary. Access and finding suitable sites were also problematic. Therefore, the hotspot section in SQ H90C-09229, located immediately upstream of this area was targeted for EWR site selection and included a gauging weir.	

Table 4.4 Locality and characteristics of J1TOUW-EWR3



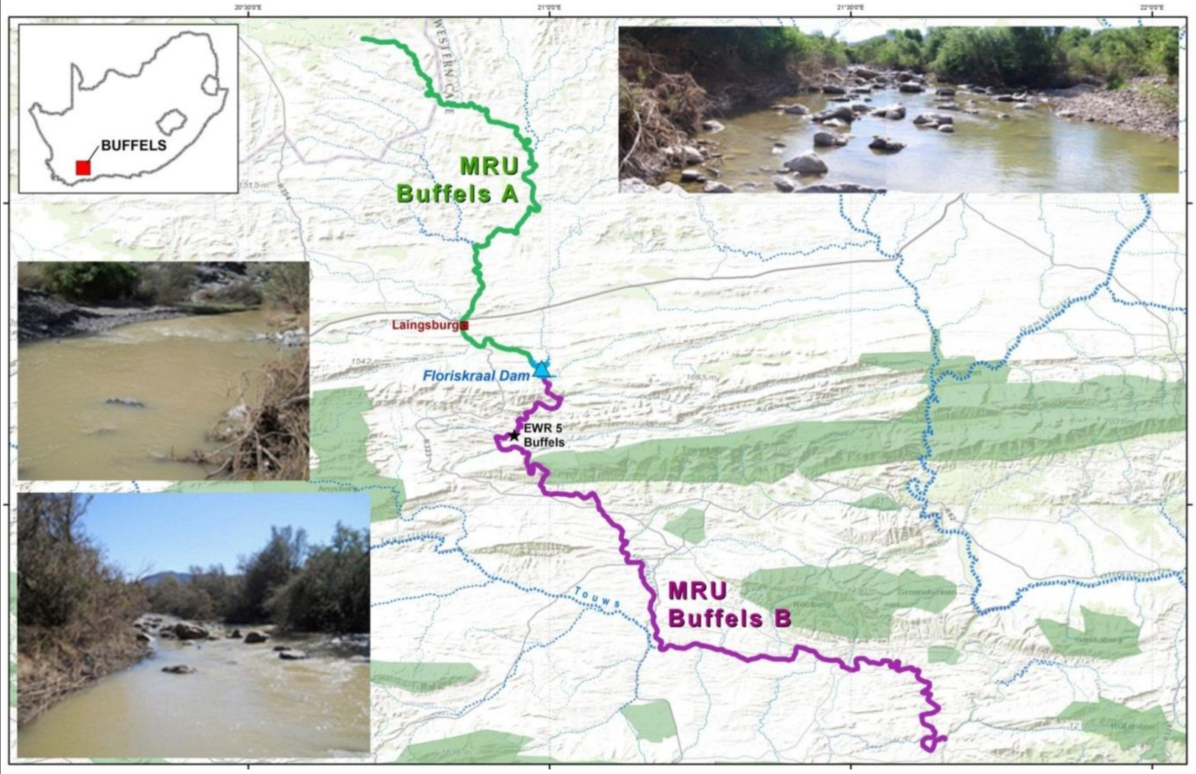
EWR and River name	J1TOUW-EWR3, Touws River
Co-ordinates	S33.72707; E21.16507
EcoRegion (Level II)	19.07
Geomorphic Zone	E Lower Foothills
Altitude (m)	271
RU	MRU Touws B
SQ	J12M-08904
Hydrological gauge	J1H018
Rationale	The Level 3 and 4 hotspots were all situated in MRU B which was the target area for site selection. Considering the complexities of a seasonal system, it was essential to use a water level logger to obtain a variety of flow levels for hydraulic calibration. The one functioning gauge in MRU B was J1H018. A suitable site was selected downstream of the gauge.

Table 4.5 Locality and characteristics of J2GAMK-EWR4



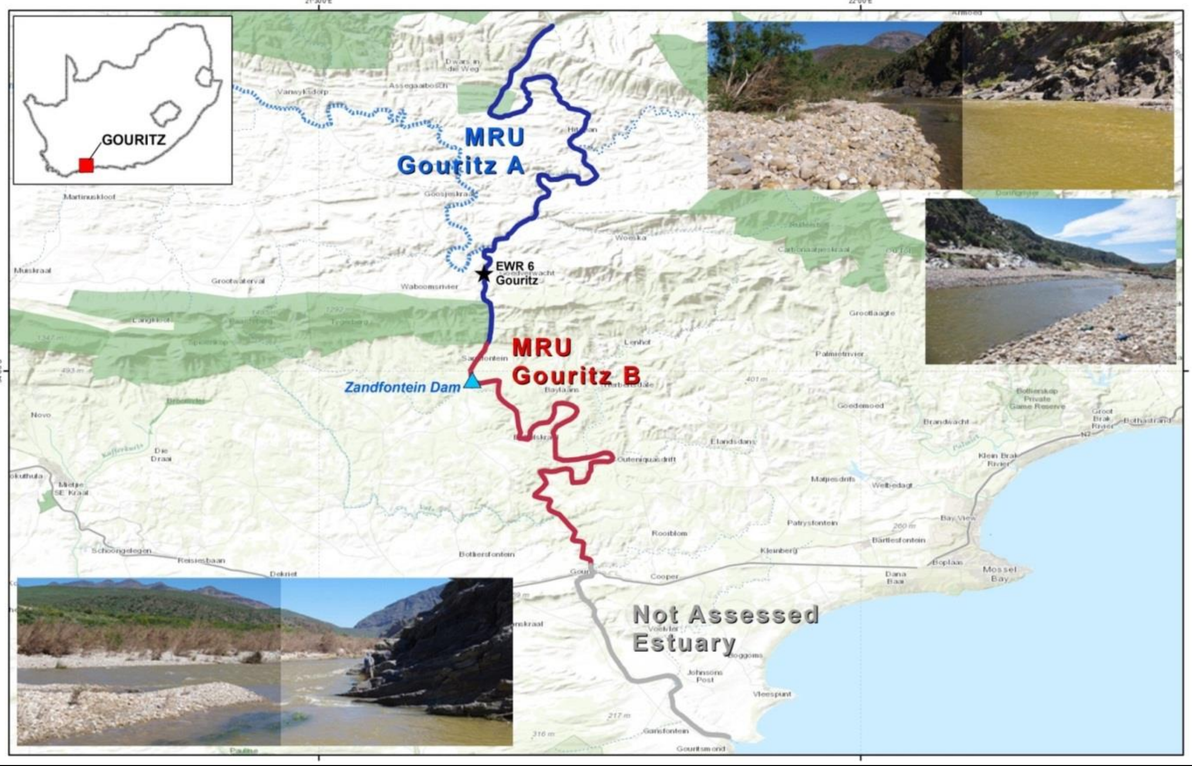
EWR and River name	J2GAMK-EWR4, Gamka River
Co-ordinates	S33.36472; E21.63051
EcoRegion (Level II)	19.09
Geomorphic Zone	E Lower Foothills
Altitude (m)	375
RU	MRU Gamka B
SQ	J25A-08567
Hydrological gauge	J2H016
Rationale	The hotspots in the Gamka River are immediately upstream and downstream of the Gamkapoort Dam. Considering that the Gamkapoort Dam was the only structure from which EWRs could be operated from, and the presence of the Gamkaskloof (Die Hel World Heritage Site) situated downstream of the dam, Die Hel was a logical place for an EWR site. Gauging was also undertaken at the Gamkapoort Dam as well as a gauging weir (J2H010) downstream of Gamkakloof.

Table 4.6 Locality and characteristics of J1BUFF-EWR5



EWR and River name	J1BUFF-EWR5, Buffels River
Co-ordinates	S33.38452; E20.94169
EcoRegion (Level II)	19.09
Geomorphic Zone	E Lower Foothills
Altitude (m)	499
RU	MRU Buffels B
SQ	J11H-08557
Hydrological gauge	-
Rationale	The EWR site had to be selected in MRU B being downstream of Floriskraal Dam which provided the only (albeit slight) opportunity for managing the river in terms of supplying the EWR. The two Reserve Assessment Units (RAUs) guided the selection of EWR sites. The downstream RAU Buffels B.2 had limited access and was not situated near a gauging weir. The upstream RAU B.1 was closer to Floriskraal Dam which did have a gauge, measuring outflows and spills and could therefore be used during flood flows and therefore an EWR site was selected in this reach.

Table 4.7 Locality and characteristics of J4GOUR-EWR6



EWR and River name	J4GOUR-EWR6, Gouritz River
Co-ordinates	S33.90982 E21.65233
EcoRegion (Level II)	19.08
Geomorphic Zone	E Lower Foothills
Altitude (m)	121
RU	MRU Gouritz A
SQ	J40B-09106
Hydrological gauge	J4H002
Rationale	An EWR site was selected in MRU Gouritz A as this MRU was in a better state than MRU Gouritz B. The locality of the gauge at J4H005 provided added motivation, however, it was later determined that the weir was a rated section and extremely unreliable for low flows.

Table 4.8 Locality and characteristics of J1DORI-EWR7

EWR and River name	J1DORI-EWR7, Doring River
Co-ordinates	S33.79137; E20.92699
EcoRegion (Level II)	19.07
Geomorphic Zone	E Lower Foothills
Altitude (m)	370
RU	N/A
SQ	J12L-09895
Hydrological gauge	-
Rational	Note that the Doring River (tributary of the Touws) was not delineated into MRUs. An EWR site in this river was only included in direct reaction to a current/future development in the Lemoenshoek Stream, a tributary of the Doring River. The EWR site was therefore selected in the Doring River as close as possible to and downstream of the confluence of the Lemoenshoek confluence with the Doring River.

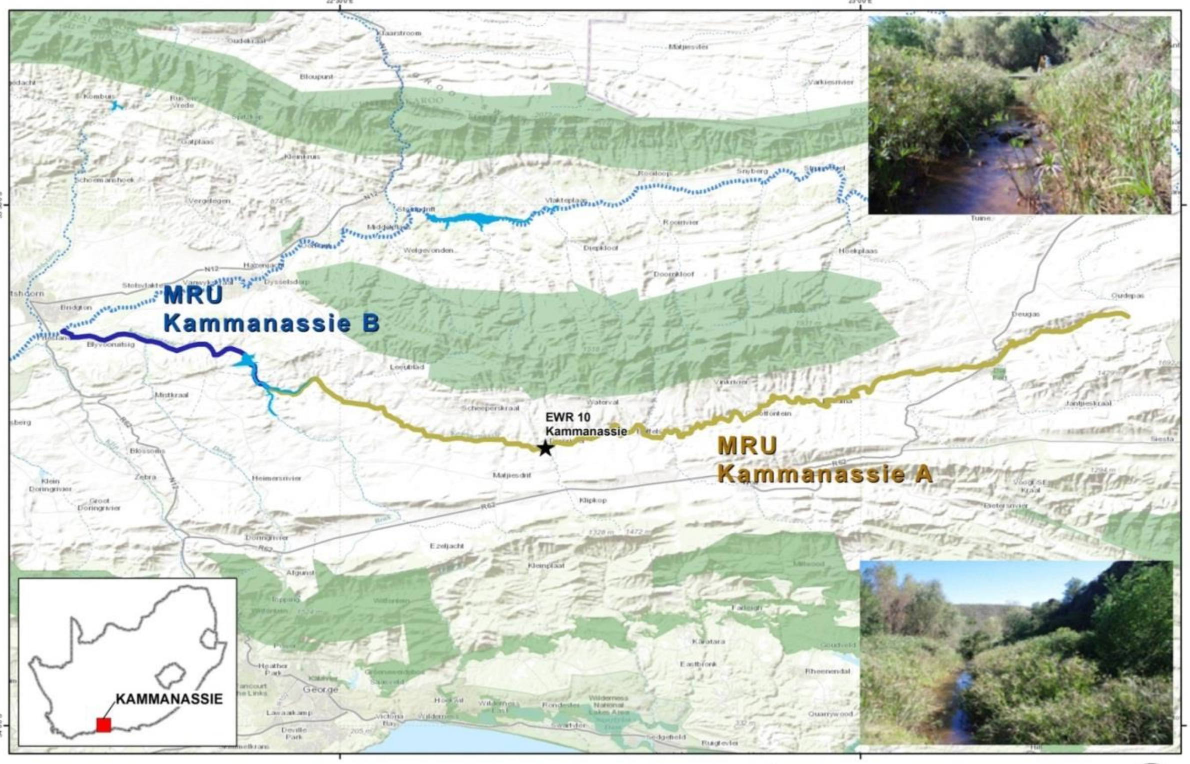
Table 4.9 Locality and characteristics of K6KEUR-EWR8

EWR and River name	K6KEUR-EWR8, Keurbooms River
Co-ordinates	S33.88955; E23.24392
EcoRegion (Level II)	20.02
Geomorphic Zone	D Upper Foothills
Altitude (m)	161
RU	MRU Keurbooms B
SQ	K60C-09882
Hydrological gauge	K6H001; K6H019
Rationale	The target area for EWR site selection was close to the lower gauging weir which was also downstream of possible development areas. This was a hotspot and would be useful for EWR determination. However, the access bridge to the gauge does not exist anymore and the riffle provided poor habitat for EWR determination. An EWR site further upstream at a good riffle was selected. The great distance from the gauging weir as well the extensive alien vegetation at the site were identified as potential problems.

Table 4.10 Locality and characteristics of J3OLIF-EWR9

EWR and River name	J3OLIF-EWR9, Olifants River
Co-ordinates	S33.43813; E23.20587
EcoRegion (Level II)	19.01
Geomorphic Zone	E Lower Foothills
Altitude (m)	621
RU	MRU Olifants A
Quaternary	J31D-08592
Hydrological gauge	-
Rationale	One EWR site had to be selected in MRU Olifants A. The area was in a reasonable PES upstream of J33A-08736 and was suitable for EWR site selection. A riffle that often had some flow (possible “subsurface flows” that surfaced at rocky areas) was identified as suitable. However, it was acknowledged that determining flow in a river with very intermittent flow that could be groundwater based, or reacted to rainfall, would be extremely complicated.

Table 4.11 Locality and characteristics of J3KAMM-EWR10



EWR and River name	J3KAMM-EWR10, Kammanassie River
Co-ordinates	S33.73286; E22.69740
EcoRegion (Level II)	19.01
Geomorphic Zone	E Lower Foothills
Altitude (m)	445
RU	MRU Kammanassie A
Quaternary	J34C-08869
Hydrological gauge	-
Rationale	It was impossible to select a site downstream of the Kammanassie Dam due to the extensive reed growth. A site upstream of the Kammanassie Dam had to be selected and preferably in the area with the better PES. However, access was dangerous and time consuming and a site at a bridge crossing upstream of this section was selected. It must be noted that due to irrigation return flows, the channel shape, structure and functioning have been changed over the years due to the extensive reed and vegetation growth.

5 RIVERS: ECOCLASSIFICATION RESULTS

Department of Water and Sanitation (DWS), 2014b. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Rivers RDM Report – Rapid Assessment. Prepared by Rivers for Africa eFlows Consulting (Pty) Ltd. for Scherman Colloty & Associates cc. Report no. RDM/WMA16/01/CON/1113.

Department of Water and Sanitation (DWS), 2015a. *Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Rivers RDM Report – Intermediate Assessment. Prepared by Rivers for Africa eFlows Consulting (Pty) Ltd. for Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/1013.

5.1 BACKGROUND

This chapter documents the results of the EcoClassification at selected EWR sites in the GRDS study Area. A total of ten EWR sites were selected (refer to **Section 3.4**). The Intermediate Ecological Reserve Methodology (IERM - DWAF, 1999) was applied during this task. For five EWR sites (referred to as Rapid EWR sites), located in the Duiwenhoks, Goukou, Doring, Olifants and Kammanassie rivers, respectively, the IERM method was followed with the only deviation from the method being the exclusion of the geomorphology component. This was done in order to increase the general confidence level in the EcoClassification results and supply the needs for the estuarine scenarios. For the other five EWR sites, located in the Touws, Gamka, Buffels, Gouritz and Keurbooms rivers respectively, the IERM method was followed and sites were generally referred to as Intermediate EWR sites. Associated with the IERM is the EcoClassification process at Level IV.

5.2 APPROACH

The EcoClassification process, which includes the Level IV EcoStatus assessment, was followed according to Kleynhans and Louw (2007). The approach consisted broadly of the following steps:

- Determine the RC for each component.
- Determine the PES for each component and the EcoStatus.
- Determine the trend for each component, as well as for the EcoStatus (dependant on available information).
- Determine the reasons for the PES and whether these are flow or non-flow related.
- Determine the EIS for the biota and habitat.
- Considering the PES and the EIS, suggest a realistic REC for each component and the EcoStatus.

5.3 RESULTS

The EcoClassification results for the EWR sites are summarised in **Table 5.1**.

Table 5.1 EWR sites: Summary of EcoClassification results

H8DUIW-EWR1: DUIWENHOKS RIVER

EIS: LOW

Highest scoring metrics in the EIS model were unique species (new record and distribution for *Redigobius dewaali*); species intolerant to physico-chemical changes (*Pseudobarbus burchelli*); diversity of habitat types and features; important migration route for cape shrimp (*Paleamon capensis*), mullet (*Myxus capensis* and *Mugil cephalus*) and *R. dewaali*. The river was relatively small and sensitive to flow changes.

PES: D

- Decreased base flows and flooding events with zero flows at times due to abstraction.
- Overall deterioration in water quality due to irrigation return flows.
- Bank modification and instability due to alien invasive vegetation and agricultural practices in riparian zones.
- Alien fish species occurred in the reach.

REC: D

The EIS was LOW and no improvement was required, therefore the REC was set to maintain the PES.

Component	PES and REC
IHI[1] Hydrology	B
Physico chemical	C
Fish	D
Invertebrates	D
Instream	D
Riparian vegetation	C/D
EcoStatus	D
Instream IHI	C
Riparian IHI	C
EIS	LOW

H9GOUK-EWR2: GOUKOU RIVER

EIS: MODERATE

Highest scoring metrics in the EIS model were unique and intolerant riparian/wetland species (Palmiet - *Prinonium serratum*); species intolerant to physico-chemical changes (*P. burchelli* and macroinvertebrate taxa) and diversity of habitat types and features that included backwaters and wetland features. The river was relatively small and sensitive to flow changes.

PES: C/D

- Decreased base flows, flooding events and zero flows at times due to abstraction and upstream dams.
- Deteriorated water quality due to the cumulative effects of agriculture and return flows.
- Bank modification and instability due to alien invasive vegetation and agriculture in the riparian zones.
- Alien fish species also occurred in the reach.
- Wood removal in the riparian zones.

REC: C/D

The EIS was MODERATE and the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	B
Physico chemical	C/D
Fish	D
Invertebrates	D
Instream	D
Riparian vegetation	C
EcoStatus	C/D
Instream IHI	C
Riparian IHI	C
EIS	MODERATE

1 Instream Habitat Integrity.

J1TOUW-EWR3: TOUWS RIVER	
EIS: HIGH Highest scoring metrics in the EIS model were rare and endangered species (*Pseudobarbus asper*); refugia and critical habitat (deep pools for *P. asper*) and importance as migration route as barriers downstream of the EWR site are absent. Six endemic riparian plant species occur at the site. The site fell within the endangered Muscadel Riviere Vegetation Type. Important riparian migration corridor - the *Acacia karoo* thicket was distinct from the upland vegetation. **PES: B/C** ▪ Reduced base flows and small floods caused by farm dams and irrigation impacted the wet season duration period. ▪ Deteriorated water quality (nutrients) due to agriculture. ▪ Bank modification and instability due to alien invasive vegetation and agricultural practices in the riparian zones. ▪ Alien vegetation species occurred in the reach. **REC: B/C** The EIS was HIGH and the REC should be set to improve the PES. However, there was uncertainty in what aspects needed to improve as the impacts and the causes were not well understood and known. It was likely that some of the ratings for the PES should have been higher, which would result in a B EC. In light of this uncertainty and that improvement would require an increase in base flows and small floods, which cannot be supplied without additional infrastructure or restrictions of allocation, the PES was set to maintain the REC.	See table below

Component	PES and REC
IHI Hydrology	B/C
Water quality	B/C
Geomorphology	B
Fish	C/D
Invertebrates	B/C
Instream	C
Riparian vegetation	B/C
EcoStatus	B/C
Instream IHI	C
Riparian IHI	C
EIS	HIGH

J2GAMK-EWR4: GAMKA RIVER	
EIS: HIGH Highest scoring metrics in the EIS model were rare and endangered species (*P. asper*) and diversity of habitat types and features. Five endemic riparian species occur at the site; diversity of riparian/wetland habitat types and features were present and the distinct band of dense woody vegetation provided an effective corridor through a terrestrial landscape that was characterised by sparse, short vegetation and extreme topography. **PES: C/D** ▪ Altered flow regime due to decreased base flows and flooding events and zero flows at times due to unseasonal and regular flood releases from the Gamkapoort Dam as well as the decreased large floods. ▪ Increased turbidity due to dam releases. ▪ Presence of alien vegetation species. ▪ Predation and competition from alien fish species. **REC: C** The EIS was HIGH and the REC was set to improve the PES by: ▪ Larger flood releases improving geomorphology. ▪ Improving nutrients although the source of the nutrients has to first be identified. ▪ Increasing of flood frequency in the summer with less flow regulation (unseasonal floods improving riparian vegetation). ▪ Eradicating alien fish species which would be ideal, although this is unlikely. The improvements required for vegetation (previous bullet) is likely to improve the fish as well as the macroinvertebrate community.	See table below

Component	PES	REC
IHI Hydrology	C/D	
Geomorphology	D	C
Water quality	B/C	B
Fish	C/D	C
Invertebrates	C/D	B/C
Instream	C/D	C
Riparian vegetation	D	C
EcoStatus	C/D	C
Instream IHI	C	
Riparian IHI	C/D	
EIS	HIGH	

J1BUFF-EWR5: BUFFELS RIVER	

EIS: MODERATE
Highest scoring metrics in the EIS model were rare and endangered species (*P. asper*); refugia and critical habitat (deep pools for *P. asper*). Five endemic riparian species occur at the site and there is a diversity of riparian/wetland habitat types and features. An effective riparian/wetland migration corridor was provided by dense woody vegetation (mostly *A. karoo*) but was also diverse due to the presence of pools dominated by grass and sedge that were utilised by waterfowl.

PES: C
- Decreased baseflows as well as reduced flood frequencies due to Floriskraal Dam. The seasonal distribution of baseflow was greatly affected (March to September showed a significant decrease in flows from natural).
- Deteriorated water quality and increased water temperatures.
- Increased woody vegetation encroachment.

REC: C
The EIS was MODERATE and the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	D
Geomorphology	D
Water quality	C
Fish	B/C
Invertebrates	C
Instream	C
Riparian vegetation	D
EcoStatus	C
Instream IHI	D
Riparian IHI	D
EIS	**MODERATE**

J4GOUR-EWR6: GOURITZ RIVER	

EIS: MODERATE
Highest scoring metrics in the EIS model were rare and endangered species (*P. asper*); important migration corridor as it occurred in a larger catchment that fish could move through and barriers were absent downstream of the EWR site. Five endemic riparian species occur at the site.

PES: C
- Baseflows as well as a decrease in volume, frequency and distribution of moderate-sized floods had occurred due to irrigation, groundwater abstraction, grazing, large dams and domestic water use.
- These activities have resulted in deteriorated water quality (high salinity and elevated nutrients).
- Some invasion by alien species and overgrazing in the upper and Macro Channel Bank zones were present.
- Alien fish species also occurred in the reach.

REC: C
The EIS was MODERATE and the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	C
Geomorphology	B
Water quality	B/C
Fish	D
Invertebrates	C
Instream	C
Riparian vegetation	B/C
EcoStatus	C
Instream IHI	C/D
Riparian IHI	C
EIS	**MODERATE**

J1DORI-EWR7: DORING RIVER

EIS: LOW

The highest scoring metrics in the EIS model were rare and endangered species (endangered *P. asper* occurring in the reach); refugia and critical habitat (deep pools) and species/taxon richness. The river was relatively small sensitive to flow changes.

PES: C/D

- Decreased base flows with zero flows at times and decreased floods due to abstraction, upstream dams and flow diversions.
- Deteriorated water quality due to polluted agricultural return flows.
- Bank modification and instability in the reach due to alien invasive vegetation and agriculture in the riparian zones.
- Clearing and overgrazing and catchment erosion had also contributed to bank and bed modification.
- Alien fish species also occurred in the reach.

REC: C/D

The EIS was LOW and no improvement was required, therefore the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	D
Physico chemical	C
Fish	C/D
Invertebrates	D
Instream	C/D
Riparian vegetation	C/D
EcoStatus	C/D
Instream IHI	D
Riparian IHI	D
EIS	LOW

K6KEUR-EWR8: KEURBOOMS RIVER

EIS: HIGH

Highest scoring metrics in the EIS model were rare and endangered species (*P. asper*); unique species (*Pseudobarbus cf. tenuis*); species intolerant to physico-chemical changes and important migration route as the site was located in the lower part of the system and the reach was important for eel migration. Three rare and endangered riparian/wetland species were present as well as two endemic species.

PES: C

- Reduced baseflows, flood frequency.
- Deteriorated water quality during the dry season due to abstraction (and return flows) for agriculture.
- Flow reduction due to extensive forestry plantations in the catchment.
- High occurrence of alien plantation species that encroach on the natural habitat as well as vegetation clearing.

REC: B/C

The EIS was HIGH and the REC was set to improve the PES by:

- Removal of alien vegetation.
- Improvement in baseflows.

Component	PES	REC
IHI Hydrology	B	
Water quality	B	B
Geomorphology	B/C	B
Fish	C	B
Invertebrates	C	B
Instream	C	B
Riparian vegetation	C/D	B/C
EcoStatus	C	B/C
Instream IHI	C	
Riparian IHI	C/D	
EIS	HIGH	

J3OLIF-EWR9: OLIFANTS RIVER

EIS: MODERATE
Three endemic riparian species occur at the site and an effective riparian/wetland migration corridor was provided by dense woody vegetation (mostly *A. karoo* and *Salsola aphylla*) in an otherwise barren and sparse landscape.

PES: C

- Irrigation has decreased baseflows and moderate flood frequency.
- Water quality deterioration especially when flows were low leading to high temperatures and low oxygen rates.
- Overgrazing in the riparian zone resulting in bank modification and decreased longitudinal connectivity.

REC: C
The EIS was MODERATE and the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	B
Water quality	C
Invertebrates	C
Riparian vegetation	C
EcoStatus	C
Instream IHI	B/C
Riparian IHI	C
EIS	**MODERATE**

J3KAMM-EWR10: KAMMANASSIE RIVER

EIS: LOW
The highest scoring metrics were rare and endangered species (endangered *P. asper* occurring in the reach); refugia and critical habitat (deep pools) and species/taxon richness. The river was relatively small and sensitive to flow changes and an important corridor in a dry environment.

PES: C/D

- Decreased base flows with zero flows at times and decreased floods due to irrigation return flows, abstraction and farm dams.
- Deteriorated water quality due to polluted agricultural return flows.
- Elevated sediment input resulting in reduced pool depth and degraded substrate for biota.
- Alien vegetation in the upper riparian zone and significant *Cyperus textillis* encroachment in the area. Possibly due to nutrient enrichment and more consistent flows or seepage from return flows during dry times.
- Alien fish species also occur in the reach.

REC: C/D
The EIS was LOW and no improvement was required, and the REC was set to maintain the PES.

Component	PES and REC
IHI Hydrology	C
Physico chemical	C
Fish	D
Invertebrates	C/D
Instream	D
Riparian vegetation	C/D
EcoStatus	C/D
Instream IHI	D
Riparian IHI	D
EIS	**LOW**

The confidence in the EcoClassification process is provided in **Table 5.2** and was based on data and information availability and EcoClassification, where:

- Data and information availability: Evaluation based on the adequacy of any available data for interpretation of the ECs.
- EcoClassification: Evaluation based on the confidence in the accuracy of the PES.

The confidence score was based on a scale of 0 – 5 and colour coded where:
0 – 1.9: Low 2 – 3.4: Moderate 3.5 – 5: High

Table 5.2 Reserve EWR sites: Confidence in EcoClassification

Component	H8DUIW-EWR1	H9GOUK-EWR2	J1TOUW-EWR3	J2GAMK-EWR4	J1BUFF-EWR5	J4GOUR-EWR6	J1DORI-EWR7	K6KEUR-EWR8	J3OLIF-EWR9	J3KAMM-EWR10
Data and information availability										
Hydrology	3.5	2.8	2	1.5	3	2	1.5	3	1.5	2.8
Water Quality	3.5	3	2.5	3	2.5	3	2	3	2.5	2
Geomorphology			3.5	3	3.5	3.5		3.5		
IHI	3	3	2.5	3	2.9	2.5	3	3	2	3
Fish	3	3	2	2	2	3	1.5	2.5		1.5
Inverts	3	3	3	3	3	3	3	3	2	3
Vegetation	4	4	3.5	3.5	3.5	3.5	3	3.5	3.5	3
Average	**3.3**	**3.1**	**2.7**	**2.7**	**2.9**	**2.9**	**2.3**	**3.1**	**2.3**	**2.5**
Median[1]	**3.4**	**3**	**2.5**	**3.0**	**3.0**	**3.0**	**2.5**	**3.0**	**2.0**	**2.9**
EcoClassification										
Hydrology	3	3.3	2.8	2.7	2.9	2.6	1.1	3.4	1.6	1.1
Water Quality	3.5	3.5	2.5	3	3	3	2	3	2	2
Geomorphology			3	3	3	2.5		2.5		
IHI	3.2	3.2	2.9	3	3.3	3	3.2	3.2	2.7	3.2
Fish	2	2	1.5	2.5	2.5	2	2	2.5		2
Inverts	2.5	2.5	2.5	2.5	2	2.5	1.5	2.5	1.5	2
Vegetation	4	3.6	3.2	3.8	3.4	3.3	3.7	3.1	3.1	3.6
Average	**3**	**3**	**2.6**	**2.9**	**2.9**	**2.7**	**2.3**	**2.9**	**2.2**	**2.3**
Median[1]	**3.1**	**3.3**	**2.8**	**3.0**	**3.0**	**2.6**	**2**	**3.0**	**2**	**2**

1 Determined based on all component scores i.e. median of hydrology, water quality, geomorphology, IHI, fish, inverts and vegetation.

5.4 CONCLUSIONS AND RECOMMENDATIONS

The confidence in the EcoClassification results was generally Moderate which was acceptable for a Rapid to Intermediate assessment. Furthermore, no further work on EcoClassification was required as it would not influence the EWR determination. However, monitoring is essential to ensure that the ecological objectives are achieved.

6 RIVERS: EWR ASSESSMENT

Department of Water and Sanitation (DWS), 2014b. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Rivers RDM Report – Rapid Assessment. Prepared by Rivers for Africa eFlows Consulting (Pty) Ltd. for Scherman Colloty & Associates cc. Report no. RDM/WMA16/01/CON/1113.

Department of Water and Sanitation (DWS), 2015a. *Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Rivers RDM Report – Intermediate Assessment. Prepared by Rivers for Africa eFlows Consulting (Pty) Ltd. for Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/1013.

6.1 BACKGROUND

This task consisted of determining the EWR for different ecological river states, i.e. different ECs.

6.2 APPROACH

The Habitat Flow Stressor Response method (HFSR) (O'Keeffe *et al*., 2002; IWR S2S, 2004; Hughes and Louw, 2010) was used to determine the EWRs. This method is one of the methods used to determine EWRs at a detailed level and a version of this has been built into the Revised Desktop Reserve Model (RDRM) (Hughes *et al*., 2014).

6.3 EWR QUANTIFICATION

The final flow requirements are expressed as a percentage of the natural Mean Annual Runoff (nMAR) in **Table 6.1**.

Table 6.1 Summary of results as a percentage of the nMAR

Site	EcoStatus	nMAR (million m^3)	pMAR[2] (million m^3)	Low flows (million m^3)	Low flows (%)	High flows (million m^3)	High flows (%)	Total flows (million m^3)	Total flows (%)
H8DUIW-EWR1	PES; REC: D	83.7	79.8	14.2	17	8.2	10.2	22.7	27.1
H9GOUK-EWR2	PES; REC: C/D	54.1	46	7.1	13.1	4.3	13.9	11.4	21
J1TOUW-EWR3	PES; REC: B/C (i.e. an Instream PES: C)	45.2	22.3	1.15	2.6	11.5	25.6	12.7	28.2
J2GAMK-EWR4	PES: C/D	85.5	61.7	3.9	4.6	17.4	20.4	21.4	25.0
J1BUFF-EWR5	PES; REC: C	29.3	18.7	1.4	4.7	6.9	23.3	8.2	28.0
J4GOUR-EWR6	PES; REC: C	543.5	310.4	27.1	5.0	102.5	18.8	129.6	23.8
J1DORI-EWR7	PES; REC: C/D	4.5	2.0	0.4	8.5	0.6	14.3	1.03	22.8
K6KEUR-EWR8	Instream PES: C	49.8	30.5	10.7	21.4	8.7	17.4	19.3	38.8

Site	EcoStatus	nMAR (million m³)	pMAR[2] (million m³)	Low flows (million m³)	Low flows (%)	High flows (million m³)	High flows (%)	Total flows (million m³)	Total flows (%)
	Instream REC: B	49.8	30.5	13.9	28.0	9.3	18.6	23.3	46.7
J3OLIF-EWR9	PES; REC: C	13.8	11.3	0.5	3.9	3.1	22.2	3.6	26.1
J3KAMM-EWR10	PES; REC: C/D	20.6	19.6	1.8	8.9	2.8	13.5	4.6	21

1 Present Day Mean Annual Runoff

6.4 CONCLUSIONS AND RECOMMENDATIONS

The confidence in all the parameters, used during EWR quantification, (**Table 6.2**) was generally Moderate, for most sites except J1DORI-EWR7. Low confidence dominated most parameters for J1DORI-EWR7 due to the lack of guage data which influenced the confidence in setting EWRs. A low confidence for hydrology was seen at J1DORI-EWR7 and J3OLIF-EWR9. At J1DORI-EWR7 the low confidence in hydrology was linked to the available hydrological model for the Doring River which was out of date. The low confidence for hydrology at J3OLIF-EWR9 was linked to the absence of a reliable gauge in the area and in turn influenced the overall confidence in low flows. Low confidence dominated the biotic responses to low flow parameters for J1TOUW-EWR3 due to non-sensitive fish species naturally present in this reach. Recommended low flows also did not achieve the EC for macroinvertebrates resuting in a reliance on the recommended high flows which appear in the early to mid summer months.

Confidence in the hydraulic modelling results overrode the confidence in the biophysical responses, except at J1TOUW-EWR3. The confidence was generally Moderate, for all the EWR sites with High confidence in the high flow determination for J2GAMK-EWR4, J4GOUR-EWR6 and H9GOUK-EWR2. The lowest confidence for low flow determination was achieved at H9GOUK-EWR2, J1BUFF-EWR5 and J1DORI-EWR7. This was because all measured flow data used for calibrating the hydraulic model was higher than the low flow EWR determination. Further work to improve the hydraulics would require additional measured calibration at very low flows.

The most effective way of improving confidence is linked to monitoring the ecological status of the river and, if required, improving the hydraulics for low flows at selected sites as part of the monitoring programme. However, this can only be successful if good reliable hydrological measurements are available. No specific studies to improve any confidences other than monitoring are therefore recommended.

The confidence score is based on a scale of 0 – 5 and colour coded where:

0 – 1.9: Low | 2 – 3.4: Moderate | 3.5 – 5: High

Table 6.2 Summary of confidence in EWR quantification at the EWR sites

EWR site	H8DUIW-EWR1	H9GOUK-EWR2	J1TOUW-EWR3	J2GAMK-EWR4	J1BUFF-EWR5	J4GOUR-EWR6	J1DORI-EWR7	K6KEUR-EWR8	J3OLIF-EWR9	J3KAMM-WR10
Low flow EWR (biotic responses)	3.2	2.8	1.5	2.5	2.3	2.7	1.8	3.7	N/A	2.5
High flow EWR (biophysical responses)	3.0	2.7	2.8	2.6	3.0	3.2	1.7	3.6	4.0	2.7
Hydrology	3.5	2.8	2.0	1.5	3.0	2.0	1.5	3.0	1.5	2.8
Hydraulics (low)	3	2.5	2.5	3.0	2.0	2.5	2.5	3.0	N/A	3
Hydraulics (high)	2.5	4	3.0	4.0	2.5	4.0	3	3.0	3.0	3
Overall low flow EWR confidence	3.0	2.5	2.3	2.9	2.4	2.6	1.8	3.2	1.5	2.5
Overall high flow EWR confidence	2.5	2.7	2.9	3.3	2.8	3.6	1.7	3.3	3.5	2.7

7 ESTUARIES: ECOCLASSIFICATION AND EWR ASSESSMENT

7.1 BACKGROUND

The Gouritz WMA includes 21 estuaries stretching from the Duiwenhoks Estuary in the west to the Bloukrans Estuary in the east. Within this WMA, 11 estuaries have been assessed a part of previous EWR studies and the GRDS therefore focused on the remaining 10 estuaries (**Table 7.1**). Of the 11 estuaries that was assessed previously, EWR assessments on eight of those did not define Ecological specifications (referred to in this document as EcoSpecs) and TPCs, nor were monitoring programmes provided. Therefore, the GRDS also defined such parameters and programmes for those eight estuaries (**Table 7.1**).

Table 7.1 The Estuaries assessed during the GRDS study

Estuary	EWR level	EcoSpecs[1]/TPCs[2]	Monitoring programme
Duiwenhoks	Intermediate (GRDS study)	✓	✓
Goukou	Intermediate (GRDS study)	✓	✓
Gourits	Intermediate (GRDS study)	✓	✓
Blinde	Desktop (GRDS study)	✓	✓
Hartenbos	Desktop (GRDS study)	✓	✓
Klein Brak	Rapid (GRDS study)	✓	✓
Maalgate	Desktop (previous EWR) (DWA, 2009a)	✓	✓
Gwaing	Desktop (previous EWR) (DWA, 2009a)	✓	✓
Kaaimans	Desktop (previous EWR) (DWA, 2009a)	✓	✓
Wilderness	Rapid (GRDS study)	✓	✓
Goukamma	Rapid (previous EWR) (DWA, 2009b)	✓	✓
Noetsie	Desktop (previous EWR) (DWA, 2009a)	✓	✓
Piesang	Desktop (GRDS study)	✓	✓
Keurbooms	Rapid (previous EWR) (CSIR, 2008)	✓	✓
Matjies	Intermediate (previous EWR) (Bornman, 2007a)	✓	✓
Sout (Oos)	Intermediate (previous EWR) (Bornman, 2007b)	✓	✓
Groot (Wes)	Desktop (GRDS study)	✓	✓
Bloukrans	Desktop (GRDS study)	✓	✓

1 Ecological Specifications 2 Thresholds of Potential Concern

Within the time and budgetary constraints it was not possible to conduct the Preliminary Reserve determination studies on the estuaries of the Gouritz WMA at a high confidence. Instead a “best attainable” approach was adopted to assess as many estuaries as possible. In selecting the level of Reserve (i.e. Intermediate, Rapid or Desktop) for various estuaries, systems were prioritised in terms of the degree to which they were already water stressed or had major future abstraction pressures. Also, their protected status or desired protected status determined during the 2011 National Biodiversity Assessment (NBA) (Van Niekerk and Turpie, 2012.) was taken into account.

7.2 DUIWENHOKS ESTUARY

Department of Water and Sanitation (DWS), 2014c. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Intermediate Assessment Volume 1 (Duiwenhoks Estuary). Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0813, Volume 1.

Using the rating system outlined in **Section 7.1**, the Duiwenhoks Estuary showed highest priority (best attainable: intermediate level). This Section presents the Intermediate level assessment on the Duiwenhoks Estuary.

7.2.1 Delineation

The Duiwenhoks Estuary is a permanently open estuary located in the warm temperate region of the Western Cape between Riversdale and Heidelberg along the Cape south coast. The geographical boundaries, as presented by the Estuarine Functional Zone (EFZ) are represented in **Figure 7.1** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34°21'54.31"S 21° 0'0.51"E
Upstream boundary:	34°15'5.87"S 20°59'30.95"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 7.1 Geographical boundaries of the Duiwenhoks Estuary

7.2.2 EcoClassification

Present Ecological State

The PES of the Duiwenhoks Estuary - assessed in terms of the degree of similarity to the reference condition (i.e. the natural, unimpacted condition) - for various abiotic and biotic components are presented in **Table 7.2**, resulting in an overall PES of Category C.

Table 7.2 PES of the Duiwenhoks Estuary

Variable	Category	Confidence
Hydrology	**D**	Medium
Hydrodynamics and mouth condition	**A**	Medium
Water quality	**B/C**	Medium
Physical habitat alteration	**B**	Low
Habitat health score	**B/C**	
Microalgae	**B/C**	Medium to Low
Macrophytes	**C/D**	Medium
Invertebrates	**C**	Medium
Fish	**C**	Medium
Birds	**B/C**	Low
Biotic health score	**C**	
OVERALL PES	**C**	**Medium**

Flow related effects specifically related to changes caused by a modification in river (volume) inflow (i.e. either base flows, seasonal distribution of flows or flood characteristics). In addition to flow modification, non-flow related factors also contributed significantly to ecological modification in the Duiwenhoks Estuary, specifically related to nutrient enrichment from agriculture, degradation of estuarine habitat through development in the EFZ, fishing pressures and human disturbance of birds.

The overall confidence of this intermediate level assessment was medium, derived from the medium confidence reflected in most of the abiotic and biotic components. In terms of the abiotic components, it was possible to define and characterise the five abiotic states for this system with medium confidence, mainly because long-term river inflow records was available, as well as long-term river water quality (collected in close proximity to the head of the estuary (H8H001)). Also, the Department of Agriculture, Forestry and Fisheries (DAFF) in conjunction with the Council for Scientific and Industrial Research (CSIR) collected salinity, as well as other water quality parameters (i.e. temperature, pH, Dissolved Oxygen (DO) and turbidity) collected as part of a long-term estuarine monitoring programme which significantly enhanced confidence in this assessment. The only exception was data on sediment dynamics (which is not a key requirement for intermediate level assessment), as well as inorganic nutrient data in the estuary (although long-term data on river inflow quality could be used to estimate conditions for various abiotic state). In terms of the biotic components, medium confidence in the macrophyte component is largely attributed to extensive, recent research conducted by the Nelson Mandela Metropolitan University (NMMU) on estuarine systems in the region. Extensive data on the fish component collected by DAFF as part of their long-term monitoring programmes in estuaries significantly contributed to the medium (even high) confidence in this component. Sufficient bird data were also available through the Coordinated Waterbird Counts (CWAC) programme. Although there was medium to low confidence in the microalgae and invertebrate components (mainly as a result of limited data on the Duiwenhoks system itself), experience gained from research on other, related estuarine systems, cannot warrant a drop in the overall confidence of this study. However, the recommended monitoring programme should focus on these components in order to improve confidence for future reviews. The confidence of the EWR study can be improved by proposed baseline surveys (2014c).

Ecological Importance

The estuarine ecological importance takes into account size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account (DWAF, 2008). This was applicable to all Estuaries assessed during the GRDS study. Using this system, the Estuarine Importance Score (EIS) for the Duiwenhoks Estuary are presented in **Table 7.3**.

Table 7.3 EIS for the Duiwenhoks Estuary

Criterion	Score
Estuary Size	100
Zonal Rarity Type	20
Habitat Diversity	90
Biodiversity Importance	77
Functional Importance	100
Weighted Estuary Importance Score	**84**

The functional importance of the Duiwenhoks Estuary was high as it is an important fish nursery with a number of Red Data and exploited fish species occurring in high numbers in the system. The estuary is also a very important conduit for eels which are listed on the Convention on International Trade in Endangered Species (CITES). Therefore, referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Duiwenhoks Estuary – a score of 84 - translates into an importance rating of “Highly Important”, formally promulgated on 17 October 2008.

Recommended Ecological Category

Applying the guidelines for the determination of the REC, the Duiwenhoks Estuary should at least be managed in a Category B. The motivation being that the estuary is highly important, requiring a minimum REC of a B. Further, the NBA 2011 assessment identified the estuary as an important nursery area for exploited fish stocks (Van Niekerk and Turpie, 2012). Considering the various flow and non-flow related factors that currently contribute to a PES of Category C, it was agreed that several of these impacts on the system are reversible, or at least partially reversible, if managed appropriately. As a result the REC for the Duiwenhoks Estuary was set as a Category B.

7.2.3 Ecological Water Requirements

A summary of the future runoff scenarios (85-year simulated data sets) assessed for the Duiwenhoks Estuary, in order to derive the flow scenario for the REC, is presented in **Table 7.4**.

Table 7.4 Summary of flow scenarios for the Duiwenhoks Estuary

Scenario	Description	MAR[1] (million m^3)	Percentage remaining
Reference	Natural MAR. H80F excluded since it discharges directly to sea.	89.29	100
Present	Present Day (based on 2004 water use).	72.91	82
1	Return 50% of natural base flows (Present Water Resource Yield Model (WRYM) - reduce afforestation and water use)	85.43	96
2	Present including low flow EWR for River Category D.	73.01	82
3	Present scenario plus 1.5 x 106 million m³ dummy dam upstream of estuary abstracting 9.5 x 106 million m³/a.	63.63	71
4	Worst case dam development[2].	49.93	56

1 Mean Annual Runoff remaining.

2 Scenario 4 was a hypothetical scenario which represented maximum abstraction. The size of a dummy dam was increased to 5 million m^3, abstracting 9.5 million m^3/a.

Using the Estuarine Health Index (EHI), the health implications of the future scenarios on various abiotic and biotic components, and the resultant ECs, for the Duiwenhoks Estuary are presented in **Table 7.5.**

Table 7.5 ECs associated with future scenarios in the Duiwenhoks Estuary

Variable	Scenario				
	Present	1	2	3	4
Hydrology	D	B	C/D	E	E
Hydrodynamics and mouth condition	A	A/B	A	A	A
Water quality	B/C	B/C	B/C	B/C	B/C
Physical habitat alteration	B	B	B	B	B/C
Habitat health score	B/C	B	B/C	C	C
Microalgae	B/C	B/C	B/C	B/C	C/D
Macrophytes	C/D	C/D	C/D	D	D
Invertebrates	C	B	B/C	C	D
Fish	C	B	C	C/D	D
Birds	B/C	B/C	B/C	D	D
Biotic health score	C	B/C	B/C	C/D	D
ECOLOGICAL CATEGORY	C	B	B/C	C	C/D

The recommended ecological flow scenario is defined as the runoff scenario (or a slight modification thereof) that represents the highest change in river inflow that will meet the REC (DWAF, 2008). Applying this guideline, only Scenario 1, in the suite of scenarios evaluated, meets the REC

(Category B). Scenario 1 was a hypothetical scenario returning 50% of the base flow through removal of alien vegetation, deforestation, as well as reducing abstraction from the river during the low flow season. However, considering the high water demand in the catchment, this may not be a realistic option. Scenario 2 (i.e. present flow including the low flow EWR for a river Category D), returning some low flows (although less than Scenario 1), can improve the health of the estuary to a Category B/C. This scenario does address the key flow-related factor contributing to the present change in ecological health and considering the significant contribution of non-flow related factors to present ecosystem health, as well as the reversibility of those impacts. Scenario 2 was identified as the recommended flow scenario for the Duiwenhoks Estuary:

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	19.1	23.2	23.5	12.4	9.9	16.5	22.2	11.5	6.5	9.0	26.3	23.1
99	15.2	17.9	13.1	9.5	8.8	11.9	21.2	11.4	6.0	8.3	22.1	13.6
90	9.3	6.6	2.5	1.8	2.7	4.1	5.4	5.7	4.3	4.6	6.0	6.3
80	4.8	4.8	1.6	0.5	0.7	2.4	3.2	3.0	3.5	3.5	5.0	5.5
70	3.8	3.0	0.6	0.4	0.4	1.7	2.5	2.4	2.4	2.8	4.0	3.9
60	2.6	1.9	0.5	0.3	0.3	1.1	1.6	1.9	2.0	2.4	3.3	3.3
50	2.3	1.4	0.4	0.2	0.2	0.5	1.0	1.3	1.6	2.1	2.8	2.8
40	1.8	0.7	0.4	0.2	0.1	0.2	0.6	1.1	1.2	1.6	2.4	2.5
30	1.5	0.5	0.3	0.1	0.1	0.1	0.6	0.8	1.1	1.4	2.1	1.9
20	1.1	0.5	0.2	0.1	0.0	0.1	0.4	0.5	0.8	1.1	1.5	1.7
10	0.8	0.4	0.2	0.0	0.0	0.0	0.2	0.3	0.5	0.9	1.1	1.3
1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.7	0.5
0.1	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	0.3

In order to improve from a Category B/C (Scenario 2 only) to the REC (Category B), the following additional non-flow related interventions are required:

- Rehabilitate peat land just upstream of the estuary to improve the regulation of river inflow to the estuary so as to maintain a River Estuary Interface (REI) zone for longer periods.
- Rehabilitate at least 10% of degraded estuarine habitat in the riparian zones, including the removal of alien vegetation.
- Control/reduce fishing effort through improved compliance monitoring of fishing activities.
- Implement an alien fish control programme; and
- Institute a control programme to reduce the number of Egyptian geese in the surrounding habitat.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B) for the Duiwenhoks Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2014c).

7.3 GOURITZ ESTUARY

Department of Water and Sanitation (DWS), 2015b. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Intermediate Assessment, Volume 2 (Gouritz Estuary). Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty and Associates cc. Report no. RDM/WMA16/04/CON/0813, Volume 2.

This section presents the Intermediate level assessment on the Gouritz Estuary.

7.3.1 Delineation

The Gouritz Estuary is a medium/large (245 ha open water area), permanently open system in the warm temperate region approximately 33 km to the south-west of Mossel Bay and enters the Indian Ocean between Bull Point and Kanonpunt. The geographical boundaries, as presented by the EFZ) are represented in **Figure 7.2** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34°20'37.31"S 21°53'7.21"E
Upstream boundary:	34° 9'27.91"S 21°44'36.78"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 7.2 Geographical boundaries of the Gouritz Estuary

7.3.2 EcoClassification

Present Ecological State

The PES of the Gouritz Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.6**, resulting in an overall PES of Category C/D.

Table 7.6 PES of the Gouritz Estuary

Variable	Category	Confidence
Hydrology	D/E	Medium
Hydrodynamics and mouth condition	A/B	Medium
Water quality	B	Medium
Physical habitat alteration	D	Low
Habitat health score	C	
Microalgae	B/C	Medium
Macrophytes	E	Medium
Invertebrates	D	Low to medium
Fish	C/D	High
Birds	B/C	Medium
Biotic health score	C/D	
OVERALL PES	C/D	Medium

Flow related effects specifically relate to changes caused by a modification in river (volume) inflow (i.e. either base flows, seasonal distribution of flows or flood characteristics). In addition to flow modification, non-flow related factors also contributed significantly to ecological modification in the Gouritz Estuary, specifically related degradation of estuarine habitat through development in the EFZ, fishing pressures and human disturbance of birds.

The overall confidence of this intermediate assessment study is medium, derived from the medium confidence reflected in most of the abiotic and biotic components. In terms of the abiotic components, it was not possible to define and characterise the five abiotic states for this system with high/medium confidence, mainly because long-term river inflow records were not available at the head of the estuary. Data from further upstream in the catchment had to be used. Water quality data on river inflow also was not available for river inflow near the head of the estuary and conditions had to be extrapolated from stations further upstream. However, the DAFF in conjunction with the CSIR collected salinity and other water quality parameters (i.e. temperature, pH, DO and turbidity) as part of a long-term monitoring programme in this estuary which enhanced confidence in the assessment of those parameters. Overall confidence in the abiotic components still came to medium, because of experience gained from collective research on other, related systems. Medium confidence in the macrophyte component is largely attributed to extensive, recent research conducted by the NMMU on estuarine systems in the region. Medium confidence in the microalgae, invertebrate is attributed to the availability of some historical data sets on this system, but mostly because of experience gained from collective research on other, related systems. Extensive data on the fish component collected by the DAFF as part of their long-term monitoring programmes in estuaries significantly contributed to the medium (even high) confidence in this component. Historical data on the bird component was also available from the CWAC programme. The character of the Gouritz Estuary also allowed the use of experience gained from collective research on other, related systems, warranting a medium confidence in the biotic components. The confidence of the EWR study can be improved by baseline surveys (DWS, 2015b).

Ecological Importance

The EIS for the Gouritz Estuary is presented in **Table 7.7**.

Table 7.7 EIS for the Gouritz Estuary

Criterion	Score
Estuary Size	90
Zonal Rarity Type	20
Habitat Diversity	60
Biodiversity Importance	88
Functional Importance	100
Weighted Estuary Importance Score	**78**

A score of 100 for functional importance was mainly attributed to the importance of this system as a nursery for exploited marine-living fish (e.g. collapsed stock: dusky cob, white steenbras), as well as the importance of catchment flows to the marine environment (e.g. sediment and detritus) and coastal connectivity, e.g. way point for fish. Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Gouritz Estuary – a score of 78 - translates into an importance rating of "Important".

Recommended Ecological Category

The Gouritz Estuary forms part of the core set of priority estuaries identified in the National Estuary Biodiversity Plan (i.e. a desired protected area). Applying the guidelines for the determination of the REC the estuary, therefore, should be managed in a Category A, or at least a Best Attainable State (BAS). Considering the various flow and non-flow related factors that currently contribute to the PES of Category C/D, specialists agreed that several of the flow related and non-flow related impacts on the system are reversible, or at least partially reversible. However, it is unlikely to fully restore the ecological status of this estuary to a Category A given the high demand for water in the catchment. The REC for the Gouritz Estuary, therefore, was set as a Category B. This was also the Category recommended in the National Estuary Biodiversity Plan.

7.3.3 Ecological Water Requirements

A summary of the future runoff scenarios (85-year simulated data sets) assessed for the Gouritz Estuary in order to derive the flow scenario for the REC, is presented in **Table 7.8**.

Table 7.8 Summary of flow scenarios for the Gouritz Estuary

Scenario	Description	MAR[1] (million m^3)	Percentage remaining
Reference	Natural flow regime before development	623.52	100
Present	Present (2004) development level	377.23	60
Scenario 1	Restore about 50% of base flow (spreadsheet manipulation)	504.48	81
Scenario 2	Restore about 25% of base flow (spreadsheet manipulation)	440.85	71
Scenario 3	Reduce Present MAR by 15% (Present WRYM with dummy dam and abstraction upstream of estuary)	296.60	48
Scenario 4	Reduce Present MAR by about 25% (Present WRYM with large dam and abstraction upstream of estuary)	225.80	36

1 Mean Annual Runoff remaining.

Using the EHI, the health implications of the future scenarios on various abiotic and biotic components, and the resultant ECs, for the Goukou Estuary are presented in **Table 7.9**.

Table 7.9 ECs associated with future scenarios for the Goukou Estuary

Variable	Scenario				
	Present	1	2	3	4
Hydrology	D/E	B/C	D	E	E/F
Hydrodynamics and mouth condition	A/B	A	A	A/B	B
Water quality	B	B	B	B/C	C
Physical habitat alteration	D	D	D	D	E
Habitat health score	C	B/C	C	C/D	D
Microalgae	B/C	B/C	B/C	C/D	D
Macrophytes	E	E	E	E	E
Invertebrates	D	A	A/B	D	D/E
Fish	C/D	A/B	A/B	D/E	E
Birds	B/C	B	B	C	C/D
Biotic health score	C/D	B/C	B/C	D	D/E
ECOLOGICAL CATEGORY	C/D	B/C	B/C	D	D

The recommended ecological flow scenario is defined as the runoff scenario (or a slight modification thereof) that represents the highest change in river inflow that will meet the REC (DWAF, 2008). However, none of the flow scenarios evaluated as part of the GRDS were able to reverse modification in the ecological state to a Category B. This is mainly as a result of significant non-flow related human impacts also contributing to the present ecological status in the estuary. However, Scenario 2 could restore the estuary to a Category B/C (just below a Category B). Scenario 2 assumes a 25% base flow return to the estuary, e.g. through removal of alien invasive plants, as well as reducing run-off river abstraction during the low flow season. Restoring some base flow addresses the key flow-related factor contributing to the changes in ecological health in the estuary, namely the re-establishment of the REI zone. Considering the significant contribution of non-flow related factors the present health in the Gouritz Estuary, as well as the reversibility of some of these impacts, Scenario 2 (achieving a Category B/C) was identified as the recommended flow scenario from an ecological perspective (important is that this estuary is very sensitive to base flow reduction below 0.5 m^3/s as it rapidly loses the REI zone under such flows, thus this effectively requires a minimum flow of 0.5 m^3/s in order to maintain the REC):

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	95.3	303.3	148.6	192.2	271.4	185.9	180.7	82.9	152.1	83.9	134.1	98.2
99	83.9	132.7	130.7	119.9	105.8	139.5	152.2	79.2	120.1	70.2	127.3	77.8
90	34.7	56.3	35.8	19.5	41.5	46.1	45.8	46.8	28.6	20.7	30.4	34.9
80	21.0	22.2	17.2	7.8	10.1	18.4	28.8	20.7	13.8	13.4	14.6	18.6
70	12.9	13.6	9.0	5.6	4.5	10.0	15.5	13.0	9.8	9.9	11.2	8.6
60	7.1	6.5	4.5	2.4	2.8	6.7	11.1	10.8	7.7	6.8	8.3	6.1
50	5.6	4.0	2.8	1.1	1.7	4.7	5.0	7.4	6.1	5.8	7.0	4.8
40	2.9	2.9	1.6	0.8	1.2	3.0	3.4	5.2	4.7	4.6	5.2	4.0
30	2.5	1.9	1.1	0.7	0.7	1.7	2.1	3.6	3.5	3.3	4.1	3.2
20	2.1	1.1	0.8	0.4	0.5	1.0	1.6	2.2	2.1	2.7	3.2	2.6
10	1.6	0.8	0.5	0.4	0.4	0.5	0.7	1.5	1.5	1.8	2.2	1.8
1	0.7	0.5	0.2	0.1	0.2	0.2	0.2	0.9	0.5	1.0	1.4	1.3
0.1	0.5	0.5	0.2	0.1	0.1	0.2	0.1	0.9	0.4	0.6	1.2	1.0

In order to improve from a Category B/C (achieved by Scenario 2) to the REC (Category B), the following additional intervention in terms of non-flow related impacts are required:

- Actively encourage stewardship programmes that promote alternative farming practices (i.e. using less water).
- Rehabilitate 20% of the flood plain by removing the agriculture levees and invasive plants.
- The abutment on the eastern side of the bridge across river will fail under flood which requires the construction of appropriate open spans/culverts.
- Water supply pipe (along western bank in the middle reaches of the estuary) should be protected by hard infrastructure (e.g. stone gabions have short life span in salty conditions) but preferably an alternative location should be investigated.
- Future planning and construction of hard structures should be prohibited as a result of the high dynamic/erodable nature of the estuary bank.
- Appropriate dune management and setback along the coast adjacent to mouth should be implemented as it affects mouth dynamics; and
- Control/reduce fishing effort through improved compliance monitoring of fishing activities and banning of night fishing.

Specialists were of the opinion that if all the above-mentioned non-flow related impacts were mitigated, the system's health is likely to improve significantly, even without additional base flow – potentially reaching a Category B/C. However, it is perhaps unrealistic to expept successful mitigation of all non-flow related impacts in which case the return of some base flow during the low flow periods (to increase the REI zone) should still be investigated in order to achieve the REC (Category B).

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B) for the Gouritz Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015b).

7.4 GOUKOU ESTUARY

Department of Water and Sanitation (DWS), 2015c. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Intermediate Assessment, Volume 3 (Goukou Estuary). Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0813, Volume 3.

This section presents the Intermediate level assessment on the Goukou Estuary.

7.4.1 Delineation

The Goukou Estuary is located on the Indian Ocean seaboard, about 300 km east of Cape Town. The estuary covers approximately 250 ha, is 19 km in length, and is embedded in a deep valley. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.3** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34°22'43.36"S, 21°25'22.19"E
Upstream boundary:	34°17'32.20"S, 21°18'29.03"E
Lateral boundaries:	5 m contour above MSL along each bank

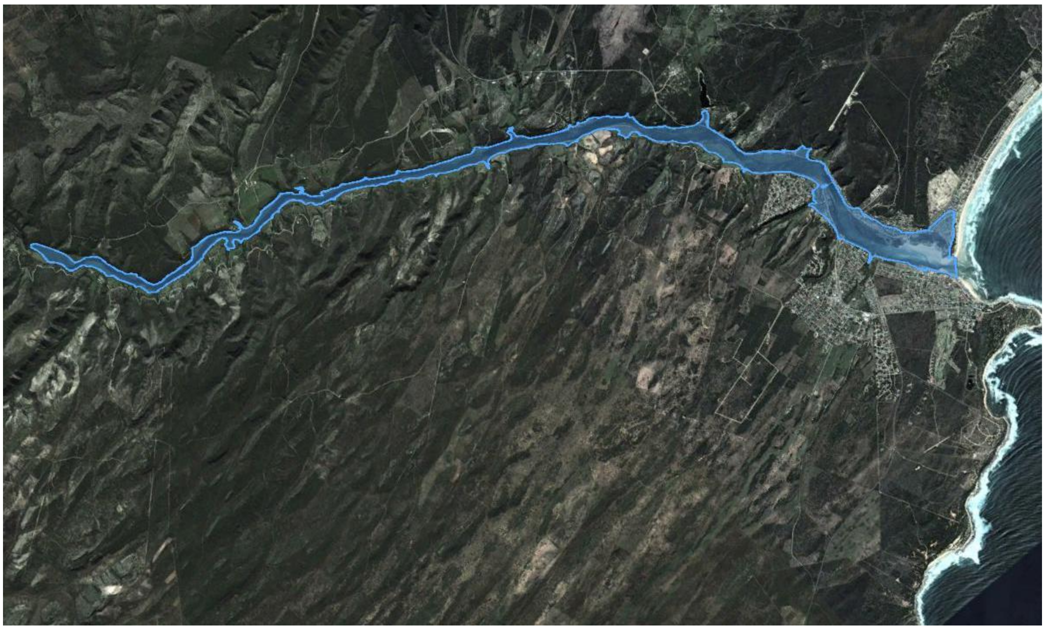


Figure 7.3 Geographical boundaries of the Goukou Estuary

7.4.2 EcoClassification

Present Ecological State

The PES of the Goukou Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.10**, resulting in an overall PES of Category C.

Table 7.10 PES of the Goukou Estuary

Variable	Category	Confidence
Hydrology	C/D	Low to Medium
Hydrodynamics and mouth condition	A	Medium
Water quality	B/C	Medium to High
Physical habitat alteration	C	Low
Habitat health score	C	
Microalgae	C/D	Medium
Macrophytes	C	Medium
Invertebrates	C/D	Medium
Fish	B/C	High
Birds	B/C	Medium
Biotic health score	C	
OVERALL PES	C	**Medium**

Flow related effects specifically relate to changes caused by a modification in river (volume) inflow (i.e. either base flows, seasonal distribution of flows or flood characteristics). In addition to flow modification, non-flow related factors also contributed significantly to ecological modification in the Goukou Estuary, specifically related to nutrient enrichment from agriculture, degradation of estuarine habitat through development in the EFZ, fishing pressures and human disturbance of birds.

The overall confidence of this intermediate level assessment is medium, derived from the medium confidence reflected in most of the abiotic and biotic components. In terms of the abiotic components, it was not possible to define and characterise the five abiotic states for this system with high/medium confidence, mainly because long-term river inflow records were not available at the head of the estuary. Data from the Duiwenhoks gauging station (H8H1) had to be used as proxy. Water quality data on river inflow also was not available for river inflow near the head of the estuary and conditions had to be extrapolated from further upstream (H9H5) as well as using downstream data from the Duiwenhoks system (H8H1). However, the DAFF in conjunction with the CSIR collected salinity and other water quality parameters (i.e. temperature, pH, DO and turbidity) as part of a long-term monitoring programme in this estuary which enhanced confidence in the assessment of those parameters. Overall confidence in the abiotic components still came to medium, because of experience gained from collective research on other, related systems. Medium confidence in the macrophyte component is largely attributed to extensive, recent research conducted by the NMMU on estuarine systems in the region. Medium confidence in the microalgae, invertebrate is attributed to the availability of some historical data sets on this system, but mostly because of experience gained from research on other, related systems. Extensive data on the fish component collected by the DAFF as part of their long-term monitoring programmes in estuaries significantly contributed to the medium (even high) confidence in this component. Historical data on the bird component was also available from the CWAC programme. The character of the Goukou Estuary along with experience gained from research on other, related systems, warranted a medium confidence in the biotic components. The confidence of the EWR study can be improved by proposed baseline surveys (DWS, 2015c).

Ecological Importance

The EIS for the Goukou Estuary is presented in **Table 7.11**.

Table 7.11 EIS for the Goukou Estuary

Criterion	Score
Estuary Size	90
Zonal Rarity Type	20
Habitat Diversity	90
Biodiversity Importance	97
Functional Importance	100
Estuary Importance Score	**83**

A score of 100 for functional importance was mainly attributed to the importance of this system as a nursery for exploited marine-living fish (e.g. collapsed stock: dusky cob, white steenbras), as well as being a very important movement corridor for river invertebrates and fish breeding in sea, e.g. eels (CITES listed species), crabs, gobies, freshwater prawn. Therefore, referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Goukou Estuary – a score of 83 - translates into an importance rating of “Highly Important”.

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Goukou Estuary should at least be managed in a Category A or at least the BAS. Considering the various flow and non-flow related factors that currently contribute to a PES of Category C, it was agreed that several of the flow related and non-flow related impacts on the system are reversible, or at least partially reversible. However, it is unlikely to fully restore the ecological status of this estuary to a Category A, given the social and economic demand for water in the catchment, as well as extensive urban development along its banks. The REC for the Goukou Estuary, therefore, was set as a Category B.

7.4.3 Ecological Water Requirements

A summary of the future runoff scenarios (85-year simulated data sets) assessed for the Goukou Estuary, in order to derive the flow scenario for the REC, is shown in **Table 7.12**.

Table 7.12 Summary of flow scenarios for the Goukou Estuary

Scenario	Description	MAR[1] (million m^3)	Percentage remaining
Reference	Natural flow regime before development	115.95	100
Present	Present Day (based on 2004 water use).	91.73	79
Scenario 1	Restore about 50% of base flow (Present WRYM with no afforestation and decreased abstractions)	101.69	88
Scenario 2	Reduce Present MAR by about 10% (Present WRYM with two dummy dams with abstractions)	82.57	71
Scenario 3	Reduce Present MAR by about 15% (Scenario 2 with increased abstraction)	73.41	63
Scenario 4	Reduce Present MAR by about 30% (Scenario 3 with increased abstraction)	55.64	48

1 Mean Annual Runoff remaining.

Using the EHI, the health implications of the future scenarios on various abiotic and biotic components, and the resultant ECs, for the Goukou Estuary are presented in **Table 7.13.**

Table 7.13 ECs associated with future scenarios for the Goukou Estuary

Variable	Scenario				
	Present	1	2	3	4
Hydrology	C/D	C/D	D	D/E	E
Hydrodynamics and mouth condition	A	A	A	A	A
Water quality	B/C	B/C	B/C	B/C	C
Physical habitat alteration	C	C	C/D	C/D	D
Habitat health score	C	B/C	C	C	C
Microalgae	C/D	C	D	E	F
Macrophytes	C	C	C	D	D
Invertebrates	C/D	C	D	D	D
Fish	B/C	A/B	C	C	D
Birds	B/C	B/C	C	C	D
Biotic health score	C	B/C	C/D	D	D/E
ECOLOGICAL CATEGORY	C	B/C	C	C/D	D

The recommended ecological flow scenario is defined as the runoff scenario (or a slight modification thereof) that represents the highest change in river inflow that will meet the REC (DWAF, 2008). Applying this guideline, none of the potential flow scenarios evaluated as part of the GRDS study were able to reverse modification in the ecological state to the REC (Category B). This is mainly as a result of significant non-flow related impacts also contributing to the PES in the estuary. However, Scenario 1 could restore the estuary to a Category B/C. Scenario 1 assumes a 50% base flow return to the estuary, e.g. through removal of alien invasive plants, as well as reducing run-off river abstraction during the low flow season. Restoring some base flow addresses the key flow-related factor contributing to the changes in ecological health in this estuary, namely the re-establishment of the REI zone. Considering the significant contribution of non-flow related factors, the present health in the Goukou Estuary, as well as the reversibility of some of these impacts, Scenario 1 was identified as the recommended flow scenario from an ecological perspective:

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	23.4	30.8	27.2	16.6	16.7	24.2	30.3	17.9	8.1	10.1	34.9	29.1
99	19.5	23.6	16.6	12.3	13.2	16.3	29.0	14.9	7.5	9.8	26.8	15.7
90	11.2	9.3	4.8	3.5	6.4	7.6	8.6	7.4	5.3	5.1	6.6	7.0
80	5.8	7.3	3.4	2.5	3.3	5.7	6.0	5.0	3.5	3.4	5.4	5.2
70	4.4	4.8	2.1	1.3	2.2	3.9	3.8	3.6	2.9	2.6	3.8	4.0
60	3.5	3.4	1.4	0.8	1.0	3.3	3.0	3.0	2.2	2.3	3.5	3.2
50	2.8	2.4	1.0	0.6	0.7	2.4	2.3	2.7	1.9	2.0	2.6	2.8
40	2.1	1.8	0.6	0.4	0.5	1.6	1.8	2.0	1.5	1.8	2.3	2.4
30	1.8	1.2	0.5	0.3	0.4	1.1	1.5	1.1	1.2	1.4	1.6	2.0
20	1.4	0.9	0.4	0.3	0.3	0.4	1.3	0.7	0.8	1.0	1.4	1.5
10	1.1	0.7	0.4	0.3	0.3	0.3	0.7	0.4	0.5	0.8	1.0	1.2
1	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.6	0.7
0.1	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6	0.5

In order to improve from a Category B/C (Scenario 1 only) to the REC (Category B), the following additional intervention in terms of non-flow related impacts are required:

- Restore 50% of the flood plain and riparian habitat along length of estuary.
- Identify all fountains, spring and seeps and ensure adequate freshwater supply to riparian zone and estuary to facilitate connectivity between estuary and terrestrial environment (critical factor for the protection of eels).
- Control/reduce fishing effort through improve compliance monitoring of fishing activities and banning of night fishing.
- Prepare and implement guidelines on appropriate bank stabilisation along the estuary.
- Control boating activities on the estuary towards mitigating bank erosion (e.g. through proper zonation and establishment and enforcement of boating carrying capacity limits).
- Institute proper stormwater management in future development planning (e.g. management of runoff from hardened surfaces and associated pollution);
- Upgrade and maintain sewage infrastructure (e.g. restore broken pipes and install back-up pumps for pump station in close proximity of the estuary).
- Ensure that the water quality and volumes discharged through the Riversdale WWTW meet permit requirements as issued under the NWA.
- Prepare and implement guidelines on appropriate (nature-friendly) structures to secure access to the estuary.

If all the above-mentioned non-flow related impacts could be mitigated, the system’s health is likely to improve significantly, even without additional base flow-potentially reaching a low Category B/C. However, it is perhaps unrealistic to expect successful mitigation of all non-flow related impacts in which case the return of some base flow during the low flow periods (to increase the REI zone) should still be investigated in order to achieve the REC (Category B).

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B) for the Goukou Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015c).

7.5 BLINDE ESTUARY

Department of Water and Sanitation (DWS), 2015d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Assessment. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0613.

This section presents the Desktop level assessment on the Blinde Estuary.

7.5.1 Delineation

The Blinde Estuary is a relatively small (1.75 ha), perched system that drains a steep sided incised valley leading to a predominantly closed mouth. The estuary remains closed for most of the year unless during a flood, but wash over from the sea can occur during high tides or storm events. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.4** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34°12'37.65"S, 22° 0'46.11"
Upstream boundary:	34°12'20.27"S, 22° 0'32.43"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 7.4 Geographical boundaries of the Blinde Estuary

7.5.2 EcoClassification

Present Ecological State

The PES of the Blinde Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.14**, resulting in an overall PES of Category C.

Table 7.14 PES of the Blinde Estuary

Variable	Category	Confidence
Hydrology	C/D	Very Low
Hydrodynamics and mouth condition	B	Very Low
Water quality	C/D	Very Low
Physical habitat alteration	A/B	Very Low
Habitat health score	B/C	
Microalgae	C	Very Low
Macrophytes	B	Very Low
Invertebrates	C/D	Very Low
Fish	E	Very Low
Birds	A/B	Very Low
Biotic health score	C	Very Low
OVERALL PES	C	**Very Low**

However, the system is on a negative trajectory of change related to key pressures in the catchment, including:

- Reduced water quality as a result of industrial activities in the catchment;
- Flow modification (high and low flows reduced), with a related shift in the onset of the high flow period and increase in the duration of the low flow period; and
- Limited bait collection and fishing.

This study is of very low confidence as it was done at a desktop level assessment with limited to no data being available. The confidence of the EWR study can be improved by proposed baseline surveys (DWS, 2015d).

Ecological Importance

Because the study was conducted at a desktop assessment level, the functional importance was not included in the rating, only the rating of criteria as per the regional assessment of Turpie and Clark (2007) (**Table 7.15)**. Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Blinde Estuary – a score of 27 – indicates that the estuary is of "Average importance".

Table 7.15 EIS for the Blinde Estuary

Criterion	Score
Estuary Size	10
Zonal Rarity Type	10
Habitat Diversity	10
Biodiversity Importance	77.5
Weighted Estuary Importance Score	**27**

The system did not form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the NBA (Turpie *et al*., 2012). Loggerhead turtles, which are associated with freshwater seeps on beaches, are known to nest at the Blinde Estuary, indicating the importance of freshwater input to this system.

Recommended Ecological Category

Applying the guidelines for the determination of the REC the Blinde Estuary – a system of "Average importance" - should at least maintain the PES (minimum Category D). Therefore, the REC for the Blinde Estuary was set as Category C, similar to its PES.

7.5.3 Ecological Water Requirements

As the Blinde Estuary study was conducted at a desktop level, no additional runoff scenarios were assessed, rather an estimate of the recommended flow requirements of the REC was provided. Flow modification has already resulted in a shift in the onset of the high flow period and an increase in the duration of the low flow period. The present flow distribution (pMAR = 0.9 x million m^3) should be maintained with no additional base flow abstraction occurring. Effort to increase base flow should be investigated as a contributing mitigating measure to reverse the negative trajectory of change. In addition, the deterioration in water quality as a result of industrial activities in the catchment should be investigated.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category C) for the Blinde Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015d).

7.6 HARTENBOS ESTUARY

Department of Water and Sanitation (DWS), 2015d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Assessment. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0613.

This section presents the Desktop level assessment on the Hartenbos Estuary.

7.6.1 Delineation

The Hartenbos Estuary is situated in the warm temperate region at the town of Hartenbos. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.5** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34° 7'0.66"S, 22° 7'27.20"E
Upstream boundary:	34° 6'42.45"S, 22° 5'3.95"E
Lateral boundaries:	5 m contour above MSL along each bank

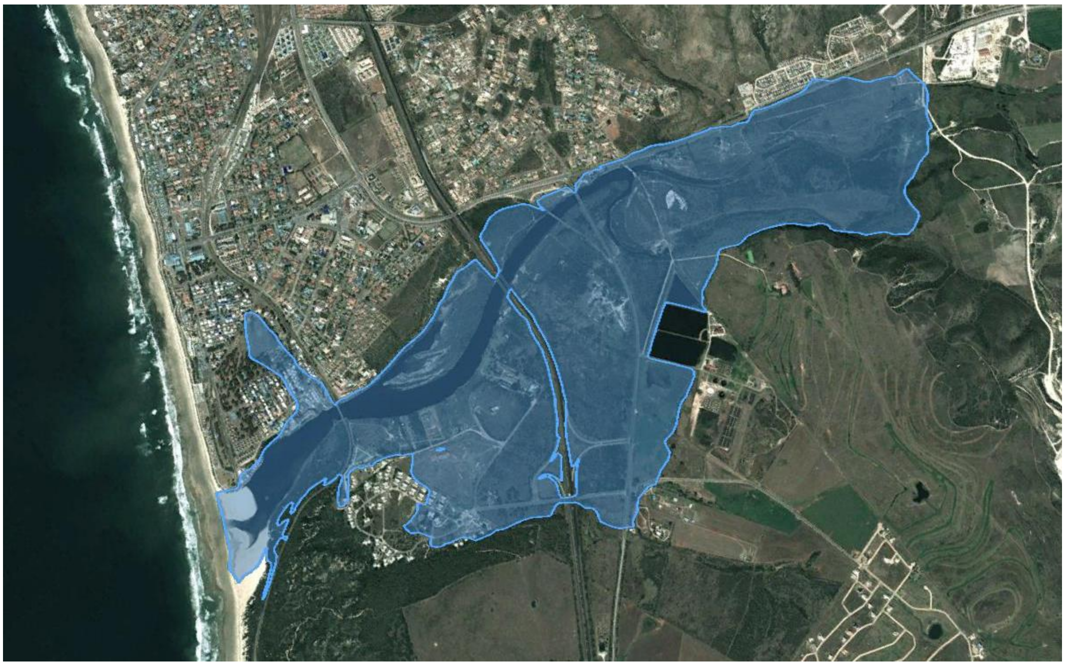


Figure 7.5 Geographical boundaries of the Hartenbos Estuary

7.6.2 EcoClassification

Present Ecological State

The PES of the Hartenbos Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.16**, resulting in an overall PES of Category D.

Table 7.16 PES of the Hartenbos Estuary

Variable	Category	Confidence
Hydrology	C/D	Very Low
Hydrodynamics and mouth condition	D	Very Low
Water quality	D/E	Very Low
Physical habitat alteration	D/E	Very Low
Habitat health score	D	
Microalgae	D	Very Low
Macrophytes	D	Very Low
Invertebrates	D	Very Low
Fish	D	Very Low
Birds	C/D	Very Low
Biotic health score	D	Very Low
OVERALL PES	D	**Very Low**

Although the Hartenbos Estuary has a PES Category D, the system was on a negative trajectory of change as a result of various flow and non-flow related pressures, including:

- Construction of the Hartebeeskuil Dam has resulted in a reduction in base flow and floods to the system, with a shift in the onset of the high flow period and increase in the duration of the low flow period.
- Artificial mouth breaching.
- Loss of tidal flows and habitat as result of bridge construction (e.g. old N2, Railway bridges).
- Infilling of estuary channel and mouth area as a result of loss of floods and artificial breaching.
- A significant reduction in water quality as a result of the Mossel Bay WWTW, agricultural return flow and urban runoff.
- Development in the EFZ.
- Alien vegetation.
- Limited bait collection and fishing effort, and
- Human disturbance (which influence bird abundance).

This assessment is of very low confidence as it was done at a Desktop level with limited to no data being available. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2015d).

Ecological Importance

Because the study was conducted at a desktop assessment level, the functional importance was not included in the rating, only the rating of criteria as per the regional assessment of Turpie and Clark (2007) (**Table 7.17)**. Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Hartenbos – a score of 66 – indicates that the estuary is “Important”.

Table 7.17 EIS for the Hartenbos Estuary

Criterion	Score
Estuary Size	70
Zonal Rarity Type	10
Habitat Diversity	60
Biodiversity Importance	86.5
Weighted Estuary Importance Score	**66**

The system does not form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the NBA (Turpie *et al.,* 2012).

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Hartenbos Estuary – an "Important" system - should be managed in a Category C, as a minimum. Considering the reversibility of existing pressures on this system, the REC was therefore set as a Category C. Mitigation of the negative trajectory of change and to raise the EC requires significant improvement in the water quality of the system (linked to the Mossel Bay WWTW discharge). Also an increase in base flow to the estuary should be investigated to restore connectivity with the marine environment. Improved mouth management and rehabilitation of riparian areas/wetlands will contribute to reversing the negative trajectory of change.

7.6.3 Ecological Water Requirements

As the Hartenbos estuary study was conducted at a desktop level, no additional runoff scenarios were assessed, rather an estimate of the recommended flow requirements was provided. In this system, dam construction has already resulted in a reduction in base flow and floods, with a shift in the onset of the high flow period and an increase in the duration of the low flow period. The present flow regime (pMAR = 2.8 x million m^3) should therefore be maintained, as a minimum. To reverse the negative trajectory of change in future, it is estimated that about 50% of the base flow will need to be returned to maintain a longer open mouth state during low flow periods. How this can be carried out will need investigation.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B) for the Hartenbos Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015d).

7.7 KLEIN BRAK ESTUARY

Department of Water and Sanitation (DWS), 2014d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Rapid Assessment Volume 1 (Klein Brak Estuary). Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0713, Volume 1.

This section presents the Rapid level assessment on the Kleinbrak Estuary.

7.7.1 Delineation

The Klein Brak Estuary (34º05´ S; 22º08´ E) is situated within the southern coastal belt, and is located approximately 12 km north of Mossel Bay. Two major tributaries, the Brandwag and Moordkuil, join approximately 3 km from the coast to form a well-developed flood-tidal delta. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.6** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34° 5'31.98"S, 22° 8'55.43"E
Upstream boundary:	Brandwag and Moordkuil tributaries: 34° 4'36.55"S, 22° 3'57.72"E / 34° 2'4.54"S, 22° 8'2.91"E
Lateral boundaries:	5 m contour above MSL along each bank

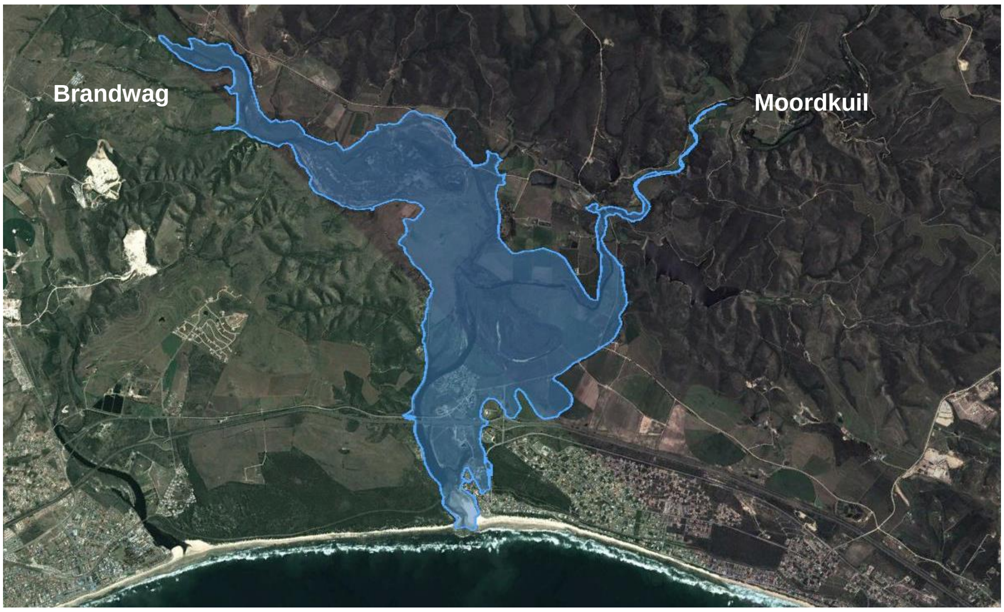


Figure 7.6 Geographical boundaries of the Klein Brak Estuary

7.7.2 EcoClassification

Present Ecological State

The PES of the Klein Brak Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.18**, resulting in an overall PES of Category C.

Table 7.18 PES of the Klein Brak Estuary

Variable	Category	Confidence
Hydrology	D	Low
Hydrodynamics and mouth condition	A	Low
Water quality	B	Medium to Low
Physical habitat alteration	D	Low
Habitat health score	C	
Microalgae	C	Medium
Macrophytes	D	Low
Invertebrates	C	Low
Fish	C/D	Medium
Birds	E	Low
Biotic health score	D	Low
OVERALL PES	C	**Low**

While the Klein Brak Estuary was in a Category C, the system was on a negative trajectory of change, i.e if the current (low) base flow regime, as well as certain non-flow related impacts were not mitigated, the estuary was likely to move into a Category C/D, or even a Category D. Flow related effects specifically related to changes caused by a modification in river (volume) inflow (i.e. either base flows, seasonal distribution of flows or flood characteristics). It was concluded that, in addition to flow modification, non-flow related factors also contributed significantly to ecological modification in the Klein Brak Estuary, specifically related to nutrient enrichment from agriculture, degradation of estuarine habitat through development in the EFZ, fishing pressures and human disturbance of birds.

The overall confidence of this rapid level study was low, mainly because of the low confidence in the simulated hydrology and limited data availability on the abiotic components. Although measured river inflows were available for both the Brandwag and Moordkuil tributaries, only limited data were available on abiotic characteristics with which to define and characterise abiotic states in this complex system (i.e. two river inflows) which is the primary mechanism by which modification in health condition from the Reference Condition to Present State determined, together with simulated river runoff scenarios. In terms of the biotic components, medium confidence in the macrophyte component is largely attributed to extensive, recent research conducted by the NMMU on estuarine systems in the region. Medium to low confidence in the microalgae and invertebrate is attributed to the availability of some historical data sets on this system. Extensive data on the fish component collected by the DAFF as part of their long-term monitoring programmes in estuaries significantly contributed to the medium (even high) confidence in this component. Historical data on the bird component was also available from the CWAC programme. Even though experience gained from research on other, related estuarine systems, the hydrodynamic complexity of this estuary, as well as the low confidence in the hydrology resulted in an overall low confidence. However, the recommended monitoring programme should focus on to improving confidence for future reviews. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2014d).

Ecological Importance

Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Klein Brak – a score of 58 – indicates that the estuary is of "Average importance" (**Table 7.19**).

Table 7.19 EIS for the Klein Brak Estuary

Criterion	Score
Estuary Size	80
Zonal Rarity Type	10
Habitat Diversity	10
Biodiversity Importance	69
Functional Importance	100
Weighted Estuary Importance Score	**58**

While, on a national scale, Klein Brak Estuary may be of average importance, it is certainly a large estuary in this region and plays a very important role as fish nursery for exploited and endangered fish species and providing an open estuary along a coast where a significant number of systems are seasonally closed. Therefore, at a finer, regional scale the Klein Brak Estuary is "Important".

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Klein Brak Estuary – a "Important" system - should be managed in a Category C, as a minimum. The REC for this estuary, therefore, was set as a Category C, similar to the PES.

7.7.3 Ecological Water Requirements

A summary of the future runoff scenarios (85-year simulated data sets) assessed for the Klein Brak Estuary in order to derive the flow scenario for the REC, are presented in **Table 7.20**.

Table 7.20 Summary of flow scenarios for the Klein Brak Estuary

Scenario	Description	MAR[1] (million m^3)	Percentage remaining
Reference	Natural	50.67	100
Present	Present Day (based on 2004 water use).	37.66	74
Scenario 1	River Class C EWR	38.97	77
Scenario 2	A dam of 10 million m^3 on the Moordkuil Tributary and an abstraction of 12.5 million m^3/a from the dam	30.11	59
Scenario 3	A dam of 10 million m^3 on the Moordkuil Tributary and an abstraction of 16 million m^3/a from the dam	25.24	50
Scenario 4	Increase the dam to 20 million m^3 and the abstraction to 20 million m^3/a. Add a run-of-river abstraction of 3 million m^3/a from K10D.	20.24	40

1 Mean Annual Runoff remaining.

Using the EHI, the health implications of the future scenarios on various abiotic and biotic components, and the resultant ECs, for the Klein Brak Estuary are presented in **Table 7.21.**

Table 7.21 ECs associated with future scenarios for the Klein Brak Estuary

Variable	Scenario				
	Present	1	2	3	4
Hydrology	D	B/C	D	E	E
Hydrodynamics and mouth condition	A	A	A/B	B	C
Water quality	B	B	B	B	B/C
Physical habitat alteration	D	D	D	D	D/E
Habitat health score	C	B/C	C	C/D	D
Microalgae	C	C	C	C	C
Macrophytes	D	D	D	D/E	E
Invertebrates	C	C	C	D	D
Fish	C/D	C/D	D	D	D
Birds	E	E	E	E	E/F
Biotic health score	D	D	D	D	D/E
ECOLOGICAL CATEGORY	C	C	C/D	D	D

The recommended ecological flow scenario is defined as the runoff scenario (or a slight modification thereof) that represents the highest change in river inflow that will meet the REC (DWAF, 2008). In the case of the Klein Brak Estuary a Category C was proposed as the REC, equivalent to the PES. However, the estuary is on a negative trajectory of change and if the current (low) base flow regime, as well as certain non-flow related impacts on the system continue, the estuary is likely to move into a Category C/D, even a Category D. To account for some of the loss in base flow, Scenario 1 (i.e. present flows including EWR for a Category C River just upstream of the estuary) was therefore selected as the recommended flow scenario for the Klein Brak Estuary:

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	7.5	18.1	12.9	10.2	8.1	10.3	11.0	9.9	5.6	5.1	11.4	11.9
99	7.3	17.0	12.3	7.5	7.7	9.2	8.6	9.4	4.1	3.6	10.1	8.4
90	4.0	5.1	2.8	2.0	2.1	3.9	4.7	2.4	1.8	1.3	2.3	4.3
80	3.2	2.9	1.4	1.2	1.1	2.1	2.6	1.7	1.0	1.0	1.2	2.5
70	2.1	2.0	0.9	0.6	0.8	1.4	1.2	0.9	0.7	0.8	0.8	1.4
60	1.4	1.2	0.7	0.3	0.3	0.8	0.7	0.4	0.4	0.5	0.5	0.9
50	0.7	0.5	0.3	0.2	0.2	0.5	0.5	0.3	0.3	0.4	0.4	0.6
40	0.6	0.4	0.3	0.2	0.1	0.3	0.3	0.3	0.3	0.3	0.3	0.4
30	0.4	0.3	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
20	0.3	0.3	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
10	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1

In order to further address the negative trajectory of change, additional interventions in terms of non-flow related impacts are essential to maintain the ecological health of the estuary in a Category C, namely:

- On both the Brandwag (34º03'43.51"S, 22◦06'47.95"E) and Moordkuil arms (34º03'15.32"S, 22◦ 07'55.24"E) there are obstructions across the estuary (i.e. roads) that prevent saline intrusion/tidal variation extending further upstream. To improve tidal connectivity these obstructions should either be removed or proper bridges should be consutructed. In doing so, the REI (roughly defined as the reach where salinity ranges between 10 and 0) will be introduced more readily, enhancing nursery function in the upper estuaries and thus contributing to the recovery of collapsed and endangered fish species, e.g. dusky cob and white steenbras.
- Further upstream in the Moordkuil arm there is also a DWS weir (34º03'11.14"S, 22º08'02.85"E). As this weir fulfils an important gauging function it may not have to be removed, but fish ladders should be installed on both sides of the weir to allow migrating species (e.g. eels) to move upstream.
- Rehabilitate degraded areas in the estuary functional zone, e.g., consolidate present access routes so as not to have a web of small roads on the salt marshes.
- Removal of invasive alien plant species in the estuary functional zone, focussing especially in supratidal areas.
- Reduce fishing pressures and (illegal) bait collecting through increased compliance (existing DAFF initiative).
- Institute a ban on night fishing to reduce the pressure on breeding stock of collapsed and endangered fish species, e.g., dusky cob (proposed DAFF initiative).

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category C) for the Klein Brak Estuary, as well as the long-term monitoring programme to test for compliance against these targets is provided in DWS (2014d).

7.8 WILDERNESS SYSTEM

Department of Water and Sanitation (DWS), 2014e. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Rapid Assessment, Volume 2 (Wilderness System). Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0713, Volume 2.

This section presents the Rapid level assessment on the Wilderness System.

7.8.1 Delineation

The Wilderness System was subdivided into **two resource units**, namely the **Touw Estuary** and the **Wilderness estuarine lakes (hereafter referred to as the Wilderness lakes)**. The motivation for this was that these two sub-systems function at markedly different spatial and temporal scales. In the case of the Touw Estuary, the system showed strong longitudinal gradients in physico-chemical characteristics (typical of estuaries) while these characteristics were more uniform in the lakes. Also, temporal variability of the hydrodynamics and water quality in the Touw Estuary showed stronger intra-annual (e.g. seasonal) variability, while the temporal variability in the lakes showed stronger inter-annual (across years).

The geographical boundaries, as presented by the EFZ are represented in **Figure 7.7** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 33°59'45.56"S, 22°34'51.01"E
Upstream boundary:	Touw: 33°58'26.64"S, 22°36'19.64" Rondevlei: 33°59'44.69"S, 22°43'7.47"E
Lateral boundaries:	5 m contour above MSL along banks

Figure 7.7 Geographical boundaries of the Wilderness System, i.e. Touw Estuary and Wilderness Lakes

7.8.2 EcoClassification

Present Ecological State

The PES of the Wilderness System - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.22.** The PES for the Touw Estuary is a Category C, while that of the Wilderness Lakes is a Category B/C.

Table 7.22 PES of the Wilderness System

Variable (Touw Estuary)	Category	Confidence
Hydrology	B/C	Low
Hydrodynamics and mouth condition	B/C	Low
Water quality	B	Medium to Low
Physical habitat alteration	C	Low
Habitat health score	B/C	
Microalgae	D	Low
Macrophytes	C	Medium
Invertebrates	D	Low
Fish	C/D	Medium
Birds	C	Low
Biotic health score	C/D	Low
OVERALL PES	C	**Low**

Variable (Wilderness Lakes)	Category	Confidence
Hydrology	B/C	Low
Hydrodynamics and mouth condition	B/C	Low
Water quality	B/C	Medium to Low
Physical habitat alteration	B	Low
Habitat health score	B/C	
Microalgae	C	Low
Macrophytes	B	Medium
Invertebrates	A/B	Low
Fish	C	Medium
Birds	D	Low
Biotic health score	B/C	Low
OVERALL PES	B/C	**Low**

The key flow related factor contributing to the modification in health condition was numerous farm dams, run-off river abstraction and afforestation. Non-flow related impacts include alien invasive (e.g. fish), as well as artificial breaching of the mouth (breaching at too low berm heights). The PES suggested that the lakes were under less direct development and fishing pressure and may have also been slightly more resilient to the flow reduction and water quality changes affecting this system compared with the estuary.

The overall confidence of this rapid level assessment study was low mainly because of the low confidence in the hydrology (especially low flows) and the uncertainty about the RC (breaching levels, duration of mouth closure, and bathymetry in the lower estuary). This, in turn affected the confidence of the definition and characterisation of abiotic states which was the primary mechanism by which modification in health condition from the RC to Present State determined, together with simulated river runoff scenarios. Due to limited data on other abiotic and biotic component the confidence of most components ranged between low to medium confidence. Even though experience gained from research on other, related estuarine systems, the complexity of the lake system, as well as the low confidence in the hydrology resulted in a low overall confidence. However, the recommended monitoring programme should focus on to improving confidence for future reviews. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2014e).

Ecological Importance

Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Wilderness Estuarine System – a score of 85 - translates into an importance rating of 'Highly Important" (**Table 7.23**).

Table 7.23 EIS for the Wilderness System

Criterion	Score
Estuary Size	90
Zonal Rarity Type	70
Habitat Diversity	70
Biodiversity Importance	88
Functional Importance	100
Weighted Estuary Importance Score	**85**

The Wilderness System scored high as it is a very important nursery for collapsed and endangered fish species, e.g. dusky cob and elf. The system also plays an important role as a way point/refuge area for fish along a coast that is known for extreme upwelling events that can cause fish kills. Further, the Wilderness System also forms part of the Garden Route National Park and contributes significantly towards South Africa's overall estuarine biodiversity targets.

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Wilderness System – as a "Highly important" system and a Protected Area - should be managed in a Category A, or at least the BAS. By far the most dominant factor determining the PES of this system (Touw Estuary: Category C and Lakes: Category B/C) was the low water levels at which the system was regularly breached to protect low lying development. Any change of rehabilitating the system to a Category A most likely would require the removal of those developments from the EFZ. It was concluded that it may not be realistic to meet natural breaching levels (i.e. +3.5 m MSL), but that there were certain other, non-flow related impacts that could be mitigated to improve the EC of the system, both the estuary and lakes, to a Category B. The REC for the Wilderness System, therefore, was set as a Category B, but realising that this would entail improvements to the present situation.

7.8.3 Ecological Water Requirements

A summary of the future runoff scenarios (85-year simulated data sets) assessed for the Wilderness System in order to derive the flow scenario for the REC, are presented in **Table 7.24**.

Table 7.24 Summary of flow scenarios for the Wilderness System

Scenario	Description	MAR[1] (million m^3)	Percentage remaining
Reference Conditions	Natural flows.	29.66	100
Present day	Present Day (based on 2004 water use).	25.15	85
Scenario 1	18% decrease in flow.	23.22	78
Scenario 2	30% decrease in flow.	20.55	69
Scenario 3	40% reduction in flow.	16.99	57
Scenario 4	60% reduction in flow.	11.68	39

1 Mean Annual Runoff remaining.

Using the EHI, the health implications of the future scenarios on various abiotic and biotic components, and the resultant ECs, for the Wilderness System are presented in **Table 7.25.**

Table 7.25 ECs associated with future scenarios for the Wilderness System

Variable (Touw Estuary)	Scenario				
	Present	1	2	3	4
Hydrology	B/C	B/C	C	C/D	D
Hydrodynamics and mouth condition	B/C	C	C/D	D	D
Water quality	B	B	B/C	B/C	B/C
Physical habitat alteration	C	C	C	C	C/D
Habitat health score	B/C	B/C	C	C	D
Microalgae	D	D	D	D	C
Macrophytes	C	C	C	C	D/E
Invertebrates	D	D	D	D	D
Fish	C/D	C/D	C/D	D	D
Birds	C	C	C/D	D	D
ECOLOGICAL CATEGORY	C	C	C/D	C/D	D

Variable (Wilderness Lakes)	Scenario				
	Present	1	2	3	4
Hydrology	B/C	B/C	C	C/D	D
Hydrodynamics and mouth condition	B/C	B/C	C	C/D	D
Water quality	B/C	B/C	B/C	C	C
Physical habitat alteration	B	B	B	B	B
Habitat health score	B/C	B/C	B/C	C	C/D
Microalgae	C	C	C	C	C
Macrophytes	B	B	B/C	B/C	C
Invertebrates	A/B	B/C	C	C	D
Fish	C	C	C	C/D	D
Birds	D	C/D	D	D	D
Biotic health score	B/C	C	C	C/D	D
ECOLOGICAL CATEGORY	B/C	B/C	C	C	C/D

The recommended ecological flow scenario is defined as the runoff scenario (or a slight modification thereof) that represents the highest change in river inflow that will meet the REC (DWAF, 2008). In the case of the Wilderness System, increasing present inflow was not considered realistic given the agricultural demand from water in the catchment and that the system still receives 85% of its natural MAR). Also, even by hypothetically returning some of the MAR (15%) it will not be possible improve from the PES to the REC due to the significant impact of other non-flow related factors. In the case of the Wilderness System mitigation of other non-flow related factor, therefore will be required to improve to the REC. However, the present inflow into the system remains a critical force to maintain open mouth conditions and further reduction in inflows to the system would increase the contribution of river flow in modification of conditions in the estuary.

Present total inflow to the system (i.e. presented as the total present inflow into the Wilderness System from adjacent catchments) was therefore recommended as the flow scenario for the Wilderness System:

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	6.08	9.94	14.20	7.52	7.10	9.69	7.73	7.66	2.78	4.38	9.90	8.85
99	5.65	8.92	6.92	6.77	6.29	7.07	5.69	7.08	1.98	2.98	8.46	8.43
90	3.85	3.50	1.90	1.76	2.10	3.29	1.97	1.63	0.64	1.45	2.16	2.64
80	1.99	1.97	1.14	1.02	0.83	1.88	1.04	0.83	0.43	0.74	0.86	1.18
70	1.04	1.00	0.60	0.55	0.40	1.16	0.50	0.46	0.33	0.35	0.61	0.75
60	0.70	0.56	0.31	0.27	0.27	0.90	0.36	0.29	0.25	0.24	0.45	0.50
50	0.41	0.16	0.06	0.16	0.06	0.51	0.23	0.21	0.21	0.19	0.31	0.33
40	0.27	0.08	0.00	0.04	0.01	0.25	0.17	0.12	0.14	0.10	0.22	0.28
30	0.15	0.02	0.00	0.00	0.00	0.12	0.09	0.07	0.08	0.08	0.16	0.17
20	0.06	0.00	0.00	0.00	0.00	0.01	0.05	0.04	0.03	0.05	0.09	0.10
10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.06	0.01
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

However, the REC for the Wilderness System, namely a Category B, can only be realised if some non-flow related factors are improved. Key interventions that should be undertaken:

- Increase breaching level at, at least to +2.9 m MSL (currently the system is breached between 2.1-2.4 m MSL). These higher levels match levels experienced during the 2007 and 2011 floods. If the system can be breached at these higher water levels, more sediment will be removed and the system will remain open to the sea for longer periods.
- The practice of artificially closing the system when the inlet becomes constricted should also be terminated.
- Alien fish and vegetation in the system should be controlled / eradicated. This can be done, for example through the establishment of a fishery that targets alien invasive fish (e.g. design seine that just catches *tilapia*). The Working for Water programme can also be used in the eradication of alien vegetation.
- Interim management measures should be considered to improved connectivity (interlinking channels) between the estuary and lakes, e.g. harvesting excessive macrophyte growth.
- Terminate *ad hoc* riparian protection practices along the banks of the estuary and the lakes and consider developing strategic guidelines for bank protection that will be more appropriate for this system.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B) for the Wilderness System, as well as the long-term monitoring programme to test for compliance against these targets is provided in DWS (2014e).

7.9 PIESANG ESTUARY

Department of Water and Sanitation (DWS), 2015d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Assessment. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0613.

This section presents the Desktop level assessment on the Piesang Estuary.

7.9.1 Delineation

The Piesang Estuary is a small estuary situated in the warm temperate region in Plettenberg Bay. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.8** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34° 3'37.62"S 23°22'43.85"E
Upstream boundary:	34° 3'44.46"S 23°21'21.04"E
Lateral boundaries:	5 m contour above MSL along each bank

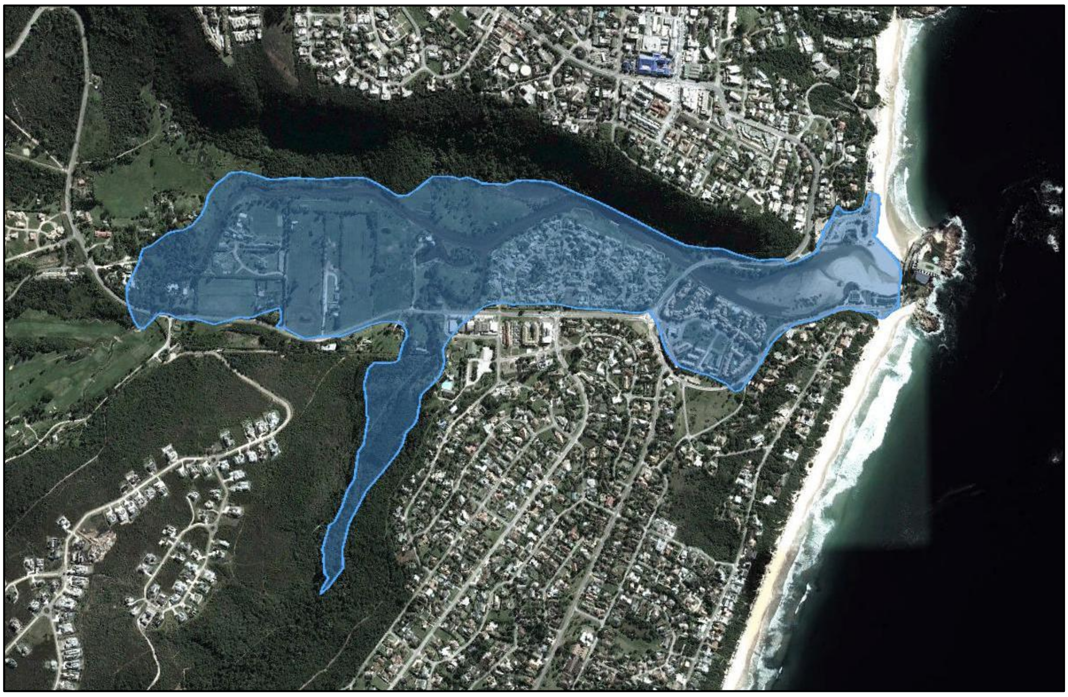


Figure 7.8 Geographical boundaries of the Piesang Estuary

7.9.2 EcoClassification

Present Ecological State

The PES of the Piesang Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.26**, resulting in an overall PES of Category D.

Table 7.26 PES of the Piesang Estuary

Variable	Category	Confidence
Hydrology	D	Very Low
Hydrodynamics and mouth condition	D/E	Very Low
Water quality	C/D	Very Low
Physical habitat alteration	D	Very Low
Habitat health score	D	
Microalgae	D	Very Low
Macrophytes	D	Very Low
Invertebrates	D	Very Low
Fish	C	Very Low
Birds	D	Very Low
Biotic health score	D	Very Low
OVERALL PES	D	**Very Low**

The following key pressures were contributing factors to PES:

- A reduction in base flows and floods to the system, with a shift in the onset of the high flow period (e.g. small farm dams and run of river abstraction).
- Direct abstraction of water from the mouth region for the desalination plant (34°03'41.91"S; 23°22'39.55"E) causing increased mouth closure and low water levels when in operation.
- Loss of tidal flows and habitat as a result of bridge construction (e.g. old and new N2 bridge, Railway bridge).
- A decline in water quality as a result of urban runoff;
- Significant development in the EFZ (e.g. low lying residential development) and related loss of habitat and related loss of habitat.
- Limited fishing effort; and
- Human disturbance (which influence bird abundance).

This assessment is of very low confidence as it was done at a Desktop level with limited to no data being available. Input data was relient on expert judgement. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2015d).

Ecological Importance

The estuarine ecological importance takes into account size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account (DWAF, 2008). Because the study was conducted at a desktop assessment level, the functional importance was not included in the rating, only the rating of criteria as per the regional assessment of Turpie and Clark (2007) (**Table 7.27)**. Referring to the estuarine importance rating system, the importance score of the Piesang Estuary – a score of 71 – indicated that the estuary was "Important".

Table 7.27 EIS for the Piesang Estuary

Criterion	Score
Estuary Size	80
Zonal Rarity Type	10
Habitat Diversity	80
Biodiversity Importance	72.5
Weighted Estuary Importance Score	**71**

The estuary showed a very high diversity of fish for such a relatively small system and was considered an important supporting nursery area for surrounding estuaries, e.g. Keurbooms Estuary. The system also forms part of the core set of priority estuaries (i.e. desired protected area) in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the NBA (Turpie *et al*., 2012). The NBA 2011 (Van Niekerk and Turpie, 2012) recommended that the Piesang Estuary be partially protected i.e. 50% of the estuary margin must be undeveloped. As development in the estuary margin already exceeds 50%, rehabilitation of some of the riparian habitat will be required to meet this target.

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Piesang Estuary – an "Important" system and needing partial protection - should be managed in a Category A or at least BAS. However, due to its transformed state, a realistic BAS was set as the REC, namely a Category B/C. For the PES, the assessment of mouth state and water level was based on data gathered from the Piesang Estuary (2011 - 2012) when the desalination plant (34°03'41.91"S; 23°22'39.55"E) was in full operation (P Huizinga, *pers. comm*., 2014). This data indicated that at full capacity the desalination plant withdrew water from the lower estuary to such low levels that the mouth of the estuary closed more frequently. This high level of abstraction at the time contributed significantly to the PES of a Category D. However, should direct abstraction from the estuary be reduced, it will contribute significantly towards improving the estuary to the REC. Further, improvement in water quality from adjacent urban areas should also be investigated, as well as the degree to which base flow can be returned to the system in low flow periods.

7.9.3 Ecological Water Requirements

As the Piesang Estuary study was conducted at a desktop level, no additional runoff scenarios were assessed, rather an estimate of the recommended flow requirements was provided. Reduced base flow into the Piesang Estuary is already contributing significantly to its modified health state. Therefore the present flow regime (pMAR = 3.4x million m^3) should be maintained as a minimum. To improve the health of the system from its current state to the REC, additional flow (through base flow and less abstraction for the desalinisation plant) would be required to keep a longer open mouth state during low flow periods. The reverse osmosis plant that is abstracting water in the lower reaches of the estuary, significantly contributes to the modified state of the system when it withdraws water to such low water levels that the mouth of the estuary closes more often. Improvement in water quality from adjacent urban areas should also be investigated, as well as the degree to which base flow can be returned to the system in low flow periods.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category B/C) for the Piesang Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015d).

7.10 KEURBOOMS ESTUARY

Department of Water and Sanitation (DWS), 2015e. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Re-evaluation of the 2008 EWR Study on the Keurbooms Estuary. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty and Associates cc. RDM/WMA16/04/CON/0613, Volume 2.

7.10.1 Background

In 2008 a Rapid level EWR assessment was conducted on the Keurbooms Estuary. While it was referred to as a "rapid level assessment", sufficient time to interrogate all available data sets and to capture such data in specialist reports (CSIR, 2008). However, concerns raised by GRDS stakeholders during a stakeholder workshop in October 2013, motivated a desktop re-assessment of the 2008 study, including additional baseline surveys (i.e. water quality, microalgae, macrophytes and invertebrates) that added in improving the confidence of the GRDS assessment.

7.10.2 Delineation

The Keurbooms Estuary is a permanently open system in the warm temperate region near Plettenberg Bay. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.9** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 34° 2'36.41"S 23°22'54.06"E
Upstream boundary:	Keurbooms arm: 33°57'8.04"S, 23°24'6.51"E Bitou arm: 33°59'58.44"S, 23°20'27.49"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 7.9 Geographical boundaries of the Keurbooms Estuary

7.10.3 EcoClassification

Present Ecological State

The PES of the Keurbooms Estuary – re-assessed in terms of the degree of similarity to the RC for various abiotic and biotic components are presented in **Table 7.28**, resulting in an overall PES of Category A/B.

Table 7.28 PES of the Keurbooms Estuary

Variable	Category	Confidence
Hydrology	A	Medium
Hydrodynamics and mouth condition	A	Low to medium
Water quality	A/B	Medium
Physical habitat alteration	B	Low
Habitat health score	A	
Microalgae	A/B	Medium
Macrophytes	B/C	Medium
Invertebrates	A	Low to medium
Fish	B/C	Low to medium
Birds	B/C	Low to medium
Biotic health score	B	
OVERALL PES	A/B	**Medium**

For the re-assessment of the EWR on the Keurbooms Estuary, the following additional data and information were available:

- Geographical boundaries of the Keurbooms Estuary as per the EFZ (NBA 2011) (Van Niekerk and Turpie, 2012).
- River inflow data and water quality data (from 2009 onwards) collected by the DWS at station K6H19 in the Keurbooms River just upstream of the Keurbooms Estuary.
- Additional field data collected on water quality, microalgae and invertebrates in the Keurbooms Estuary on 9 December 2013. and
- Personal observations regarding human disturbance of birds along the estuary (J Turpie, *pers. comm*., 2014).

Based on the additional data and information, the following was evident:

- The flow ranges allocated to various abiotic state in the Keurbooms Estuary during the 2008 study were still considered to be appropriate:

	State	Flows (m^3/s)
	State 1: Marine Dominated	< 0.5
	State 2: Saline with full salinity gradient	0.5 - 1.0
	State 3: Fresh with full salinity gradient	1.0 - 10.0
	State 4: Freshwater Dominated	> 10.00

- Data collected from the DWS station K6H19 indicated that modification in inorganic nutrient concentrations (dissolved inorganic nitrogen and dissolved inorganic phosphate) in river inflow from reference to present was over-estimated during the 2008 study. As a result the health score allocated to inorganic nutrients (measured as similarity between Reference Condition and Present State) increased slightly, from 88 to 90.

- With the amended geographical boundaries – the EFZ - the area previously considered for assessing the health of the supra-tidal estuarine vegetation was less. However, the extended area comprises areas that have been modified by development. As a result the health score for macrophytes reduced from 85 to 75.
- The influence of human disturbance on bird populations was mostly likely under-estimated in the health score allocated to birds in the previous study. Therefore the similarity score for birds reduced from 83 to 77.

The above reconsiderations resulted in a slight overall decrease in the similarity to the RC, but the PES remained in the Category A/B as in the 2008 EWR study.

Based on additional data collected by DWS on river inflow form the Keurbooms River, as well as the additional baseline surveys, confidence in the results improved to medium. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2015e).

Ecological Importance

Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Keurbooms Estuary – a score of 88 - translates into an importance rating of "Highly Important" (CSIR, 2008) (**Table 7.29**).

Table 7.29 EIS for the Keurbooms Estuary

Criterion	Score
Estuary Size	100
Zonal Rarity Type	20
Habitat Diversity	90
Biodiversity Importance	95
Functional Importance	100
Weighted Estuary Importance Score	**88**

Recommended Ecological Category

Applying the guidelines for the determination of the REC (DWAF, 2008), the Keurbooms Estuary – a "Highly Important" system - should be managed in a Category A or at least BAS.

As concluded with the previous assessment, it was agreed the current level of urban development around the estuary (and related tourist activities), as well as the collapsed status of certain line fish species make it unlikely for the system to be rehabilitated to a Category A. The REC, therefore, was set as Category A/B, similar to the PES.

7.10.4 Ecological Water Requirements

A precautionary approach was adopted in setting the recommended flow scenario in the 2008 study (CSIR, 2008). Despite the Keurbooms Estuary being classified as a permanently open estuary, uncertainty around potential closure remains a concern during extended periods of low inflow. Without long-term data to confirm the behaviour of the mouth at various positions along the berm, it was considered irresponsible to recommend any flow scenario that includes a significant dam development (when extended low flow periods may become a reality especially during drought periods) for such an ecologically important estuary as the Keurbooms system. The precautionary approach previously adopted to set the recommended flow scenario should prevail until such time as suitable data is available for refinement. Therefore the Ecological Flow Scenario recommended for maintaining the Keurbooms Estuary in a Category A/B remains as proposed in the 2008 study (CSIR, 2008), that is **Present flows (92.7% of MAR) but including a 0.45 m^3/s diversion to Plettenberg Bay, a 0.145 m^3/s to Roodefontein and the recommended EWR for the river:**

%ILE	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
99.9	25.67	27.17	18.66	15.52	16.33	18.03	28.70	45.23	25.72	24.66	38.84	29.62
99	20.58	17.91	14.06	8.27	10.96	11.67	10.32	18.86	16.55	12.03	21.14	18.36
90	15.50	16.00	9.22	7.01	8.59	8.71	8.79	11.18	8.24	10.70	14.36	13.02
80	9.60	10.46	5.38	5.30	5.06	6.03	6.70	6.10	5.60	6.02	9.15	10.16
70	7.58	7.38	4.17	4.18	3.15	4.75	4.86	4.61	4.64	4.51	7.01	8.41
60	7.00	5.47	3.37	2.46	2.52	3.89	3.92	3.70	4.03	3.83	5.87	6.83
50	5.87	3.82	2.38	1.77	2.30	3.12	2.60	2.88	2.86	3.16	4.64	5.35
40	4.79	3.06	2.01	1.35	1.77	2.18	2.01	2.17	2.34	2.76	3.49	4.52
30	3.83	2.58	1.58	0.86	1.35	1.56	1.58	1.70	1.87	2.09	2.76	3.21
20	3.17	2.13	1.04	0.65	0.92	0.92	1.30	0.82	1.18	1.43	2.07	2.62
10	1.94	1.61	0.57	0.53	0.62	0.55	0.70	0.56	0.58	1.03	1.45	1.78
1	0.82	1.04	0.35	0.30	0.33	0.31	0.30	0.34	0.33	0.58	0.55	0.56
0.1	25.67	27.17	18.66	15.52	16.33	18.03	28.70	45.23	25.72	24.66	38.84	29.62

As recommended in the 2008 study (CSIR, 2008), the following actions should also be undertaken as soon as possible to stabilise the health state of this estuary. Highest priority mitigation measures are provided below (as per CSIR, 2008):

- *Bitou Drift:* The drift through the Bitou River should be removed in total including all foreign rock material.
- *Northern floodplain of the lower Bitou arm of estuary:* Remove all exotic invasive trees from the flood plain. No further development should be allowed on the floodplain to prevent further loss of floodplain functionality. Remove the old gravel road to the south of the R340.
- *Southern floodplain of the lower Bitou arm of estuary:* Remove all exotic invasive plant species from the floodplain, remove the infilling, create a buffer zone (~ 10 m wide separating the wetland from the agricultural activities on the floodplain).
- *Road Bridge across the lower Bitou arm of estuary:* Remove concrete piers of the old road bridge to facilitate flow and tidal exchange in the Bitou arm and investigate establishing connection with old Bitou channel.
- *Middle reaches of the Keurbooms arm of estuary:* Remove all alien trees from the banks and The Island. Establish a buffer adjacent to the estuary and restrict new development on the banks of the system.
- *Upper reaches of the Ganse Spruit (connected to the estuary):* Remove all exotic vegetation from the stream bed.

- *The Ganse Spruit Wetlands (connected to the estuary)*: Install a sufficient number of large culverts in the roads bisecting the wetlands to allow the free flow of surface water through the wetlands and remove all exotic invasive tree species.
- *Earthen barricades across tidal channels in the Bitou Arm:* Completely remove all earthen barricades to restore connectivity on the supratidal marsh. Maintain freshwater flow from the northern sections into the supratidal marsh south of the R340.
- *Middle reaches of the Bitou arm:* Remove all exotic tree species from this area, allow the artificial canal to naturally silt up, allow salt marsh to naturally re-colonise the extensive *Stenotaphrum* grasslands, insert culverts below the road bisecting the floodplain to link up the old channels.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category A/B) for the Keurbooms Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015e).

7.11 GROOT (WES) ESTUARY

Department of Water and Sanitation (DWS), 2015d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Assessment. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0613.

This section presents the Desktop level assessment on the Groot (Wes) Estuary.

7.11.1 Delineation

The Groot (Wes) Estuary is a small to medium size (39 ha) temporarily open/closed estuary, entering the sea at Nature’s Valley. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.10** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 33°58'53.41"S 23°34'8.32"E
Upstream boundary:	33°57'49.27"S 23°33'23.77"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 7.10 Geographical boundaries of the Groot (Wes) Estuary

7.11.2 EcoClassification

Present Ecological State

The PES of the Groot (Wes) Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.30**, resulting in an overall PES of Category B.

Table 7.30 PES of the Groot (Wes) Estuary

Variable	Category	Confidence
Hydrology	B	Very Low
Hydrodynamics and mouth condition	A/B	Very Low
Water quality	A	Very Low
Physical habitat alteration	A/B	Very Low
Habitat health score	A/B	
Microalgae	A/B	Very Low
Macrophytes	B	Very Low
Invertebrates	B	Very Low
Fish	B	Very Low
Birds	A/B	Very Low
Biotic health score	B	Very Low
OVERALL PES	B	**Very Low**

The following key pressures have contributed to the slight modification in ecological health in this system:

- Some reduction in base flow and floods to the system as a result of forestry in the catchment and abstraction by adjacent town, with a shift in the onset of the high flow period.
- Loss of tidal flows and habitat as result of bridge construction.
- Some development in the EFZ and related loss of habitat; and
- Limited bait collection and fishing.

This study is of very low confidence as it was done at a desktop level assessment with limited to no data being available. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2015d).

Ecological Importance

Because the study was conducted at a desktop assessment level, the functional importance was not included in the rating, only the rating of criteria as per the regional assessment of Turpie and Clark (2007) (**Table 7.31**). Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Groot (Wes) Estuary – a score of 62 – indicates that the estuary is “Important”.

Table 7.31 EIS for the Groot (Wes) Estuary

Criterion	Score
Estuary Size	70
Zonal Rarity Type	10
Habitat Diversity	50
Biodiversity Importance	83.5
Weighted Estuary Importance Score	**62**

The Groot (Wes) Estuary is situated in the Tsitsikamma National Park. The system therefore forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the NBA (Turpie *et al*., 2012). The NBA 2011 (Van Niekerk and Turpie, 2012) recommends that the estuary be fully protected, and that 50% of the estuary margin be undeveloped.

Recommended Ecological Category

Applying the guidelines for the determination of the REC the Groot (Wes) Estuary – an “Important” system in a protected area - should be managed in a Category A, or at least BAS. The REC was set as a Category A, as key pressures were considered reversible. This can be achieved by improved mouth management practices, as well as returning base flow during low flow periods. The latter can, for example, be achieved through investigating alternative practices to supply water to the adjacent town (i.e. not drawing from the river during low flow periods). Reducing fishing effort and bait collection will also contribute towards achieving the REC.

7.11.3 Ecological Water Requirements

As the Groot (Wes) Estuary study was conducted at a desktop level, no additional runoff scenarios were assessed, rather an estimate of the recommended flow requirements of the REC was provided. Flow to the estuary has already been reduced as a result of increased forestation and abstraction of water for the adjacent town which have already contributed to changes in ecological health in this small system. As a minimum, the present flow regime (pMAR = 11.1 x million m^3), but the extent to which base flows can be returned to this system needs to be investigated.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category A) for the Groot (Wes) Estuary, as well as the long-term monitoring programme to test for compliance against these targets are provided in DWS (2015d).

7.12 BLOUKRANS ESTUARY

Department of Water and Sanitation (DWS), 2015d. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Estuaries RDM Report – Desktop Assessment. Prepared by the Council for Scientific and Industrial Research (CSIR) for Scherman Colloty & Associates cc. Report no. RDM/WMA16/04/CON/0613.

This section presents the Desktop level assessment on the Bloukrans Estuary.

7.12.1 Delineation

The Bloukrans Estuary is a small (4 ha) permanently open estuary. The estuary has a strongly tidal mouth that opens to the sea between steep valley sides. The geographical boundaries, as presented by the EFZ are represented in **Figure 7.11** and geo-referenced as follows:

Downstream boundary:	Estuary mouth 33°58'47.08"S 23°38'51.29"E
Upstream boundary:	33°58'33.85"S2 23°38'44.31"E
Lateral boundaries:	5 m contour above MSL along each bank

Figure 7.11 Geographical boundaries of the Bloukrans Estuary

7.12.2 EcoClassification

Present Ecological State

The PES of the Bloukrans Estuary - assessed in terms of the degree of similarity to the reference condition for various abiotic and biotic components are presented in **Table 7.32**, resulting in an overall PES of Category A.

Table 7.32 PES of the Bloukrans Estuary

Variable	Category	Confidence
Hydrology	**A**	Very Low
Hydrodynamics and mouth condition	**A**	Very Low
Water quality	**A**	Very Low
Physical habitat alteration	**A**	Very Low
Habitat health score	**A**	
Microalgae	**A**	Very Low
Macrophytes	**A**	Very Low
Invertebrates	**A**	Very Low
Fish	**A/B**	Very Low
Birds	**A**	Very Low
Biotic health score	**A**	Very Low
OVERALL PES	**A**	**Very Low**

This study is of very low confidence as it was done at a desktop level assessment with limited to no data being available. Input data was relient on expert judgement. The confidence of the EWR study can be improved by proposed baseline surveys in DWS (2015d).

Ecological Importance

Because the study was conducted at a desktop assessment level, the functional importance was not included in the rating, only the rating of criteria as per the regional assessment of Turpie and Clark (2007) (**Table 7.33**). Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Bloukrans Estuary – a score of 51 – indicates that the estuary is of "Average importance".

Table 7.33 EIS for the Bloukrans Estuary

Criterion	Score
Estuary Size	70
Zonal Rarity Type	50
Habitat Diversity	10
Biodiversity Importance	63.5
Weighted Estuary Importance Score	**51**

However, the Bloukrans Estuary is situated in the Tsitsikamma National Park. The system therefore forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan for the NBA (Turpie *et al*., 2012). The NBA 2011 (Van Niekerk and Turpie, 2012) recommends that the estuary be fully protected, and that 100% of the estuary margin be undeveloped, i.e. must remain in near pristine state.

Recommended Ecological Category

Applying the guidelines for the determination of the REC the Bloukrans Estuary, although of "Average Importance" is located in a protected areas and should therefore be managed in a Category A, or at least BAS. The REC was set as a Category A, similar to the PES. Presently, no management interventions are required to meet the REC.

7.12.3 Ecological Water Requirements

As the Bloukrans Estuary study was conducted at a desktop level, no additional runoff scenarios were assessed, rather an estimate of the recommended flow requirements of the REC was provided. The estuary is relatively resilient to flow reduction. About 1 - 5% of the pMAR may therefore still be available for abstraction. However, until more detailed studies have been undertaken to confirm, the present flow regime (pMAR = 39.3x million m^3) must be maintained.

The EcoSpecs and TPCs for various habitat (abiotic) and biotic components representative of the REC (Category A) for the Bloukrans Estuary, as well as the long-term monitoring programme to test for compliance against these targets is provided in DWS (2015d).

7.13 CONCLUSIONS AND RECOMMENDATIONS

An overview of the Preliminary Reserve determination of estuaries in the Gouritz WMA (i.e. Duiwenhoks to Bloukrans estuaries) is presented in **Table 7.34**. This information was derived from the GRDS, as well as previous EWR studies.

Table 7.34 Summary of the Preliminary Reserve determination for estuaries in the Gouritz WMA

Estuary	Confidence	EcoClassification				Recommended mitigation measures											
						Water			Land-use and development						Fisheries		
		PES	Importance	Protection Status	REC	Restore base flows	Restore Floods	Improve Water Quality	Restore connectivity/ hydrological functioning	Improve mouth management	Rehabilitate riparian areas/ wetlands	Remove alien vegetation	Implement cattle exclusion zone	Control human disturbance of birds	Important nurseries	Remove/reduce fishing pressure/ bait collection	Remove alien fish
Duiwenhoks	M	C	5	1	B	●									●	●	
Goukou	M	C	5	5	B	●		●			●			●	●	●	●
Gouritz	M	C/D	4	5	B	●	●	●			●				●	●	
Blinde	VL	C	3	1	C	●		●									
Tweekuilen[1]		D/E	4	1	D	●		●									
Gericke[1]		D/E	3	1	D			●									
Hartenbos	VL	D	4	1	C	●	●	●			●						
Klein Brak	L	C	3	1	C	●		●	●					●	●	●	
Groot Brak[2]		D	4	1	C	●	●			●		●		●	●	●	
Maalgate[2]		B/C	3	1	B	●											
Gwaing[2]		B/C	3	1	C			●									
Kaaimans		B	3	5	A/B	●		●									
Wilderness	L	B/C	5	5	B	●		●	●	●						●	●
Swartvlei[2]		B	5	5	B	●				●					●		
Goukamma[2]		B	4	5	A	●								●		●	
Knysna[2]		B	5	5	B	●								●	●	●	
Noetsie[2]		B	3	5	A			●									
Piesang	VL	D	4	5	B/C	●		●		●		●			●		
Keurbooms	M	A/B	5	5	A/B									●	●		
Matjies[2]		B	3	1	B												

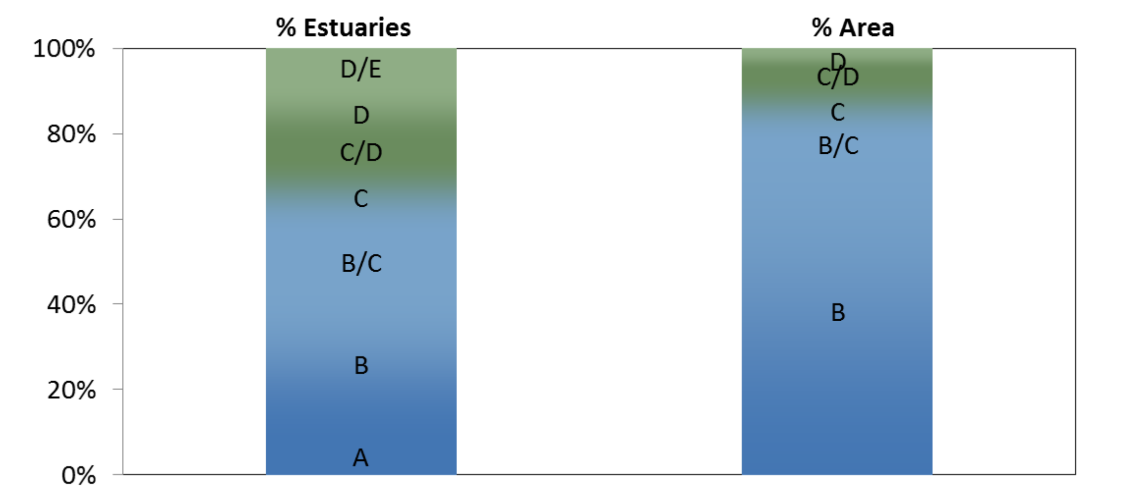
Estuary	Confidence	EcoClassification				Recommended mitigation measures											
						Water			Land-use and development						Fisheries		
		PES	Importance	Protection Status	REC	Restore base flows	Restore Floods	Improve Water Quality	Restore connectivity/ hydrological functioning	Improve mouth management	Rehabilitate riparian areas/ wetlands	Remove alien vegetation	Implement cattle exclusion zone	Control human disturbance of birds	Important nurseries	Remove/reduce fishing pressure/ bait collection	Remove alien fish
Sout (Oos) [2]		A	3	5	A												
Groot (Wes)	VL	B	4	5	A	●										●	
Bloukrans	VL	A	3	5	A												

1 Micro estuaries identified as part of recent WRC project (Van Niekerk *et al*., 2014).
2 Obtained from previous EWR studies.

The summary includes:

- The PES and REC.
- Estuary Importance (rated as 3 = "Average Importance" (Importance score 0 – 60), 4 = "Important" (Importance score 61 – 80) or 5 = "High Importance" [Importance score > 80). Priority estuaries identified in the South African National Estuary Biodiversity Plan are allocated a rating of 5 for protection status); and
- Recommended mitigation measures to achieve the REC, organised in the various management sectors, namely water, land-use and development, and fisheries.

Only about 9% of the estuaries in the WMA are in excellent health (Category A), while about half the systems (52%) are in a good state (Category B and B/C) (**Figure 7.12**). An additional 40% is in a fair state (Categories C to D). The remainder of the estuaries in this region are in a poor state as reflected by 9% in Category D/E.



	% Estuaries	% Area
D/E	8.7	0.4
D	13.0	4.8
C/D	4.3	2.2
C	17.4	14.3
B/C	13.0	1.5
B	34.8	76.7
A	8.7	0.2

Figure 7.12 Summary of PES of estuaries in the Gouritz WMA illustrating the continuum in estuary condition

When analysed according to "estuarine area" rather than the number of estuaries, 79% is in a good condition (Category B and B/C), while about 21% of the estuarine area in the WMA is in a fair state (Category C to D). This indicates that the high number of near pristine estuaries in this WMA is of a very small size. The high percentage good condition systems in the WMA are reflecting the state of the large estuarine lakes that dominate from an estuarine habitat perspective.

Overall, smaller estuaries tend to be in a better state of health because there are fewer pressures on them, with a high number of them occurring in provincial or national protected areas along this coast. However, these small systems may not be as resilient to change as large estuaries, primarily due to their small size and higher residence time brought about by limited tidal exchange. This is one of the key reasons for the poor conditions of the urban systems, e.g. Hartenbos and Piesang estuaries. In contrast, larger estuaries are more heavily affected by catchment and direct pressures (e.g. development in the EFZ and fishing), which lead to degradation and a reduced health status, but are more resilient due to higher absorption capacity and/or strong tidal exchange associated with this type of system. It should also be stressed that these larger systems generally are important as fish nursery grounds are of higher economic and ecological importance and that there is a considerable risk that the percentage degraded estuaries could increase further if appropriate management actions are delayed. While most of the estuarine habitat in the WMA is in a good to fair state, there is a risk that the percentage of fair to poor (Categories C to E) estuaries could increase if appropriate management actions are delayed.

From an estuarine importance perspective 26% (6 systems) of the estuaries in this WMA are rated as “highly important”, while an additional 26% (6 systems) are rated as “important”, with the remaining 48% (11 systems) rated as of “average to low importance” (**Table 7.33**). Further, about 57% (13 systems) of estuaries are either in formally protected areas or form part of the core set of estuaries required to meet biodiversity targets for the region.

The RECs allocated to the various estuaries show that 74% of estuaries (17 systems) need to improve in health condition in order to achieve overarching biodiversity and related ecosystem services objectives. This high percentage is driven by the high number of estuaries in protected areas, or desired protected areas in the region. The type of mitigation measures that would be required to meet RECs are summarised in **Figure 7.13**.

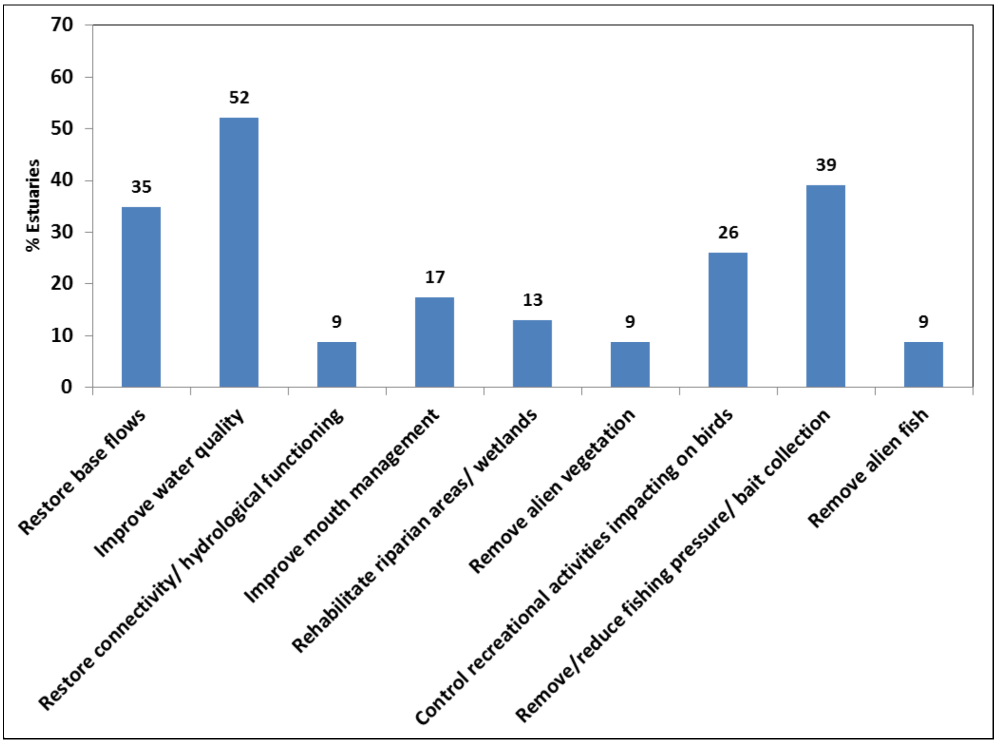


Figure 7.13 Recommended mitigation measures to achieve RECs in the estuaries of the Gouritz WMA

From the water sector perspective, about 35% of estuaries in the WMA require some restoration in base flow condition (especially during the low flow period), while 52% needs improvement in water quality. From the land-use and development sector outlook, 9% of systems require increased connectivity with the sea and/or improved hydrological functioning, while 17% requires an improvement in mouth management operations. Nearly 13% of estuaries requires rehabilitation of the riparian habitat and/or restoration of floodplain/wetland habitat, while 9% require the removal of alien vegetation from their surrounding environs. About 26% of systems require some control of recreational activities, such as boating or hiking, to reduce disturbance to birds. From the fisheries sector perspective, about 39% of estuaries require the reduction/removal of fishing effort (i.e. no-take estuaries, zonation for closed areas, or closed periods such as night fishing ban), while about 9% of estuaries required the removal of alien fish species to allow for the recovery of indigenous populations.

It is recommended that the implementation of the EWR (e.g. mitigations, additional baseline surveys and long-term monitoring programmes) be undertaken in collaboration with various responsible departments in the DWS, as well as other national and provincial departments and institutions responsible for estuarine resource management such as DAFF, Department of Environmental Affairs (DEA): Oceans and Coasts, South African National Biodiversity Institute (SANBI), CapeNature, SANParks as well as relevant municipal authorities. It is recommended that the estuarine management planning process and the associated institutional structures (as required under the Integrated Coastal Management Act 2008) be used as a mechanisms through which to facilitate the implementation these programmes.

8 BASIC HUMAN NEEDS RESERVE

This section was prepared by Greg Huggins. Maps produced by Marco Da Cunha; also of Nomal Consulting.

8.1 BACKGROUND

This study included a surface water Basic Human Needs Reserve (BHNR), undertaken to determine the prescribed minimum standard of water supply services necessary for the reliable supply of a sufficient quantity and quality of water to households, including informal households, to support life and personal hygiene (subsistent use as per Schedule one of the NWA, 1998).

8.2 APPROACH

The method followed the approach revised by DWS during October 2008, with additional steps to improve projections. In this method, the BHNR only applies to the areas in which informal water sources are the means by which communities are provided with, as stated above, Schedule 1 rights.

The method adopted is summarised below:

- Quaternary catchments falling within the WMA16 were determined, and the area of each catchment calculated on a Geografic Information System (GIS).
- Quaternary catchments were overlayed on the smallest aggregations of Census 2011 or "wards". All wards, either wholly or partially, within the quaternary catchments were captured.
- Wards falling completely or partially in each quaternary catchment were used to determine total household numbers and total population in order to determine the average household density and population density for each catchment.
- Wards falling completely or partially in each quaternary catchment were used in order to determine households with access to formal and informal water supplies. The former included all households with access to piped water in any configuration, while the latter covers all households **without** access to piped water and therefore would be reliant on other informal sources. The latter are considered household that **qualify** in this study.
- Water supply was determined by household and therefore the method needed to adjust the value to account for individuals. Average individuals per household were determined via the analysis of Census 2011. Total qualifying households multiplied by the average number of individuals was used to determine the total population qualifying under the BHNR.

Having calculated the qualifying population per quaternary catchment the next step in determining the BHNR is to project the population to a target date. In this instance the WMA is not expected to grow in terms of overall population. Although some urban areas may experience growth this is likely to be counterbalanced by migration from the rural areas. As such the figures given for requirements in 2011 will remain constant for the predictable future.

8.3 RESULTS

The method adopted has allowed the determination of the BHNR for the Gouritz WMA. In total 72005 people were found to be dependent on informal water supply for their domestic household needs. While not all of these will be relying on run-of-river and many may, for example, have boreholes, the conservative approach is to assume that these are potentially requiring the services of run-of-river. The BHNR demand (for year 2011 and by extension, given the no growth scenario, also for 2014) is estimated at 659 065 m^3/per annum and 1 316 114 m^3/per annum for the 25 and 50 litre limits, respectively. Details per quaternary catchment are provided in **Table 8.1**. Maps showing total population numbers and areas potentially dependent on run-of-river are shown in **Figure 8.1** and **Figure 8.2** respectively. According to Census 2011, dependency on river or streams as the primary water supply by the local population is very low. On average, only 0.2% of the resident population utilised local rivers or streams in 2011, while the highest dependency rate was only 1.5%. Assuming a threshold estimate that 1% of the total population of the quaternary catchments is reliant on rivers or streams, the quaternary catchments most reliant on river or streams include J12M, J13A, J13B, J13C, H90B, H90C, K30C, J11B, J11C and J31C.

Table 8.1 Population and household by quaternary catchment with BHNR demand

Quat	Qualifying persons per catchment (Census, 2011)	BHNR (25 L/day) measured in m^3 per annum	BHNR (50 L/per day) measured in m^3 per annum
		2014	2014
H80A	256	2336	4672
H80B	211	1925	3849
H80C	329	3002	6004
H80D	259	2360	4721
H80E	387	3532	7064
H80F	222	2027	4054
H90A	372	3393	6787
H90B	198	1806	3613
H90C	521	4758	9515
H90D	1123	10244	20489
H90E	737	6721	13442
J11A	49	448	896
J11B	71	652	1303
J11C	28	258	516
J11D	114	1041	2081
J11E	204	1857	3715
J11F	189	1724	3449
J11G	200	1826	3652
J11H	358	3266	6532
J11J	479	4375	8751
J11K	661	6035	12069
J12A	140	1279	2557
J12B	196	1791	3583
J12C	239	2180	4359

Quat	Qualifying persons per catchment (Census, 2011)	BHNR (25 L/day) measured in m^3 per annum	BHNR (50 L/per day) measured in m^3 per annum
		2014	2014
J12D	1701	15523	31047
J12E	155	1413	2826
J12F	1457	13291	26581
J12G	251	2292	4584
J12H	583	5319	10639
J12J	1542	14071	28143
J12K	779	7105	14210
J12L	1145	10445	20889
J12M	731	6666	13333
J13A	655	5981	11963
J13B	442	4029	8058
J13C	478	4366	8732
J21A	629	5744	11488
J21B	178	1623	3245
J21C	176	1609	3217
J21D	217	1984	3968
J21E	204	1858	3716
J22A	83	756	1513
J22B	61	556	1111
J22C	69	631	1262
J22D	227	2071	4143
J22E	278	2534	5069
J22F	142	1292	2585
J22G	108	985	1969
J22H	271	2469	4939
J22J	126	1151	2303
J22K	177	1612	3225
J23A	373	3402	6804
J23B	383	3497	6995
J23C	251	2294	4589
J23D	351	3204	6408
J23E	111	1016	2033
J23F	221	2016	4032
J23G	115	1049	2099
J23H	129	1174	2348
J23J	113	1029	2058
J24A	218	1992	3985
J24B	282	2571	5142
J24C	542	4949	9897
J24D	583	5317	10635
J24E	493	4499	8999
J24F	212	1935	3871
J25A	235	2145	4290

Quat	Qualifying persons per catchment (Census, 2011)	BHNR (25 L/day) measured in m^3 per annum	BHNR (50 L/per day) measured in m^3 per annum
		2014	2014
J25B	534	4870	9740
J25C	211	1928	3857
J25D	363	3312	6624
J25E	368	3354	6707
J31A	731	6669	13338
J31B	488	4449	8899
J31C	194	1768	3536
J31D	626	5708	11416
J32A	206	1882	3765
J32B	267	2436	4871
J32C	305	2784	5569
J32D	98	892	1784
J32E	315	2877	5753
J33A	925	8441	16883
J33B	1351	12328	24656
J33C	212	1937	3873
J33D	128	1171	2342
J33E	837	7639	15278
J33F	1248	11387	22774
J34A	613	5592	11185
J34B	830	7572	15144
J34C	774	7062	14124
J34D	728	6642	13285
J34E	529	4826	9652
J34F	1140	10401	20801
J35A	1207	11018	22036
J35B	2610	23817	47635
J35C	672	6130	12260
J35D	1289	11765	23530
J35E	456	4162	8324
J35F	866	7899	15798
J40A	959	8754	17508
J40B	229	2085	4170
J40C	570	5205	10410
J40D	1171	10682	21364
J40E	830	7578	15156
K10A	560	5112	10224
K10B	266	2423	4846
K10C	164	1498	2996
K10D	316	2882	5764
K10E	418	3815	7631
K10F	447	4076	8152
K20A	758	6917	13833

Quat	Qualifying persons per catchment (Census, 2011)	BHNR (25 L/day) measured in m^3 per annum	BHNR (50 L/per day) measured in m^3 per annum
		2014	2014
K30A	2674	24397	48794
K30B	2263	20653	41307
K30C	2644	24128	48255
K30D	465	4239	8478
K40A	228	2084	4167
K40B	465	4248	8495
K40C	684	6245	12489
K40D	546	4985	9970
K40E	1887	17222	34445
K50A	824	7519	15038
K50B	1169	10666	21331
K60A	467	4260	8520
K60B	416	3797	7595
K60C	368	3355	6711
K60D	586	5347	10695
K60E	200	1827	3654
K60F	1142	10421	20841
K60G	1609	14684	29367
K70A	344	3135	6269
K70B	196	1785	3571
Total	**72005**	**659064**	**1316114**

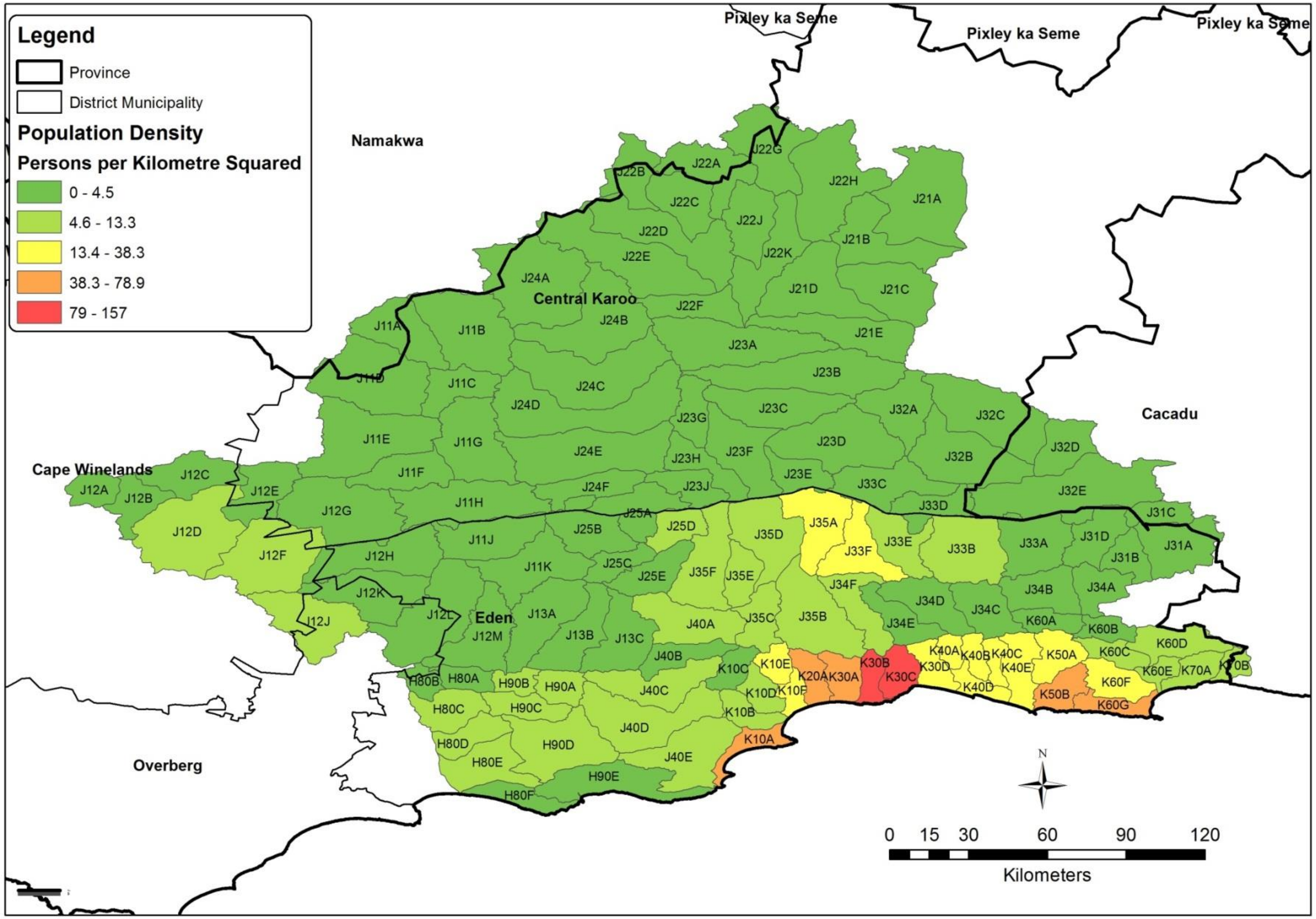


Figure 8.1 Gouritz WMA: Population density

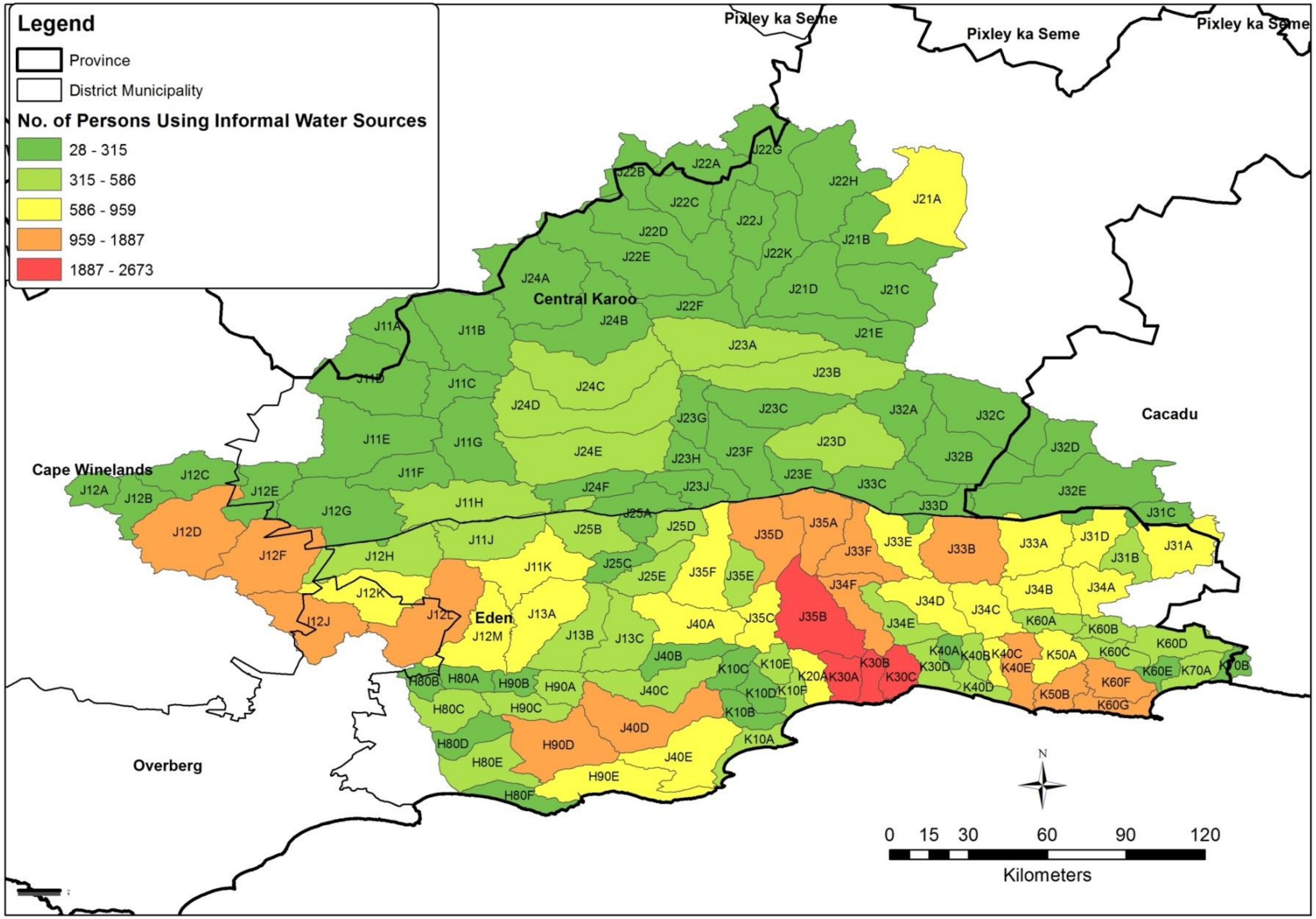


Figure 8.2 Gouritz WMA: Number of persons utilising informal water sources by quaternary catchment

9 WETLANDS

Department of Water and Sanitation (DWS), 2015f. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Wetland Report. Prepared by Fluvius Environmental Consultants for Scherman Colloty & Associates cc. Report no. RDM/WMA16/03/CON/0513.

9.1 BACKGROUND

The wetland component builds upon the earlier work undertaken in selected coastal catchments of the Breede-Gouritz WMA (DWA, 2009c) and aims to provide a description of the types of wetlands within the study area; a baseline status quo desktop assessment of wetlands within key catchments, and a rapid EcoStatus assessment of select priority wetlands within the study area. In addition, the wetlands were grouped into Wetland Resource Units (WRUs) to enable the development of management recommendations and identification of recommended ecological specifications.

9.2 APPROACH

Individual priority wetlands in the study area were identified from the literature, desktop sources and in conjunction with the local wetland forum. Two of the highest high priority wetlands were assessed in the field to provide information on Ecostatus and management recommendations necessary to achieve the REC.

Across the entire study area, however, there are thousands of wetlands and it was not possible to assess each wetland individually. A baseline assessment of wetland EIS and average PES at the quaternary catchment scale was undertaken across the Gouritz WMA. Quaternary catchments with more than 0.5% by area of wetlands were assessed. RECs for these key catchments were determined from the baseline Ecostatus data.

In order to develop a catchment understanding of wetland types and processes, WRUs, which denote large areas with similar wetland types within them, were delineated. Wetland types, processes, management concerns and recommended Ecological Specifications for the different WRUs, and for individual key quaternary catchments, were generated from available desktop information, baseline Ecostatus information and field experience of the area.

9.3 WETLAND RESOURCE UNITS

There are thousands of wetlands in South Africa, and their sheer number precludes a site-specific approach to wetland management. In order to effectively manage these many wetlands, WRUs were delineated. Nine WRUs were identified across the Gouritz WMA (**Figure 9.1**). The characteristics of typical hydrogeomorphic (HGM) wetland types found within each are described in **Table 9.1**. To facilitate more efficient and informed water use authorisation evaluation and licence processing, recommended ecological specifications for the management of wetlands within the different WRUs are provided in DWS (2015f).

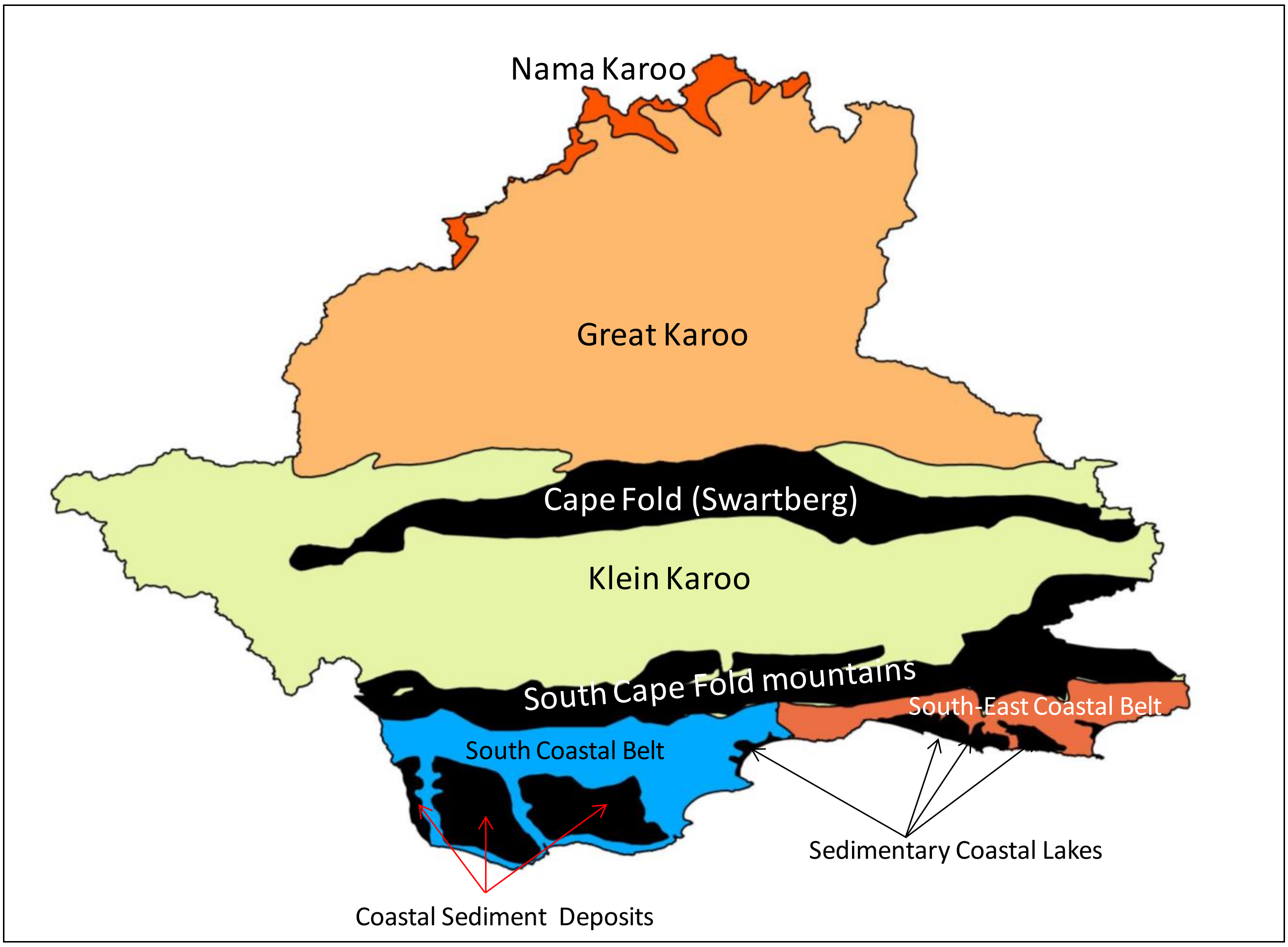


Figure 9.1 The WRUs of the Gouritz study area

Table 9.1 Summary of typical wetland characteristics and HGM wetland types in each WRU of the study area

WRU	Typical wetlands	NFEPA[1] HGM types	Characteristics of HGM type
Nama Karoo	Seeps with a likely high degree of groundwater dependence.	Depression	Saline, temporary to seasonal
		Seep	Groundwater-dependant, seasonal or permanent
Great Karoo	Small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence respectively.	Valley bottom	Saline, temporary to seasonal
		Seep	Groundwater-dependant, seasonal or permanent
		Depression	Saline, temporary to seasonal
		Depression	Seasonal to permanently saturated or inundated
Klein Karoo	Small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence respectively.	Valley bottom	Saline, temporary to seasonal
		Seep	Direct or indirect groundwater link, seasonal or permanent

WRU	Typical wetlands	NFEPA[1] HGM types	Characteristics of HGM type
Swartberg Cape Fold Mountains	Small seeps associated with groundwater-fed springs.	Seep	Groundwater-dependant, seasonal or permanent
South Cape Fold Mountains	Small seeps associated with groundwater-fed springs.	Seep	Groundwater-dependant, seasonal or permanent
South Coastal Belt	Channelled and unchannelled valley bottom wetlands; extensive seepage wetlands (especially in granitic areas).	Valley bottom	Permanently saturated
		Valley bottom	Seasonally saturated
		Seep	Groundwater-dependant, seasonal or permanent
		Depression	Brack to fresh, temporary to seasonal
South-East Coastal Belt	Channelled and unchannelled valley bottom wetlands.	Valley bottom	Seasonal or permanent
		Seep	groundwater-dependant, seasonal or permanent
Sedimentary (Coastal Lakes)	Lakes and wetland flats.	Depression	Coastal lakes ranging from fresh to brackish
Coastal Sedimentary Deposit	Desktop information shows wetlands are very infrequent – possibly due to deep infiltrating soils and a lack of shallow/perched water tables. Interdune depressional wetlands are present, suggesting groundwater contributions.	Valley bottom	Seasonal or permanent
		Flat	Seasonal or permanent
		Seep	Probably seasonal

1 National Freshwater Ecosystem Priority Area.

9.4 BASELINE ASSESSMENT OF WETLANDS: QUATERNARY CATCHMENT SCALE

There was a very low density of wetlands in the drier interior – most catchments have less than 0.5% wetlands by area compared with typically at least ten times that proportion in the coastal catchments. Quaternary catchments with 0.5% area or more of wetlands within them were identified using available wetland maps. The average EIS and PES for wetlands within these catchments were estimated using a desktop assessment tool.

9.4.1 Wetland EIS

Moderate EIS scores (**Figure 9.1**) dominated the study area. The high rainfall coastal zone of the study area was characterised by catchments with Moderate, High and Very High EIS wetlands (**Figure 9.2**). These catchments included the 1300 ha Wilderness Lakes, an internationally designated Ramsar wetland, as well as Groenvlei Lake and the Knysna lagoon. These were located in quaternary catchments K30 and K40D. Although there were comparatively few wetlands in the more arid, low rainfall interior of the catchment, the wetlands did provide important grazing resources, as well as trapping flood flows, and could play an important role in water table recharge functions.

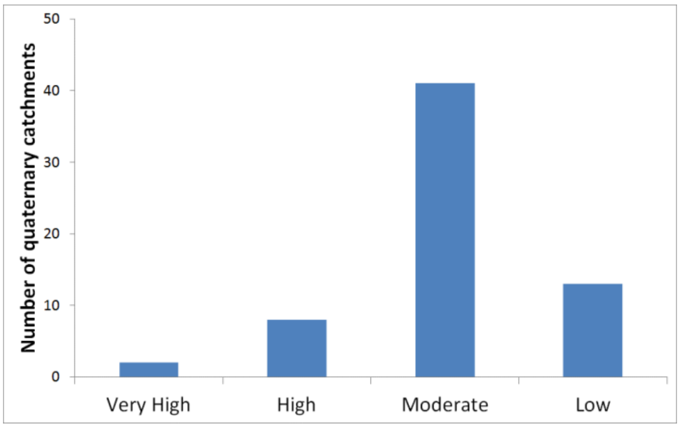


Figure 9.2 Summary of the EIS scores for the assessed quaternary catchments

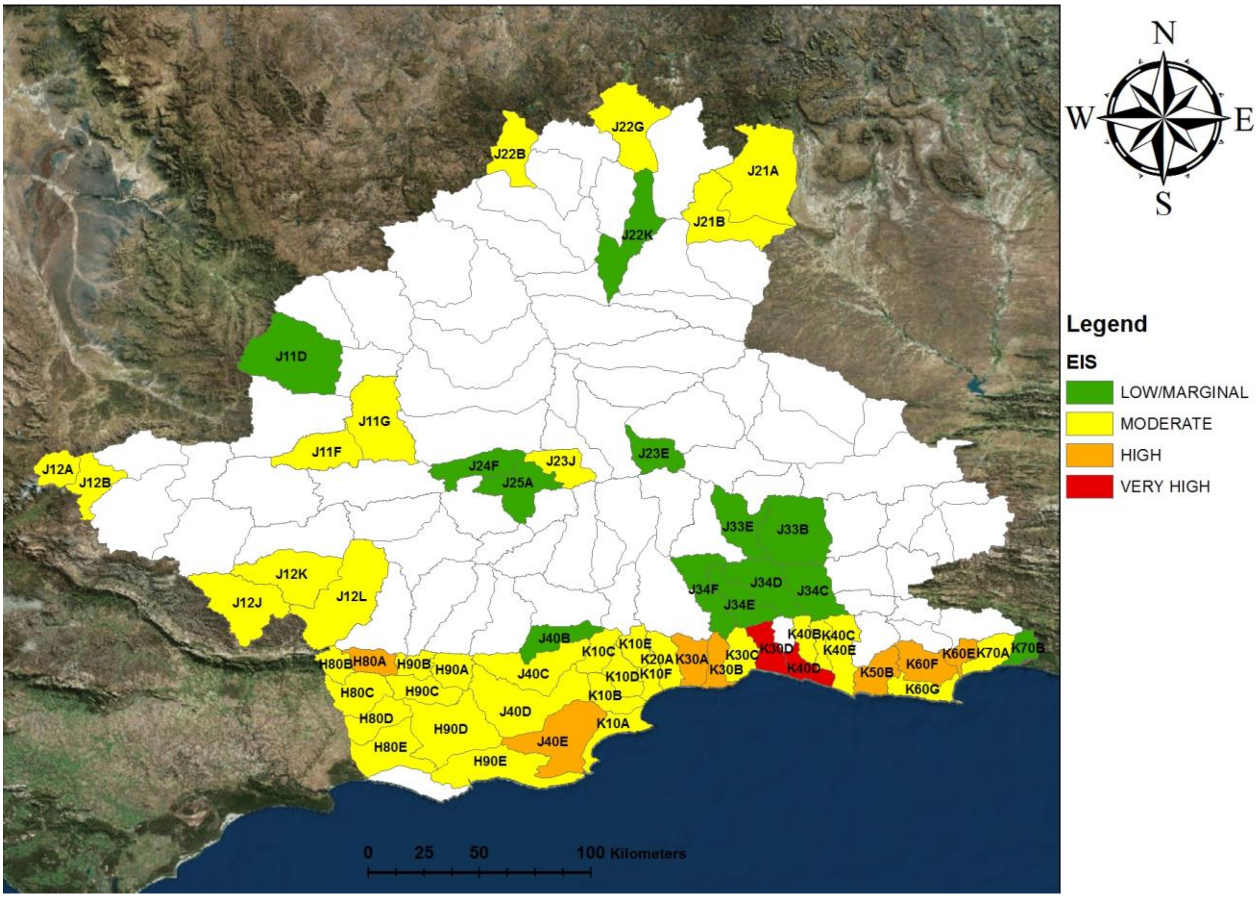


Figure 9.3 The average EIS of wetlands within select catchments

9.4.2 Wetland PES

The overall condition of wetlands in the interior catchments was estimated to be mostly in B and C ECs (**Figure 9.3**). The majority of the wetlands in the study area were concentrated in the wetter coastal zone, in catchments that were often highly transformed by agricultural activities (pastures and cropping), forestry (afforestation) and urban areas as the majority of the population is in this zone. In addition to the direct impacts of these landuse practices on wetlands, additional factors, such as dams, flow reduction, nutrient enrichment and the spread of invasive vegetation into wetlands, have all impacted upon the PES of the wetlands in the coastal catchments. Consequently, wetlands were on average in a poorer condition along the coast than in the interior (**Figure 19.4**).

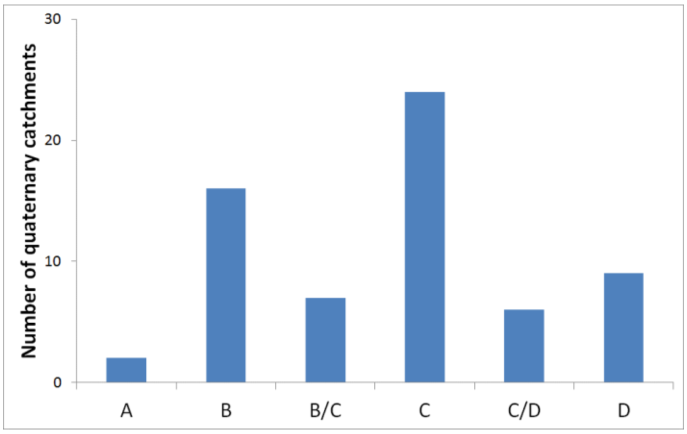


Figure 9.4 Summary of the PES scores for the assessed quaternary catchments

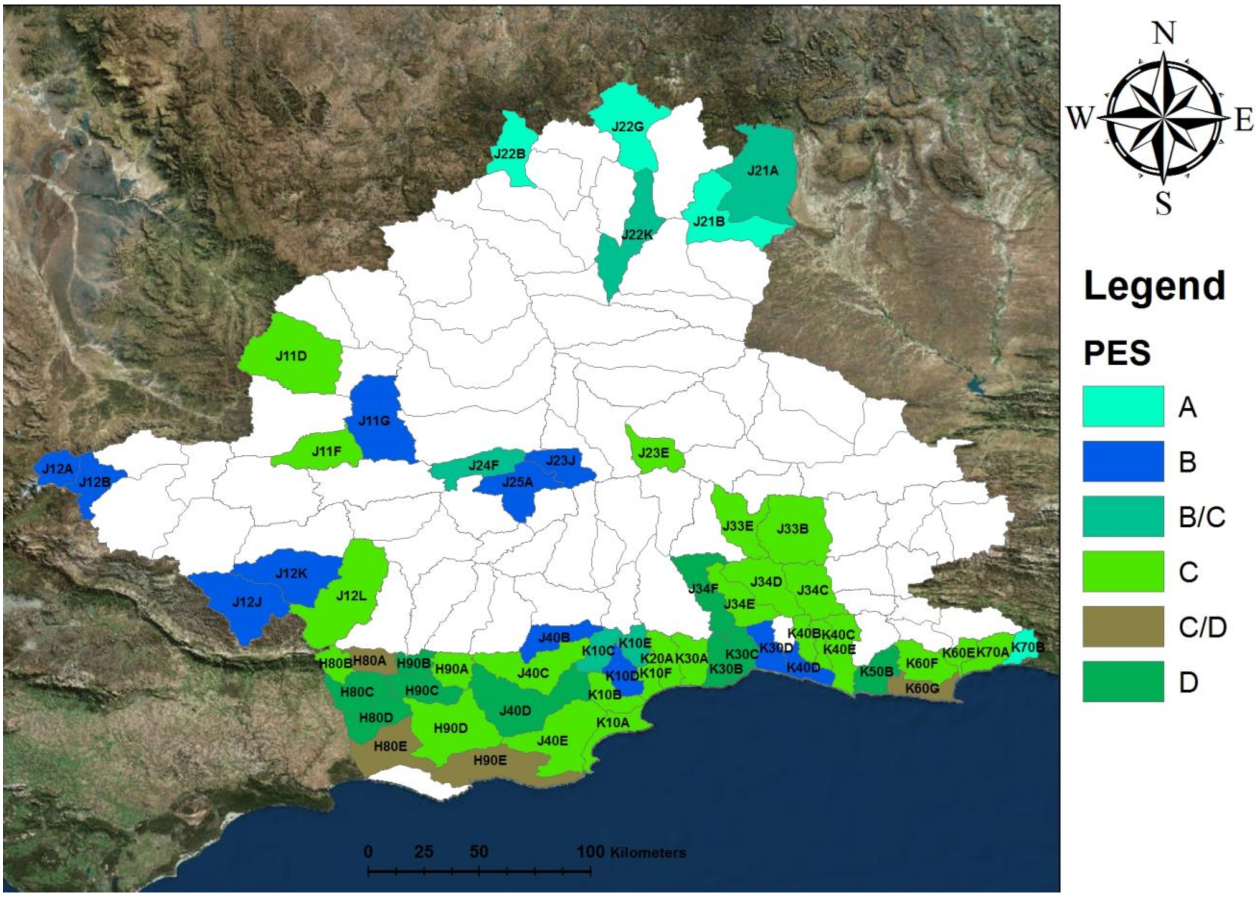


Figure 9.5 The average PES of wetlands in select catchments

Although there were few wetlands in the interior of the catchment, many wetlands and streams in the Karoo were degraded by erosive gullies (dongas) caused by overgrazing, large camp systems, tree removal and burning. Further impacts were caused by the presence of "thirsty" alien trees that reduce flow or even totally dry up springs and lower water tables.

Each quaternary catchment characterised by High or Very High EIS scores was assessed in terms of best attainable RECs in light of their high EIS status. Select catchments with high EIS could achieve an improvement in the PES with the implementation of moderate (non-flow related) management actions (**Table 9.2** - High and Very High EIS and high (A and B) PES catchments are highlighted). Across the study area, the control of invasive vegetation in and alongside wetlands is a key management action to achieve the REC.

Table 9.2 The average EIS and PES of wetlands for assessed catchments in the study area

Quaternary Catchment	Desktop Wetland EIS		Weighted Desktop PES		REC	How to achieve the REC
	Score	EIS	Score	PES		
K10A	1.8	Moderate	3.6	C	C	Control invasive alien vegetation, erosion and landuse encroachment.
K10B	1.9	Moderate	3.2	C	C	
K10C	1.9	Moderate	4.0	B/C	B/C	
K10D	2.0	Moderate	4.1	B/C	B/C	
K10E	1.9	Moderate	4.0	B/C	B/C	
K10F	2.0	Moderate	3.4	C	C	
K20A	1.9	Moderate	3.3	C	C	
K30A	2.8	High	3.3	C	C	
K30B	2.7	High	2.8	D	C/D	Buffers in urban and agricultural areas, manage water quality, erosion and invasive vegetation.
K30C	2.0	Moderate	2.4	D	D	Control invasive alien vegetation, erosion and landuse encroachment.
K30D	3.6	Very High	4.1	B	B	
K40A	2.0	Moderate	2.7	D	D	
K40B	2.0	Moderate	3.8	C	C	
K40C	2.0	Moderate	3.4	C	C	
K40D	3.6	Very High	4.4	B	B	
K40E	2.0	Moderate	4.0	B/C	B/C	
K50A	2.0	Moderate	3.9	B/C	B/C	
K50B	2.8	High	2.9	C/D	C	Protect and improve the condition of remaining wetland patches, control invasive vegetation.
K60A	2.0	Moderate	4.1	B	B	Control invasive alien vegetation, erosion and landuse encroachment.
K60B	2.0	Moderate	4.5	B	B	
K60C	2.0	Moderate	4.5	B	B	
K60D	2.1	High	4.9	A	A	

Quaternary Catchment	Desktop Wetland EIS		Weighted Desktop PES		REC	How to achieve the REC
	Score	EIS	Score	PES		
K60E	2.1	High	3.8	C	C	
K60F	2.4	High	3.4	C	C	
K60G	1.9	Moderate	3.3	C	C	
K70A	1.6	Moderate	3.5	C	C	
K70B	1.0	Low	4.7	A	A	
H80A	2.1	HIGH	3.0	C/D	C	
H80B	1.7	Moderate	3.2	C	C	
H80C	1.4	Moderate	2.3	D	D	
H80D	1.4	Moderate	2.5	D	D	
H80E	1.5	Moderate	2.9	C/D	C/D	
H90A	1.9	Moderate	3.5	C	C	
H90B	2.0	Moderate	2.8	D	D	Control invasive alien vegetation, erosion and landuse encroachment.
H90C	2.0	Moderate	2.6	D	D	
H90D	1.6	Moderate	3.3	C	C	
H90E	1.7	Moderate	3.0	C/D	C/D	
J11D	1.0	Low	3.6	C	C	
J11F	1.1	Moderate	3.9	C	C	
J11G	1.1	Moderate	4.1	B	B	
J12A	1.8	Moderate	4.2	B	B	
J12B	2.0	Moderate	4.4	B	B	
J12J	1.8	Moderate	4.3	B	B	
J12K	1.9	Moderate	4.5	B	B	
J12L	1.6	Moderate	3.6	C	C	
J21A	1.6	Moderate	4.1	B/C	B/C	
J21B	1.6	Moderate	4.5	B	B	
J22B	1.1	Moderate	4.5	B	B	
J22G	1.1	Moderate	4.5	B	B	
J22K	1.0	Low	3.9	B/C	B/C	
J23E	1.0	Low	3.4	C	C	
J23J	1.2	Moderate	4.4	B	B	
J24F	1.0	Low	3.8	C	C	
J25A	0.9	Low	4.3	B	B	
J33B	1.0	Low	3.3	C	C	
J33E	0.9	Low	3.4	C	C	
J34C	0.9	Low	3.6	C	C	
J34D	0.7	Low	3.4	C	C	
J34E	1.0	Low	3.1	C/D	C/D	
J34F	0.9	Low	2.9	D	D	

Quaternary Catchment	Desktop Wetland EIS		Weighted Desktop PES		REC	How to achieve the REC
	Score	EIS	Score	PES		
J40B	1.0	Low	4.3	B	B	
J40C	1.4	Moderate	3.1	C/D	C/D	
J40D	1.4	Moderate	2.8	D	D	
J40E	2.1	High	3.3	C	C	

9.5 PRIORITY WETLANDS

In addition to the identification and assessment of important catchments, some wetlands were also assessed on an individual level. Based on information from the local Southern Cape Wetlands forum and the regional DWS, 33 potential priority wetlands were identified in the WMA. Prioritisation was based on the physical, hydrological and ecological condition of the wetland and the threats to degradation. Two high priority wetlands, the Duiwenhoks unchannelled valley bottom, a large palmiet-dominated wetland, and the Bitou floodplain, were assessed in the field. Both wetlands had a Moderate importance. The Duiwenhoks was in a D Category, largely due to extensive erosion of the palmiet wetland. The Bitou wetland was in a C category, largely attributable to landuse conversion. Like many wetlands across the WMA, the impacts of invasive alien vegetation were ubiquitous and the removal and control of woody alien trees could greatly reduce or even reverse some of the wetland degradation in the region.

10 GROUNDWATER

Department of Water and Sanitation (DWS), 2015g. Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area: Groundwater Report. Prepared by Exigo[3] for Scherman Colloty & Associates cc. Report no. RDM/WMA16/02/CON/0413.

10.1 INTRODUCTION

The objectives of the GRDS groundwater study were to:

- Perform a Desktop-Rapid level groundwater Reserve determination for the entire Gouritz WMA to identify hotspots/areas of water resource concern and areas in the Gouritz WMA where limited groundwater is available after the Reserve is allocated.
- Perform intermediate groundwater Reserve determinations for selected catchments / Groundwater Resource Units (GRUs) that are classified as stressed based on the classification of the desktop Reserve; and
- Report on groundwater Reserve figures and findings for the Gouritz WMA and selected GRUs and make recommendations on where more detailed future studies should be performed.

10.2 APPROACH

10.2.1 Desktop-Rapid groundwater Reserve determination

The purpose of the Desktop-Rapid Reserve determination was to identify hot spots and areas in the Gouritz WMA where limited groundwater is available after the Reserve is allocated. It was performed based on existing information with the outputs being a classification and maps with the rapid Reserve results for all 130 quaternary catchments in the Gouritz WMA. It also serves to guide the selected field hydrocensus surveys to hot spots and areas classified as priority through the Reserve, within the Gouritz WMA.

After evaluation of existing literature and data, a Desktop-Rapid Reserve was performed for the Gouritz WMA using primarily the Groundwater Resource Assessment Phase II (GRAII) raster datasets and the new Groundwater Reserve Determination Methodology (GRDM) software database (Dennis *et al.*, 2012). Vector overlay and raster extraction of the GRAII data was performed and compared to the new GRDM software database reference values for flow balance components such as recharge, baseflow and groundwater abstraction.

10.2.2 Hydrocensus

The purpose of the hydrocensus is to verify the data used for the Intermediate Reserve determination. A hydrocensus was completed on selected quaternary catchments and GRUs to determine the borehole locations, springs, groundwater levels, groundwater use, and groundwater quality. An optimised hydrocensus was guided by hotspot areas and the outputs of the Desktop-Rapid Reserve level results.

A total of 97 geosites (boreholes and springs) were surveyed during the optimised hydrocensus in the Waboomskraal, southern Kammanassieberg, western Kammanassieberg and upper Olifants River areas. Accurate and recent groundwater level data is available for all actively monitored DWS boreholes. A total of 86 groundwater levels were measured during the Gouritz hydrocensus, depending on where they could be accessed.

10.2.3 Intermediate Reserve determination

Based on the Desktop-Rapid Reserve outcomes and identified groundwater hotspots, quaternary catchments and GRUs were selected to perform more detailed (Intermediate) qualitative and quantitative Reserve determinations on, and was done using the Groundwater Yield Model for the Reserve (GYMR) (DWA, 2010a) method. The method includes the following tasks:

- Statistical rainfall analysis: From the rainfall analyses, it was important to determine assurance levels and the potential impacts of droughts on groundwater availability.
- Updating the conceptual groundwater flow models from the Desktop-Rapid Reserve that would take the required flow components into account. These components included all groundwater recharge and discharge components important to the Reserve such as rainfall-recharge, dam seepage, boreholes, springs, wetlands, riparian vegetation, irrigation, forestry and evaporation losses.
- Qualitative and quantitative groundwater volume modelling using the GYMR method for the present day case. This is based on the minimum groundwater balance approach (Vivier, 2013).
- Development scenarios and scenario modelling to reflect the pristine and potential future cases.
- Specific reference given to the BHNR.
- Groundwater quality consideration and influence of groundwater quality on the Reserve. Selected samples were taken during the hydrocensus for groundwater quality analyses.
- Surface water-groundwater interaction and integration to determine groundwater outputs to baseflow and the EWRs.

10.3 RESULTS

These Desktop-Rapid Reserve results were used in conjunction with known problem or groundwater hotspot[4] areas (as stated during the October 2013 Stakeholder Workshop) as well as Reserve studies already performed in the Gouritz WMA, to identify groundwater hotspots and selected / priority GRUs (**Figure 10.1** and **Table 10.1**).

[4] A groundwater hotspot can be an area or town where large groundwater abstraction takes place, can be an ecologically sensitive area where environmental impact is expected due to groundwater abstraction, or is an area where groundwater is of strategic importance to many stakeholders and its shared use can potentially create conflict.

Present Status Category	Stress Index	Total Quats	Total percentage
I	< 5%	55	42%
I	5% - 20%	21	16%
II	20 - 40%	15	12%
III	40 - 65%	13	10%
III	65 - 95%	6	5%
III	>95%	16	12%
Zero Recharge	Erroneous	4	3%

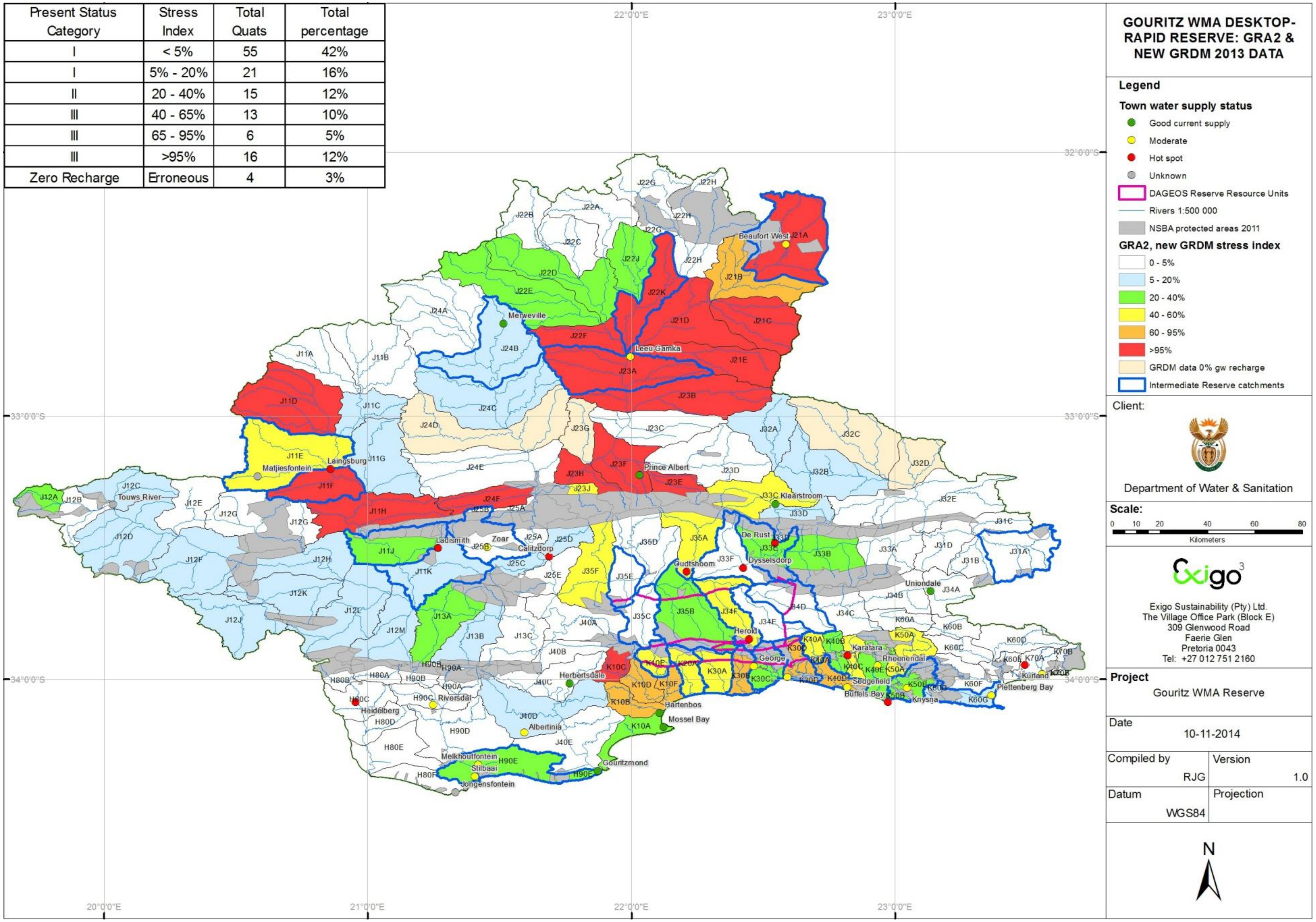


Figure 10.1 Desktop-Rapid Reserve results for average conditions (P_{50}) and hotspots of the Gouritz WMA

Table 10.1 Final selected quaternary catchments for Intermediate Reserve GRUs

Secondary Catchment Rivers	Quaternary Catchment (28 catchments)
Goukou River	H90E
Groot River	J11E, J11F, J11J, J11K
Gamka River	J21A, J22K, J23A, J24B, J25B
Olifants River	J31A, J33E, J33F, J34D, J34E, J34F, J35B, J35C, J35E
Klein-Brak River	K10E
Groot Brak River	K20A
Gwaing/Kaaimans/Touws Rivers	K30A, K30B, K30C, K30D,
Sedgefield River	K40D
Knysna River	K50B
Keurbooms River	K60G
	22% of total (130) quaternary catchments

The Desktop-Rapid Reserve determination indicated that 28 of the 130 quaternary catchments are potentially stressed. The hydrocensus results showed that the shallowest water level was 0.21 magl (metres above ground level), the deepest water level was 100 mbgl (metres below ground level) (actual >100 m, dip meter limitation) and mean groundwater level was calculated to be at 16.32 mbgl.

During the Intermediate Reserve, these 28 catchments were modelled in more detail to take account of storage and transient variability in rainfall. Results from the Intermediate Reserve determination are shown in **Figure 10.2** and **10.3** with the detail provided in the Groundwater Report for the GRDS study (DWS, 2015g). It shows that under normal (MAP) rainfall conditions, eight out of the 28 GRUs or quaternary catchments potentially show groundwater stress conditions if the Reserve requirements are to be met. During drought conditions 22 of the 28 intermediate GRUs will have a groundwater balance deficit for drought years.

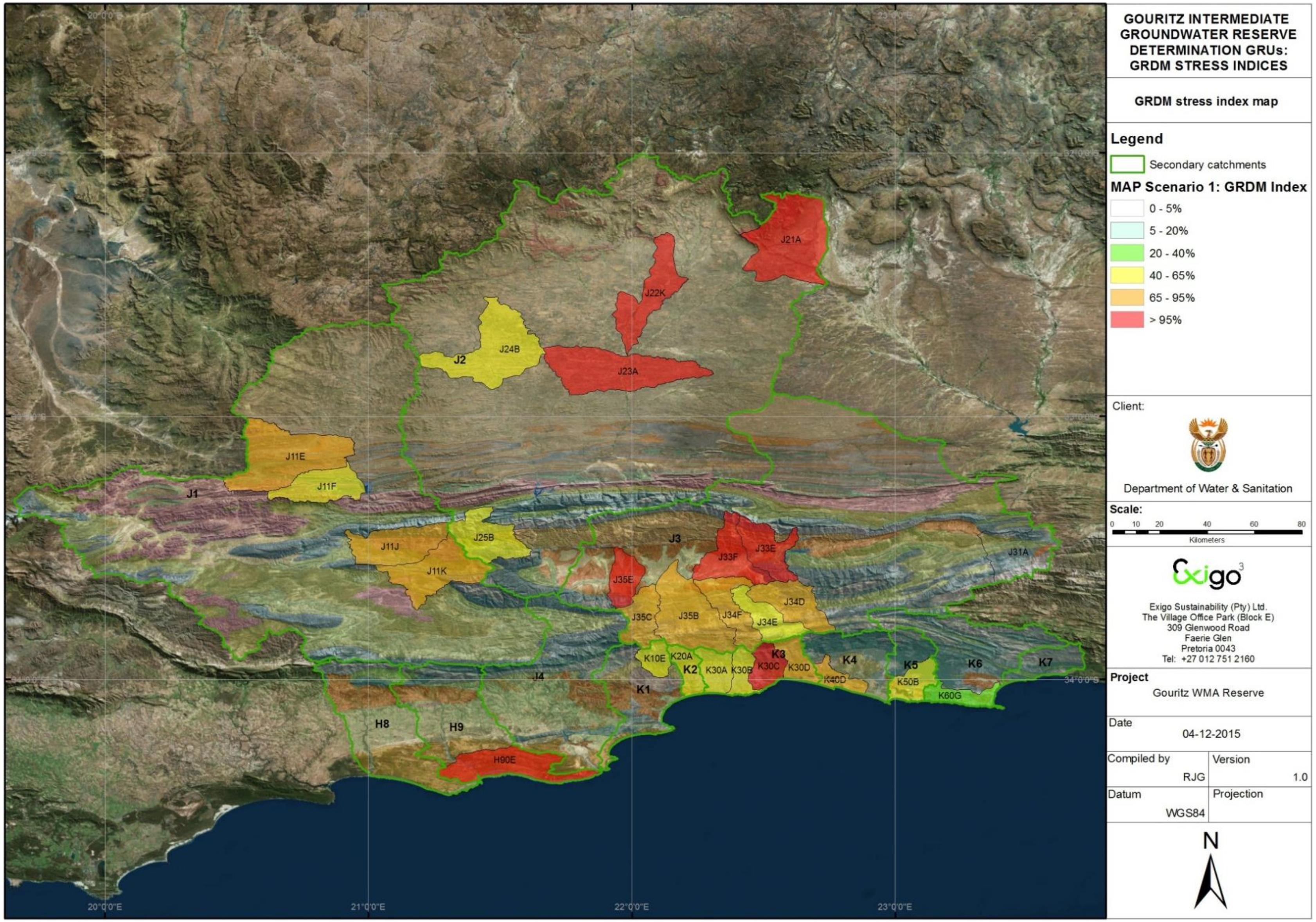


Figure 10.2 Present day MAP scenario showing GRDM stress index per intermediate Reserve selected catchment in the Gouritz WMA

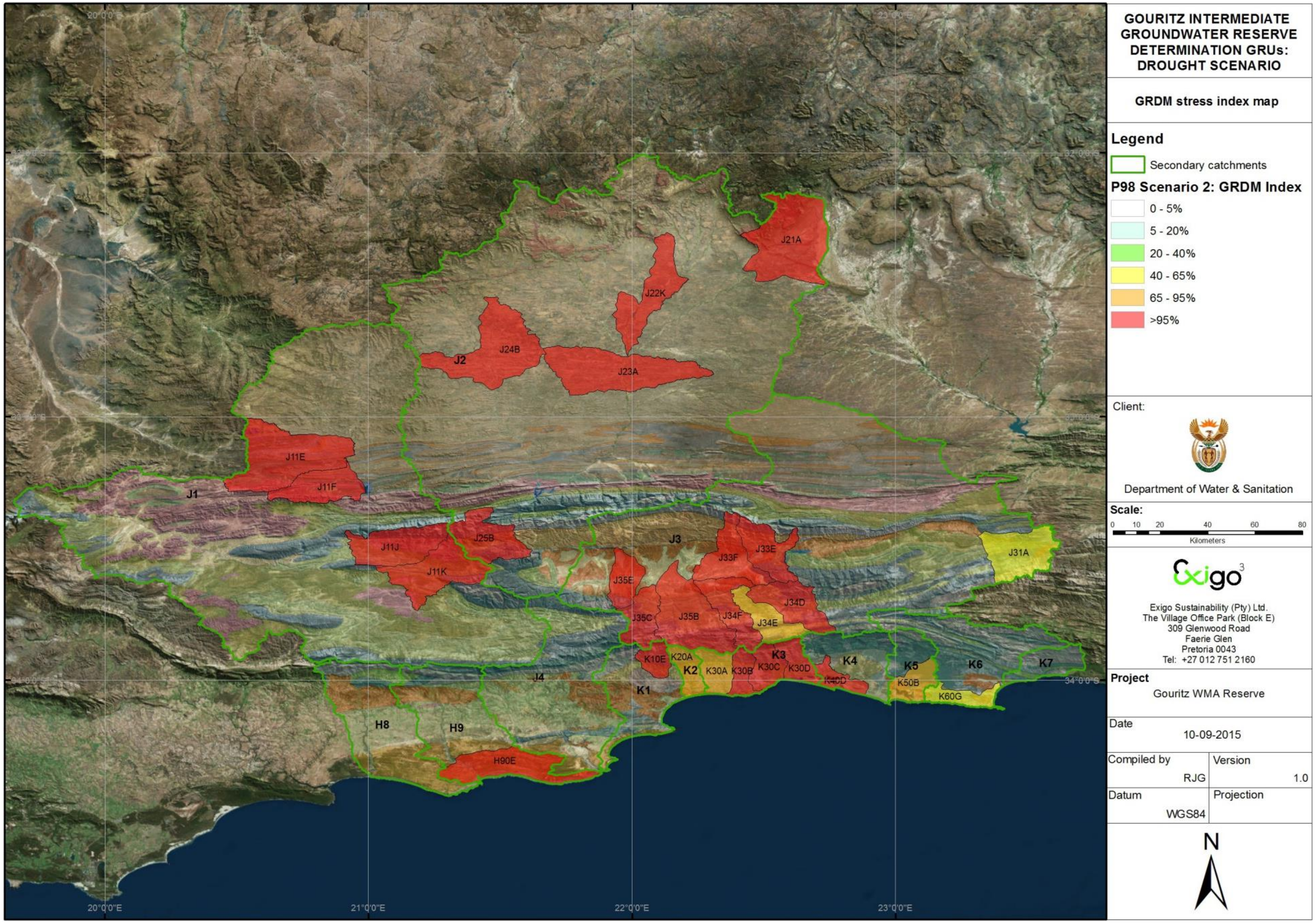


Figure 10.3 Map showing GRDM stress index per Intermediate Reserve catchment: Scenario 2: 98% assured rainfall (drought)

10.4 CONCLUSIONS

The following summarises some of the main findings of the GRDS groundwater study:

- Groundwater forms an important part of the water resources in the Gouritz WMA. In the semi-arid areas north of the Outeniqua Mountains, the Klein Karoo and north of the Swartberg Mountains, groundwater is the dominant water resource. This is especially true during drought cycles, as groundwater becomes the sole water source when dams dry up. Groundwater supports water supply to local communities, towns and farms.
- The Intermediate Reserve results indicated that 1) alien vegetation has the potential to reduce groundwater recharge/groundwater potential significantly and 2) irrigation also has one of the biggest influences on the groundwater balance. When irrigation land use and typical irrigation water use are considered, the volumes are so large that it was concluded that there must be large surface water dams, river abstraction or irrigation canals present to justify these volumes. An assumption was made that 10 - 15% of all irrigation comes from groundwater.
- There is a good correlation between catchments indicated as stressed and deeper groundwater levels. This may indicate that catchments highlighted as stressed are in fact experiencing groundwater stress. Further studies are, however, required to verify this.
- The Gouritz WMA is indicated to be stressed in a number of areas, more specifically in the Great Karoo basin as well as the Klein Karoo area and H90E. In the coastal areas further east, e.g. K50B and K60G, less groundwater stress is experienced due to the availability of surface water.
- In the present day (status quo) scenario, using MAP, eight catchments (29%) of the 28 selected catchments show a groundwater deficit.
- In the 1 in 50 year drought conditions, with rainfall at a 98 % level of assurance, 22 of the 28 selected quaternary catchments show a groundwater deficit. This shows that the methodology declassified the high stress status of six catchments that were analysed too conservatively in the Desktop-Rapid Reserve iteration.
- The groundwater quality of the regional area is generally good but influenced by the local geology. Certain lithologies within the Table Mountain Group (TMG) aquifers have a high iron content that exacerbates borehole clogging during abstraction when oxygen enters the system. The Bokkeveld- and Witteberg-Groups and the Dwyka Group in the Karoo generally have salinity problems. Most of the groundwater quality problems can be overcome with the latest water treatment technologies.
- The deep confined Peninsula Aquifer (GRU 2) is recharged by inflow from the semi-confined shallow aquifer (GRU 1):
  - A conceptual numerical model[5] was developed for the shallow and deep aquifers (GRU 1 and GRU 2) to determine the regional groundwater flow balance (Exigo, 2015). The potential flow from the shallower semi-confined aquifer (GRU 1) to GRU 2, under conditions of abstraction, would in time reduce the baseflow contribution of GRU 1 for the system to balance.
  - From the groundwater modelling, it is expected that it would take 15 - 20 years for the planned abstraction of the Mossel Bay groundwater exploration of Phase 1 (of Peninsula

[5] Conceptual groundwater flow models were developed for both the shallow and known deep aquifers. These components would include all recharge- and discharge-components that are relevant to the Reserve such as rainfall-recharge, dam seepage, boreholes, springs, wetlands, riparian vegetation, irrigation, forestry and evaporation losses.

Fm. confined aquifer wellfield implementation) at 3.8 million m3/a (120 ℓ/s) to affect the northern reaches of the shallow semi-confined aquifer along the Doring River (Exigo, 2015). Increased leakage from surface streams due to abstraction may negate the partial dewatering of the deep confined aquifer but with an impact on the surface water streams.
  - Based on this assessment, the combined yield of GRU 1 and 2 is 8.2 million m^3/a, for average conditions (P_{50}) and the assured yield (P_{98}) is 5.2 million m^3/a. It is estimated that a yield of 1.5 million m^3/a, during average conditions and 1.0 million m^3/a, during drought conditions, may be applicable for GRU 2, i.e. the deep confined aquifer. This will, however, need to be proven with more detailed follow up monitoring and modelling.
  - An option for long-term sustainable use of the deep confined aquifer is to utilise storage which can be replenished via surface water artificial recharge during flood peaks. If this is a management option, it will have to be evaluated in more detail through a detailed feasibility study.
- Long-term monitoring data from the Klein Karoo Rural Water Supply Scheme (KKRWSS) indicates that yield and recharge of the Vermaaks River valley TMG is lower than initially estimated (GEOSS, 2014). There are at least two plausible reasons for this: one is that there is iron bacteria clogging of the well screens and pumps that has to be remediated; it is also possible that abstraction from agricultural users around the Kammanassieberg could be contributing to a decline in the hydraulic head.
- Groundwater development potential is possible in ±70% of the catchments. The allocable groundwater potential is between a minimum of 31 million m^3/a, and 60 million m^3/a, if advantage can be taken from reducing losses.

Conjunctive use between surface water, groundwater and artificial recharge are two future water use strategies that would be important to explore. Artificial recharge during times of flood or surplus flow conditions into deep aquifers could be a useful future strategy to store water for drought conditions.

10.5 RECOMMENDATIONS

The following summarises some of the recommendations made from the study, which largely relate to either improving groundwater availability through certain actions and intervention, or additional work to verify issues which remain unclear:

- Alien vegetation must be monitored and eradicated as far as possible in the Gouritz WMA. The catchments that classified as the highest GRDM index should be targeted first. Alien vegetation should preferably be removed first in riparian-, spring- and wetland-areas. The water gained from Working for Water alien vegetation eradication programmes as well as the financial input for such programmes need to be justified, hence estimates of alien vegetation water use must be accurate (Mallory *et al.*, 2011).
- Groundwater monitoring should be performed across the WMA, but with preference in the hotspot (or focus) areas and catchments that classified with high GRDM stress indices.
- The general authorizations in the 28 potentially stressed catchments must be reviewed and reduced to sustainable levels and in some cases it may be zero.
- Detailed groundwater investigations and numerical flow management models using models such as MIKE SHE and Finite Element subsurface FLOW system (FEFLOW), should be developed to characterise catchments H90E, J33E and J33F to verify the role that groundwater

storage can play in the buffering of dry cycles. It will be important to verify the water use quantities. The deep Peninsula Aquifer will require a detailed three dimensional numerical groundwater flow model to refine and verify the yield.

- The yield of the semi-confined shallow aquifer (GRU 1) and the deep confined Peninsula Aquifer (GRU 2) must be quantified using detailed 3D numerical groundwater flow models based on the latest data sets. The potential constraints of protected areas and surface water features, e.g. streams and dams such as the George Dam, must be evaluated and environmental impacts qualified. It will be important to manage the groundwater abstraction from both GRU 1 and GRU 2 so as to ensure that the environmental flow requirements are met.
- The groundwater contribution to baseflow should be verified in the catchments that flagged with a high GRDM index rating. Sampling of the water quality changes and parameter tracing based on hydrogeochemical mixing models can be considered to achieve this.
- Detailed field investigations and models should be used to determine a buffer zone to mitigate saline water intrusion. This aspect should be further investigated at K40D, K50B, K40E and K10A.
- More research is required to determine under which conditions more groundwater may be available if losses can be reduced.
- Additional groundwater development in the hotspot- and stressed-areas should be prevented if the stressed situation is verified. Options to regionally distribute groundwater abstraction to alleviate local concentrated abstraction should be investigated.
- The Intermediate Reserve EWR must be refined as it could be less than the volumes that were conservatively estimated in this study.
- Conjunctive use strategies between surface water and groundwater should be investigated and a guideline document be compiled that would account for the constraints in each catchment.
- Artificial recharge should be considered as a future water management option. Notable artificial recharge case studies include Prince Albert and Plettenberg Bay that fall within the Gouritz WMA.
- The water management strategy for the deep confined TMG aquifers should be reviewed and a guideline document be compiled to ensure sustainable development and utilisation of the deep groundwater systems.
- Shale gas exploration (fracking) in the Karoo formations should be done with due diligence and care should be taken not to adversely affect the groundwater quality and supplies. The level of information on the hydrogeology of the deep Karoo Aquifers is currently too limited to make informed decisions on this aspect. Recent progress has been made in improving knowledge on the processes of deep groundwater circulation in Karoo aquifers and their flow mechanisms.

11 MONITORING

Department of Water and Sanitation (DWS), 2015h. *Reserve Determination Studies for Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area:* Monitoring Report. Prepared by Koekemoer Aquatic Services and Scherman Colloty and Associates cc. Report no. RDM/WMA16/00/CON/1213.

11.1 BACKGROUND

The purpose of this task was to provide the EcoSpecs and TPCs for habitat and biota as well as to include guidelines for a monitoring programme.

11.1 RIVERS: APPROACH

Resource Quality Objectives (RQOs) are specified during Water Resource Classification (WRC), with EcoSpecs defined during Reserve studies forming the ecological input to the RQOs. For the purpose of RQO determination and monitoring, the following differentiation is made between biota and habitat EcoSpecs and RQOs.

EcoSpecs are associated with the Ecological Reserve process and are provided at EWR sites. EWR sites are situated in High priority RUs or MRUs, a term used in the Reserve process, and therefore detailed EcoSpecs must be provided as the output of the Reserve study. Detailed RQOs (which include EcoSpecs) must be provided as the output of the Classification process. EcoSpecs are the detailed or numerical ecological input to RQOs as they are quantifiable, measurable, verifiable and enforceable and therefore ensure protection of all components of the resource, which together define ecological integrity. As EcoSpecs are presented in a numerical quantitative format, they can be used for monitoring and compliance purposes. When setting EcoSpecs, the work is usually based on field surveys that have been undertaken. A monitoring baseline is therefore available and monitoring is to either ensure that the present state is maintained, or that the REC is reached."

RQOs are determined after Classification has been undertaken according to the NWRCS and the Reserve has been undertaken. As the Gouritz study is a Reserve study only, and focusses only on the high priority RUs or MRUs (DWA, 2014a), only EcoSpecs are determined.

A monitoring programme has to be designed according to the principles of adaptive management to provide guidance on how to address issues if the EcoSpecs and TPCs (Rogers and Bestbier, 1997) are exceeded. The broad objectives of monitoring are to:

- Set EcoSpecs and TPCs for rivers.
- Provide a monitoring programme to measure the responses and effectiveness in terms of trend and change in EC.

Further information on Ecological Water Resources Monitoring (EWRM) can be obtained from DWA (2009d), DWA (2010b) and ORASECOM (2013).

Rivers: Principles of EWRM, EcoSpecs and TPC**s**

GRDS Monitoring focussed on measuring the ecological state, i.e. the EC. EcoSpecs and TPCs therefore described the PES and/or the REC for each of the biota and habitat indicators. The key principles and concepts were the following:

- The data collated during field surveys form the baseline.
- Future monitoring has to compare conditions to the baseline.
- For rivers the EcoSpecs and TPCs therefore described the baseline so monitoring can determine whether the PES is being maintained, if further degradation of the the system is taking place , or if the REC is being met
- Monitoring should be initiated soon after the baseline data has been collated to ensure that this data represents the recent baseline.
- Monitoring has to be applied within an Adaptive Management Framework.
- The concept of the TPCs provides the basis of a Decision Support System (DSS). When TPCs are exceeded, management actions will be necessary.

Management actions were designed to maintain, or attain (if different from the PES) the REC. These management actions related to the management objectives which were described in terms of the flow and quality (water quality) EcoSpecs. Additional land use objectives were also described if non-flow related aspects were contributing to the PES of the system. A clear distinction was made between setting management objectives in terms of the habitat to achieve/maintain certain ECs, and defining EcoSpecs for the biophysical responses that describe the ECs.

In essence, during an EWR study, flow requirements (i.e. the main habitat driver) that could result in a certain ecological state are defined through an EC. These flow requirements inform the management objectives supported by the other habitat driver components. Note that the word 'could' is used as the biological responses to habitat driver conditions are all predicted and must be tested through monitoring.

Monitoring the ecological responses would test the predictions made during an EWR study. It furthermore would test whether adjustments to the EcoSpecs and TPCs are required and whether the overall management objective in terms of the REC is being achieved. It is therefore crucial that monitoring be driven by objectives as it forms the foundation of a monitoring project (cf. Elzinga *et al*., 1998).

11.2 RIVERS: DIFFERENT LEVELS OF MONITORING

Monitoring programmes have generally in South Africa failed due to amongst others the following reasons:

- The lack of a monitoring DSS and an Adaptive Management Framework.
- Technical and skilled capacity to implement the monitoring, and
- The perceived high cost associated with the application of an EWR monitoring programme.

The design of a cost-effective monitoring programme was based on different levels of monitoring as follows:

- Level 1: Desktop approaches at a high frequency (e.g. annually).
- Level 2: Surveys and specialist analysis at low frequency (e.g. every 3 years).

If Level 1 monitoring indicated that TPCs were exceeded, the initiation of Level 2 monitoring surveys could be required in order to determine the management actions required to address potential problems. Level 1 and Level 2 monitoring was included in the design of this monitoring programme.

11.3 RIVERS: LEVEL 1 MONITORING PROGRAMME

Level 1 monitoring refers to monitoring that is undertaken at a higher frequency (yearly or monthly or as specified by the current DWS monitoring programme) than more detailed Level 2 monitoring (3-yearly), which also include response indicators. The Level 1 monitoring focuses only on water quality, diatom and woody vegetation monitoring. The Level 1 monitoring programme is summarised in **Table 11.1**.

Table 11.1 Rivers: Water quality, diatom and woody vegetation Level 1 monitoring programme

Water Quality	
Indicator	All variables measured as standard by DWS as a minimum requirement. Note that temperature and dissolved oxygen should be monitored at all EWR sites as no baseline currently exists for these parameters and they are strongly linked to biotic responses.
Monitoring action	Include additional variables in the formal DWS monitoring programme as indicated by EcoSpecs, specifically periphyton chlorophyll-a and diatoms. Include toxics monitoring if indicated by biotic response (conducted as part of Level 2 monitoring). Institute water quality monitoring at J1DORI-EWR7, Doring River, if required. Note that this site was not identified as an ecological hotspot and the need for inclusion in the EWR monitoring programme would have to be ascertained.
Temporal scale (frequency and timing)	1. Monthly, or as determined by current monitoring programme per monitoring point. 2. Institute twice a month monitoring at EWR sites with no water quality gauging weir in place. 3. Use Google Earth © and available information where data are not available and cannot be collected to identify driving land-uses, associated driving water quality variables and preliminary current state for water quality.
Spatial scale	1. Relevant water quality monitoring point at gauging weir. 2. Institute a monitoring point downstream of the EWR site if no water quality gauging weir is in place for use.
Diatoms	
Monitoring action	Baseline data is depauperate especially at all the Rapid EWR sites as well as at J2GAMK-EWR4, J1BUFF-EWR5 and J3OLIF-EWR9. Collect baseline data to develop EcoSpecs and TPCs. Field work.
Temporal scale (frequency and timing)	Six monthly at all sites preferable during summer and winter or high and low flow conditions.
Spatial scale	All EWR sites and sites where water quality hotspots have been identified.
Woody vegetation cover within the riparian zone	
Monitoring action	Assessment of satellite imagery: Each time new Google Earth © coverage becomes available (check coverage dates monthly)
Temporal scale (frequency and timing)	1. Monthly checks for new satellite data. 2. Vegetation assessment whenever new data become available.

Spatial scale	EWR reach.

11.4 RIVERS: LINK TO LEVEL 2 MONITORING PROGRAMME

Level 2 monitoring should be applied on a regular basis at the EWR sites. Monitoring should include water quality, diatoms and hydrology as outlined in the previous sections as well as other indicators. More detail is provided for habitat and biota in DWS (2015h). Therefore, whereas Level 1 monitoring focuses on water quality and diatoms as well as the continuous hydrological gauging; Level 2 focuses on the more detailed work at a lower frequency required for biota and habitat. Note that Level 1 monitoring runs parallel with the Level 2 monitoring, and monitoring for water quality should be the same as for Level 1 as it is understood that water quality data may assist in explaining biotic response. As mentioned for Level 1 monitoring, testing for toxics should only be undertaken in response to biotic indicators, where already being assessed as part of the existing DWS programme, or where a specific toxic has been mentioned in the water quality EcoSpecs. Note that monitoring for water quality will therefore be more frequent than the 3-yearly monitoring recommended for biotic indicators and will follow Level 1 guidelines.

There are current initiatives in DWS with the revitalising of the River Health Programme and the use of the Rapid Habitat Assessment Method (RHAM - DWA, 2009d) in determining and measuring EcoSpecs at a rapid level. It is recommended that this monitoring dictates the level required and the methods to be followed. As the RHAM is a rapid approach, this may well fit into the Level 1 monitoring programme described in DWS (2015h). However, at priority EWR sites, detailed work to determine and update the ECs (i.e. ecological responses) for the fish, macroinvertebrate and riparian vegetation should be undertaken, albeit at a lower frequency. This response monitoring is described in this chapter as the Level 2 monitoring.

Habitat and biota monitoring should be applied as part of Level 2 monitoring. This implies detailed monitoring at a lower frequency than Level 1. It is acknowledged that resources may not be available to undertake this work (even at a lower frequency) at all EWR sites.

In **Table 11.2** monitoring programme for Level 2 is provided at for riparian vegetation, fish and macroinvertebrates.

Table 11.2 Rivers: Level 2 monitoring programme at EWR sites

Riparian vegetation	
Indicator	1. Woody vegetation within the riparian zone, both terrestrial and indigenous riparian vegetation. 2. Reeds. 3. Alien vegetation. 4. Non-woody vegetation including sedges, grasses, and dicotyledonous forbs, but excluding reeds or palmiet. 5. Overall PES for riparian vegetation.
Monitoring action	Field assessments using VEGRAI[1] level IV. Fixed point photography.
Temporal scale (frequency and timing)	Every three years, same month for subsequent surveys.
Spatial scale	All EWR sites.
Fish	
Indicator	Species richness and specific indicator fish species with a preference for specific habitat features (such as substrate) or being intolerant to specific impacts (such as water quality deterioration, flow reduction).
Monitoring action	Field assessment (electrofishing and where appropriate using a minnow seine).
Temporal scale (frequency and timing)	Every two years (dry season, same as baseline).
Spatial scale	All EWR sites as above and other sites in RU as specified.
Macroinvertebrates	
Indicator	Composition and abundance
Monitoring action	Field assessment (SASS5[2]) (high priority).
Temporal scale (frequency and timing)	Every two years.
Spatial scale	All EWR sites as above.

1 Vegetation Response Assessment Index South African Scoring System version 5

11.5 ESTUARIES: BASELINE SURVEYS AND LONG-TERM MONITORING

For estuaries monitoring requirements are divided into additional baseline surveys and long-term monitoring programme. The purpose of additional baseline surveys is to collect data and information to improve understanding of the ecosystem functioning of a specific system in order to improve the confidence of EWR results. These surveys are often short-term, more intensive studies, while long-term monitoring programmes are usually less intensive. Long-term monitoring programmes primarily are implemented to test compliance with EcoSpecs and TPCs, as well as to improve and refine these targets through an iterative management process.

Although baseline surveys and long-term monitoring programmes have different purposes, it is important that long-term monitoring programmes follow on from similarly structured baseline studies. In essence, the monitoring activities selected for the long-term monitoring programme should be derived from the monitoring actions conducted as part of the baseline studies, but implemented on less intensive spatial and/or temporal scales.

The EWR methods for estuaries (DWAF, 2008) provides guidance on the type of actions to be considered in these surveys and programmes, specifically designed to inform these type of studies. Components and elements to consider include:

Component	Description
Hydrodynamics	Flow recording of river inflow
	Water level recordings at mouth
	Aerial photos
Sediment dynamics	Bathymetric/topographical surveys and grab samples
	Sediment loads
Water Quality	River inflow water quality
	Effluent discharges
	Water quality in estuary
	Sediment surveys of toxic substances
Microalgae	Phytoplankton (water column)
	Benthic microalgae
Macrophytes	Aerial photos, transects and quadrats
Invertebrates	Zooplankton
	Benthic invertebrates (Benthos)
	Macrocrustaceans (Hyper benthos)
Fish	Seine and Gill net sampling
Birds	Full bird counts

For the GRDS, detailed baseline and long-term monitoring programmes were developed for the estuaries assessed at intermediate (i.e. Duiwenhoks, Goukou and Gouritz estuaries) and rapid (i.e. Klein Brak and Wilderness system) levels. For the estuaries that were assessed at a desktop levels (i.e. Blinde, Hartenbos, Piesang, Groot (Wes) and Bloukrans estuaries), as well as the estuaries for which previous EWR studies did not provide baseline or long-term monitoring programmes, a generic programme was developed. The monitoring programme previously provided for the Keurbooms Estuary as part of the EWR study was also re-assessed (CSIR, 2008). Detailed additional baseline surveys and long-term monitoring programmes are provided (DWS, 2015h). Limited financial and human resources are often a reality in the deployment of these surveys and programmes. As a result a list of priority actions were identified for various estuaries based on site-specific information needs and importance.

11.6 WETLANDS

The approach outlined below is for desktop monitoring of priority and key wetlands in the study area. The best available wetlands maps should be used in conjunction with Google Earth or other similar available landcover records to evaluate the condition of invasive alien vegetation, erosion and landuse encroachment within wetland areas. Compare the baseline (2015) records with the most recent available imagery.

11.6.1 Priority wetland 1: Duiwenhoks wetland – EcoSpecs

Monitoring should ensure that:

- There is no additional erosion in intact wetland sections.
- There is no encroachment of agricultural areas in to wetlands.
- There is removal and control of invasive alien vegetation within and along margins of the wetland. The draining of the wetland areas and/or diverting of flows have already initiated widespread erosion in former pristine wetland areas and further degradation of this type must be prevented; and
- The EC must achieve or exceed the 2015 baseline.

11.6.2 Priority wetland 2: Bitou floodplain - EcoSpecs

Monitoring should focus on the key impacts which affect the wetlands and place at risk the achievement of the REC:

- No encroachment of agricultural or residential areas in to wetlands.
- Removal and control of invasive alien vegetation within and along margins of the wetland. The draining of the wetland areas and/or diverting of flows have already initiated widespread degradation and further degradation of this type must be prevented.
- The EC must achieve or exceed the 2015 baseline.

An additional recommendation would be to promote the vegetation of buffer areas along streams and canals. This would assist to reduce turbidity and sediment losses from the floodplain through stabilised stream and canal banks. The vegetation may also assist with some nutrient trapping and thus a potential reduction in nutrient-rich runoff from the agricultural areas.

11.6.3 Wetlands in key catchments of the Gouritz WMA – EcoSpecs

The monitoring of important quaternary catchments should ensure that:

- Invasive alien vegetation, especially woody vegetation, within and alongside wetlands does not expand from the baseline (2015) conditions.
    - For quaternary catchments K30B, K50B and K80A where the REC is higher than the baseline condition, the extent of invasive alien vegetation should decline relative to the baseline condition.
- Erosion dongas, which desiccate wetlands and cause the degradation of wetland habitats, should be stabilised through rehabilitation structures. The unchecked expansion of erosion dongas will cause wetlands to be degraded and lost. Rehabilitation interventions can be implemented in conjunction with the DAFF, DEA and Working for Wetlands (WfWetlands).
- Residential, industrial and agricultural landuse encroachment in to wetlands should not take place.
- The EC must achieve or exceed the 2015 baseline, and meet the REC.

11.7 GROUNDWATER

Although a good coverage of the most important GRUs and selected intermediate Reserve quaternaries is achieved with the existing active monitoring boreholes, there are still some areas in the WMA where an additional groundwater monitoring borehole would be prudent. One observation to the active monitoring borehole network is that there are often concentrations of monitoring boreholes at specific towns while other towns have none. It is however also true that one has to consider for each town if groundwater level data is really necessary given the town's type of water use (surface- or groundwater-source).

Based on these considerations the following areas have been identified:

- The primary area for inclusion of hydraulic head monitoring data in DWS active monitoring boreholes database is the coastal region between George and Plettenberg Bay.
- A second area for consideration is the H90E Stilbaai, Jongensfontein/Gouritzmond coastal dune aquifers area. The reason being that some of the potable water for Stilbaai is supplied from groundwater from springs and boreholes. There is already a number of monitoring boreholes being actively monitored at Albertina close by.

Although there are no DWS active monitoring boreholes at Laingsburg, Stilbaai or the J31A quaternary catchment, there is active monitoring taking place at these towns and major abstraction boreholes. This groundwater monitoring is handled by the town municipalities and in almost all cases contracted out to geohydrological service providers. In the case of the former mentioned municipalities the data was readily made available for this study by the geohydrological service providers (GEOSS, 2012a;b; GEOSS, 2013).

Every attempt should be made by these municipalities to make the groundwater data accessible to specialists for evaluation, either directly on the website, a contact link to obtain via e-mail or as favoured method provide the data to DWS in the correct format for inclusion in their active monitoring borehole database. In some rare cases data accessibility is problematic due to the involvement of service providers instead of the data being directly managed by DWS.

Data from the specific wellfield developments and strategic GRU areas such as the KKRWSS and the Deep Artesian Groundwater Exploration for Oudtshoorn Supply (DAGEOS) GRUs is available and can be supplied upon request from the service providers involved via DWS. Evaluations of the hydraulic head and water quality data can be found in the respective wellfield groundwater specialist reports (GEOSS, 2014; Hartnady *et al*., 2014).

Sedgefield and Ladismith have both had further groundwater development in the last three years and monitoring by the municipalities should be strongly considered in order to sustainably manage the groundwater resources.

There should be an attempt to include current active monitoring conducted by service providers into the DWS active monitoring boreholes database so that the data is readily available from DWS for any groundwater assessments that need to be performed in specific areas. At the simplest level, Geosite identifiers or borehole numbers with coordinates of active monitoring boreholes should be included in the DWS list/table of active monitoring boreholes. A column (field) can be added to include which organisation is performing the monitoring so that the groundwater investigator can at least know whom to contact for this data. The complete list of active monitoring boreholes will also then provide a complete picture of all active groundwater monitoring taking place. It is recommended that data supply from service providers be realised through an easy to use web-upload interface with registration of the consultants assisting the DWS with monitoring or a specific project that requires access to the data. Those only accessing the data can have read-only rights to the database. Given the simplest level of monitoring consultant participation in the DWS active monitoring borehole database as mentioned above, it would require minimal database maintenance effort from both DWS and the service provider.

12 CONCLUSIONS: PRELIMINARY ECOLOGICAL RESERVE CATEGORIES

12.1 BACKGROUND

The Ecological Reserve Categories associated with the Preliminary Reserve provided in this section were arrived at through consideration of driving ecological considerations in the GRDS study area, an evaluation of future developments and associated scenarios where available, and discussions with the DWS in September 2015, and stakeholders at two meetings in October 2013 and 2015.

These results therefore represent the final categories for which the system will be managed, and form the ecological output from the GRDS to the Breede-Gouritz Classification study to be initiatied in 2016. During the Classification process the Preliminary Ecological Reserve Categories will be assessed, modified if required, and gazetted as the Reserves for the study area.

The last stakeholder activitiy of the study was the presentation of these categories at a meeting on 16 October 2015 held in Wilderness town. The aims of this second and final Stakeholder Workshop were as follows:

- Present study results to stakeholders.
- Evaluate scenarios per Intermediate and Rapid estuary system.
- Evaluate possibilities for trade-offs between catchments if such opportunities exist; and
- Present the final Ecological Reserve Categories to stakeholders for their evaluation and assessment.

The Ecological Reserve Categories presented in this section therefore reflect the outcome of the discussions with DWS on 11 September 2015, as well as that from the Stakeholder Meeting of 16 October 2015.

Results will be presented as follows: Wetlands, Rivers and Estuaries with a combined River/Estuary section for those systems where both the river and estuary components were covered. The detailed results can be seen in the series of reports for the GRDS, as well as earlier chapters of this document.

12.2 WETLANDS: BITOU FLOODPLAIN

The Bitou floodplain is located in quaternary catchment K60F upstream of the confluence of the Bitou River with the Keurbooms Estuary. The upper reaches of the floodplain are characterised by a meandering alluvial channel through a floodplain which is extensively under agricultural use. This gradually changes to an increasingly estuarine-influenced system towards the confluence with the Keurbooms.

The Bitou floodplain is a popular birding area and most of the land is agricultural and under private ownership. The spatial development plan for the area recommended that agricultural activities be removed from the floodplains and the land be converted to a private nature reserve; ironically with simultaneous development of farmers markets on the main roads. With extensive rehabilitation of the floodplains, this would improve the PES of the floodplain, but the DWS's support for this long term vision of floodplain restoration should be weighed against the loss of agricultural resources and potential reduction of local employment opportunities.

In the short term, the Moderate importance and PES condition (Category C) of the wetland suggests that the REC should be to maintain the PES. Due to the existing infrastructure and economic dependence of agriculture on the floodplain, it is unlikely to be able to achieve a B condition wetland across the entire system. The following management interventions will need to be put into place to maintain the **Ecological Reserve Category** of a **C**:

- Invasive woody alien vegetation should be removed from the floodplain wherever possible, and must be removed from all riparian zones along the river channel. This will promote an increase in the indigenous vegetation through reduced shading.
- Vegetated buffer areas along streams and canals would assist in reducing turbidity and sediment losses from the floodplain through stabilised stream and canal banks. They may also assist with some nutrient trapping and thus a potential reduction in nutrient-rich runoff from the agricultural areas.

12.3 WETLANDS: UPPER DUIWENHOKS

The Duiwenhoks wetland is located in the H80A quaternary catchment. The upper catchment is within the Southern Fold Mountain EcoRegion, but where the river flows out into the flatter coastal belt. The Duiwenhoks wetland was once a very large wetland system characterised by unchannelled and weakly channelled valley bottom wetlands which would have been dominated by palmiet and *Phragmites* vegetation. In the upper western section of the basin where some large intact wetland patches remain, the wetland is still impacted by invasive alien vegetation and, most importantly, an extensive actively eroding donga

The moderate Importance and degraded condition (D Category) of the wetland suggests that the REC will be equal to the PES. This is supported by the impracticable and expensive remediation that would be necessary to redress the extensive, widespread erosion across the wetland. It is not practical, or affordable, to rehabilitate the wetland back to a higher category as the erosion dongas are too wide, deep and long to fill in.

However, since the wetland is still actively eroding, to maintain the PES (and thus ensure the REC in the longer term), the current ongoing impacts will need to be reduced and stabilised. This is important for both the wetland, and for downstream river and estuary reaches which are affected by the sediment loads and reduced dry season baseflows resulting from the widespread erosion. The following management interventions will need to be put into place to maintain the **Ecological Reserve Category** of a **D**:

- Preventing erosion in the remaining sections of the wetland is the most important task. The stabilisation and remediation of peat erosion in this catchment will aid in part in the achievement of the REC for the Duiwenhoks Estuary. The Department of Agriculture Western Cape (DAWC) has committed extensive funding for the construction of large scale rehabilitation structures to reduce the sediment eroded from the wetland from flowing downstream and smothering further aquatic habitat, and further reducing the flood capacity of the downstream river reaches.

- As a secondary objective to prevent any additional degradation, woody alien vegetation should be removed and prevented from re-establishing within or alongside the wetland areas. Woody invasive trees shade out the indigenous wetland vegetation, directly reducing the wetland condition, but the reduced cover of wetland vegetation can also encourage further erosion of the wetland which will further degrade the condition of the wetland vegetation, but also reduce hydrological functions and encourage more sediment deposition downstream.
- No encroachment of agricultural areas within the wetland, or immediately alongside it, should be permitted. The draining of the wetland areas and/or diverting of flows have already initiated widespread erosion in former pristine wetland areas and further degradation of this type must be prevented.

12.4 DUIWENHOKS RIVER AND ESTUARY

12.4.1 Duiwenhoks River

The main issues impacting on the present state of the Duiwenhoks River are the following:

- Decreased base flows and flooding events with zero flows at times due to abstraction.
- Overall deterioration in water quality due to irrigation return flows.
- Bank modification and instability due to alien invasive vegetation and agricultural practices in riparian zones.
- Alien fish species occurring in the reach.

As the EIS for the river is Low and no improvement is required, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **D Category**.

12.4.2 Duiwenhoks Estuary

The Duiwenhoks Estuary is a permanently open estuary located in the warm temperate region of the Western Cape between Riversdale and Heidelberg along the Cape south coast. The importance rating is High, thereby requiring an elevation from the PES of a C Category to a REC of a B. The estuary is an important fish nursery, with a number of Red Data and exploited fish species occurring in high numbers in the system. It is also a very important conduit for eels which are listed on CITES.

Scenario 2 (slightly improved flows, including the low flow EWR (Category D) for the Duiwenhoks River) was the selected scenario for achieving an improvement in the system. Returning some low flows will result in some improvement in estuarine health, while the management of non flow-related interventions can further improve the system. However, due to the lack of confidence regarding the present day hydrology for the system, and the uncertainty as to whether a 1% return of baseflow to the estuary is needed or possible, the **Ecological Reserve Category** was set as a **B/C**, with the implementation of the following non flow-related interventions being the selected approach to achieve this category:

- Rehabilitate peat land just upstream of the estuary to improve the regulation of river inflow to the estuary so as to maintain a River Estuary Interface (REI) zone for longer periods.
- Rehabilitate at least 10% of degraded estuarine habitat in the riparian zones, including the removal of alien vegetation.
- Control/reduce fishing effort through improved compliance monitoring of fishing activities.

- Implement an alien fish control programme; and
- Institute a control programme to reduce the number of Egyptian geese in the surrounding habitat.

An additional release of some baseflows to the estuary should assist in achieving the REC of a B Category.

12.5 GOURITZ RIVER AND ESTUARY

12.5.1 Gouritz River

The main issues impacting on the present state of the Gouritz River are the following:

- Impacts on baseflows as well as a decrease in volume, frequency and distribution of moderate-sized floods have occurred due to irrigation activities, groundwater abstraction, grazing, large dams and domestic water use.
- These activities have resulted in deteriorated water quality, i.e. high salinity and elevated nutrients).
- Some invasion by alien species and overgrazing in the Upper and Macro Channel Bank zones were present.
- Alien fish species also occurring in the reach.

As the EIS for the river is Moderate and no improvement is required, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **C Category**.

12.5.2 Gouritz Estuary

The Gouritz Estuary is a medium/large (245 ha open water area), permanently open system in the warm temperate region approximately 33 km to the south-west of Mossel Bay and enters the Indian Ocean between Bull Point and Kanonpunt. The Gouritz Estuary forms part of the core set of priority estuaries identified in the National Estuary Biodiversity Plan to meet biodiversity targets and is therefore classified as Important. In order to meet these requirements the Gouritz Estuary needs partial protection (e.g. include a no-take fishing zone and 50% of riverine area left untransformed). The REC for the Gouritz Estuary was set as a Category B, which is an improvement from the current PES of a C/D. This was also the Category recommended in the National Estuary Biodiversity Plan.

The recommended ecological flow scenario for the Gouritz was Scenario 2, i.e. a 25% base flow return to the estuary, through removal of alien invasive plants, as well as reducing run-off river abstraction during the low flow season. Due to the unavailability of additional water in the upstream catchments, non flow-related interventions were selected as the approach to achieve the **Ecological Reserve Category** of a **B/C**. The following interventions will be required. Note that ALL interventions will be needed to achieve the selected management category.

- Actively encourage stewardship programmes that promote alternative farming practices (i.e. using less water).
- Rehabilitate 20% of the flood plain by removing the agriculture levees and invasive plants.

- The abutment on the eastern side of the bridge across river will fail under flood thus requiring the construction of appropriate open spans/culverts.
- Water supply pipe (along western bank in the middle reaches of the estuary) should be protected by hard infrastructure (e.g. stone gabions have short life span in salty conditions) but preferably an alternative location should be investigated.
- Future planning and construction of hard structures should be prohibited as a result of the high dynamic / erodablility of the estuary bank.
- Appropriate dune management and setback along coast adjacent to mouth should be implemented as it affects mouth dynamics; and
- Control/reduce fishing effort through improved compliance monitoring of fishing activities and banning of night fishing.

12.6 GOUKOU RIVER AND ESTUARY

12.6.1 Goukou River

The main issues impacting on the present state of the Goukou River are the following:

- Decreased base flows, flooding events and zero flows at times due to abstraction and upstream dams.
- Deteriorated water quality due to the cumulative effects of agriculture and associated return flows.
- Bank modification and instability due to alien invasive vegetation and agriculture in the riparian zones.
- Alien fish species occurring in the reach.
- Wood removal in the riparian zones.

As the EIS for the river is Moderate and no improvement is required, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **C/D Category**.

12.6.2 Goukou Estuary

The Goukou Estuary is located on the Indian Ocean seaboard, about 300 km east of Cape Town. The estuary covers approximately 250 ha, is 19 km in length, and is embedded in a deep valley. The Goukou Estuary is part of the Stilbaai Marine Protected Area (MPA) and is classified as Highly Important. The REC for the estuary was therefore set as a B Category, which is an improvement from the current C Category.

None of the flow scenarios evaluated as part of this study were able to reverse modification in the ecological state to the REC, mainly due to the impact of significant non-flow related impacts. However, Scenario 1 could restore the estuary to a Category B/C. This scenario assumes a 50% base flow return to the estuary, e.g. through removal of alien invasive plants, as well as reducing run-of-river abstraction during the low flow season. Restoring some base flow addresses the key flow-related factor contributing to the changes in ecological health in this estuary, namely the re-establishment of the REI zone.

However, due to the uncertainty regarding returning baseflows to the estuary, the implementation of the following non flow-related interventions was signed off as the selected approach to achieve the **Ecological Reserve Category** of a **B/C**:

- Restore 50% of the flood plain and riparian habitat along length of estuary.
- Identify all fountains, spring and seeps and ensure adequate freshwater supply to riparian zone and estuary to facilitate connectivity between estuary and terrestrial environment (critical factor for the protection of eels).
- Control/reduce fishing effort through improve compliance monitoring of fishing activities and banning of night fishing.
- Prepare and implement guidelines on appropriate bank stabilisation along the estuary.
- Control boating activities on the estuary towards mitigating bank erosion (e.g. through proper zonation and establishment and enforcement of boating carrying capacity limits).
- Institute proper stormwater management in future development planning (e.g. management of runoff from hardened surfaces and associated pollution);
- Upgrade and maintain sewage infrastructure (e.g. restore broken pipes and install back-up pumps for pump station in close proximity of the estuary).
- Ensure that the water quality and volumes discharged through the Riversdale WWTW meet permit requirements as issued under the NWA.
- Prepare and implement guidelines on appropriate (nature-friendly) structures to secure access to the estuary.

12.7 KEURBOOMS RIVER AND ESTUARY

12.7.1 Keurbooms River

The main issues impacting on the present state of the Keurbooms River are the following:

- Reduced baseflows and altered flood frequency.
- Deteriorated water quality during the dry season due to abstraction (and return flows) for agriculture.
- Flow reduction due to extensive forestry plantations in the catchment.
- High occurrence of alien plantation species that encroach on the natural habitat
- Vegetation clearing.

As the EIS for the river is High, the integrated REC (B/C) was set to improve the PES (C). The **Ecological Reserve Category** for the river was therefore set at a **B/C Category.** This can be achieved by the following:

- Maintain present day flows, but improve base flows.
- Removal of alien vegetation.

These activities should achieve the B/C Category, and over time the B Category for the instream REC should also be reached.

12.7.2 Keurbooms Estuary

The Keurbooms Estuary is a permanently open system in the warm temperate region near Plettenberg Bay. In 2008 a Rapid level EWR assessment was conducted on the Keurbooms Estuary, which resulted in the assignment of a PES and REC of an A/B Category. The reassessment during the GRDS resulting in the same recommendations, but in higher confidence. As concluded with the previous assessment, it was agreed that the current level of urban development around the estuary (and related tourist activities), as well as the collapsed status of certain line fish species, make it unlikely for the system to be rehabilitated to a Category A. The **Ecological Reserve Category** assigned is therefore an **A/B**.

The following actions should also be undertaken as soon as possible to stabilise the health state of this estuary, with the primary concern being possible mouth closure:

- *Bitou Drift:* The drift through the Bitou River should be removed in total including all foreign rock material.
- *Northern floodplain of the lower Bitou Estuary:* Remove all exotic invasive trees from the flood plain. No further development should be allowed on the floodplain to prevent further loss of floodplain functionality. Remove the old gravel road to the south of the R340.
- *Southern floodplain of the lower Bitou Estuary:* Remove all exotic invasive plant species from the floodplain, remove the infilling, create a buffer zone (~ 10 m wide separating the wetland from the agricultural activities on the floodplain).
- *Road Bridge across the lower Bitou Estuary:* Remove concrete piers of the old road bridge to facilitate flow and tidal exchange in the Bitou Estuary and investigate establishing connection with old Bitou channel.
- *Middle reaches of the Keurbooms Estuary:* Remove all alien trees from the banks and The Island. Establish a buffer adjacent to the estuary and restrict new development on the banks of the estuary.
- *Upper reaches of the Ganse Spruit:* Remove all exotic vegetation from the stream bed.
- *The Ganse Spruit Wetlands*: Install a sufficient number of large culverts in the roads bisecting the wetlands to allow the free flow of surface water through the wetlands and remove all exotic invasive tree species.
- *Earthen barricades across tidal channels in the Bitou Arm:* Completely remove all earthen barricades to restore connectivity on the supratidal marsh. Maintain freshwater flow from the northern sections into the supratidal marsh south of the R340.
- *Middle reaches of the Bitou Estuary:* Remove all exotic tree species from this area, allow the artificial canal to naturally silt up, allow salt marsh to naturally re-colonise the extensive *Stenotaphrum* grasslands, insert culverts below the road bisecting the floodplain to link up the old channels.

12.8 RIVERS OF THE STUDY AREA

12.8.1 Gamka River

The main issues impacting on the present state (C/D Category) of the Gamka River are the following:

- Altered flow regime due to decreased base flows and flooding events and zero flows at times due to unseasonal and regular flood releases from the upstream Gamkapoort Dam, as well as the decreased large floods.
- Increased turbidity due to dam releases.
- Presence of alien vegetation species.
- Predation and competition from alien fish species.

As the EIS for the river is High, the REC was set to improve the PES. The **Ecological Reserve Category** for the river was therefore also set at an improved state, i.e. **C Category.** This can be achieved by the following:

- Larger flood releases from Gamkapoort Dam to improve geomorphology.
- Reducing instream nutrient loads although the source of the nutrients has to first be identified.
- Increasing of flood frequency in the summer with less flow regulation (resulting in aseasonal floods improving riparian vegetation). The shape of the flood can be adjusted through consultation with the irrigation farmers and Irrigation Board to allow for a receding limb to allow for fish spawning. This will therefore require an adaptation to the way in which Gamkapoort Dam is operated.
- Eradicating alien fish species. The improvements required for vegetation are likely to also improve the fish as well as the macroinvertebrate community.

12.8.2 Touws River

The main issues impacting on the present state of the Touws River are the following:

- Reduced baseflows and small floods caused by farm dams and irrigation impacted the wet season duration period.
- Deteriorated water quality (nutrients) due to agriculture.
- Bank modification and instability due to alien invasive vegetation and agricultural practices in the riparian zones.
- Alien vegetation species occurring in the reach.

As the EIS for the river is High, the REC should be set to improve the PES. However the causes of the present state are not well understood or known. Improvement would also require an increase in baseflows and small floods, which cannot be supplied without additional infrastructure or restrictions of allocation. The **Ecological Reserve Category** for the river was therefore set at a **B/C Category** so as to maintain the present state, but monitoring of the system is considered critical.

12.8.3 Buffels River

The main issues impacting on the present state of the Buffels River are the following:

- Decreased baseflows as well as reduced flood frequencies due to the upstream Floriskraal Dam. The seasonal distribution of baseflows was greatly affected (March to September showed a significant decrease in flows from natural) thereby impacting on the habitat template.
- Deteriorated water quality and increased water temperatures.
- Increased woody vegetation encroachment.

As the EIS for the river is Moderate and no improvement is required, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **C Category**.

12.8.4 Doring River

The main issues impacting on the present state of the Doring River are the following:

- Decreased base flows with zero flows at times and decreased floods due to abstraction, upstream dams and flow diversions.
- Deteriorated water quality due to polluted agricultural return flows.
- Bank modification and instability in the reach due to alien invasive vegetation and agriculture in the riparian zones.
- Clearing and overgrazing and catchment erosion had also contributed to bank and bed modification.
- Alien fish species also occurring in the reach.

As the EIS for the river is Low, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **D Category.** As the system may be improving with more consistently present instream flows, monitoring is recommended as a priority.

12.8.5 Olifants River

The main issues impacting on the present state of the Olifants River are the following:

- Irrigation activities have resulted in lower baseflows and moderate flood frequency.
- Water quality deterioration especially when flows are low lead to high temperatures and low oxygen rates.
- Overgrazing in the riparian zone resulting in bank modification and decreased longitudinal connectivity.

As the EIS for the river is Moderate, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **C Category**.

12.8.6 Kammanassie River

The main issues impacting on the present state of the Kammanassie River are the following:

- Decreased base flows with zero flows at times and decreased floods due to irrigation return flows, abstraction and farm dams.
- Deteriorated water quality due to polluted agricultural return flows.
- Elevated sediment input resulting in reduced pool depth and degraded substrate for biota.
- Alien vegetation in the upper riparian zone and significant *Cyperus textillis* encroachment in the area. Possibly due to nutrient enrichment and more consistent flows or seepage from return flows during dry periods.
- Alien fish species also occur in the reach.

As the EIS for the river is Low, the REC was set to maintain the PES. The **Ecological Reserve Category** for the river was therefore set at a **C/D Category**.

12.9 ESTUARIES OF THE STUDY AREA

12.9.1 Klein Brak Estuary

The Klein Brak Estuary is situated within the southern coastal belt, and is located approximately 12 km north of Mossel Bay. Two major tributaries, the Brandwag and Moordkuil, join approximately 3 km from the coast to form a well-developed flood-tidal delta.

The REC and PES were both determined to be a C Category, with the estuary being Important on a regional scale. However, the estuary is on a negative trajectory of change and if the current (low) base flow regime, as well as certain non-flow related impacts on the system continue, the estuary is likely to move into a Category C/D or D Category. To account for some of the loss in base flow, Scenario 1 (i.e. present flows including EWR for a Category C River just upstream of the estuary) was therefore selected as the recommended flow scenario for the Klein Brak Estuary.

The **Ecological Reserve Category** was signed off as a **C Category**, with the followed non flow-related actions needed to prevent further deterioration and stop the negative trajectory of change:

- On both the Brandwag (34◦03’43.51”S, 22◦06’47.95”E) and Moordkuil arms (34◦03’15.32”S, 22◦ 07’55.24”E) there are obstructions across the estuary (i.e. roads) that prevent saline intrusion/tidal variation extending further upstream. To improve tidal connectivity these obstructions should either be removed or proper bridges should be consutructed. In doing so, the REI (roughly defined as the reach where salinity ranges between 10 and 0) will be introduced more readily, enhancing nursery function in the upper estuaries and thus contributing to the recovery of collapsed and endangered fish species, e.g. dusky cob and white steenbras.
- Further upstream in the Moordkuil arm there is also a DWS weir (34◦03’11.14”S, 22◦08’02.85”E). As this weir fulfils an important gauging function it may not have to be removed, but fish ladders should be installed on both sides of the weir to allow migrating species (e.g. eels) to move upstream.
- Rehabilitate degraded areas in the estuary functional zone, e.g. consolidate present access routes so as not to have a web of small roads on the salt marshes.
- Removal of invasive alien plant species in the estuary functional zone, focussing especially in suptratidal areas.
- Reduce fishing pressures and (illegal) bait collecting through increased compliance (existing DAFF initiative).
- Institute a ban on night fishing to reduce the pressure on breeding stock of collapsed and endangered fish species, e.g., dusky cob (proposed DAFF initiative).

12.9.2 The Wilderness system: Touw Estuary and Wilderness lakes

The Wilderness System was subdivided into **two resource units**, namely the **Touw Estuary** and the **Wilderness estuarine lakes (hereafter referred to as the Wilderness lakes)**. The motivation for this was that these two sub-systems function at markedly different spatial and temporal scales. The PES of the Touw Estuary is a C Category, with that of the Wilderness lakes being a B/C. The system is Highly Important as it is a very important nursery for collapsed and endangered fish species, e.g. dusky cob and elf. The system also plays an important role as a way point/refuge area for fish along a coast that is known for extreme upwelling events that can cause fish kills. Further, the Wilderness Estuarine System also forms part of the Garden Route National Park and contributes significantly towards South Africa's overall estuarine biodiversity targets. The REC for the Wilderness system was therefore set at a B Category. Due to the significance of the system, the **Ecological Reserve Category** was also signed off as a **B**.

Increasing present inflow was not considered realistic given the agricultural demand from water in the catchment and that the system still receives 85% of its natural MAR. The present inflow into the systems remains a critical force to maintain open mouth conditions as further reduction in inflows to the system would increase the contribution of river flow in modification of conditions in the estuary. Mitigation of other non-flow related factors, as shown below, will therefore be needed to achieve the B Category and include:

- Increase breaching level at, at least to +2.9 m MSL (currently the system is breached between 2.1 - 2.4 m MSL). These higher levels match levels experienced during the 2007 and 2011 floods. If the system can be breached at these higher water levels, more sediment will be removed and the system will remain open to the sea for longer periods.
- The practice of artificially closing the system when the inlet becomes constricted should also be terminated.
- Alien fish and vegetation in the system should be controlled / eradicated. This can be done, for example through the establishment of a fishery that targets alien invasive fish (e.g. design seine that just catches *tilapia*). The Working for Water programme can also be used in the eradication of alien vegetation.
- Interim management measures should be considered to improved connectivity (interlinking channels) between the estuary and lakes, e.g. harvesting excessive macrophyte growth.
- Terminate *ad hoc* riparian protection practices along the banks of the estuary and the lakes and consider developing strategic guidelines for bank protection that will be more appropriate for this system.

12.9.3 Blinde Estuary

The Blinde Estuary is a relatively small (1.75 ha), perched system that drains a steep sided incised valley leading to a predominant closed mouth. The estuary remains closed for most of the year unless during a flood, but wash over from the sea can occur during high tides or storm events. The system is in a PES of a Category C but is on a **negative trajectory** of change related to key pressures in the catchment, including:

- Reduced water quality as a result of industrial activities in the catchment;
- Flow modification (high and low flows reduced), with a related shift in the onset of the high flow period and increase in the duration of the low flow period; and
- Limited bait collection and fishing.

The **Ecological Reserve Category** signed off on a desktop level, is a **C Category**, i.e. to maintain the PES. The present flow distribution should be maintained with no additional base flow abstraction. Efforts to increase baseflow should be investigated as a contributing mitigating measure to reverse the negative trajectory of change. In addition, the deterioration in water quality as a result of industrial activities in the catchment should be investigated.

12.9.4 Hartenbos Estuary

The Hartenbos Estuary is situated in the warm temperate region at the town of Hartenbos. The Hartenbos Estuary is in a PES EC of a D, with the system being on a negative trajectory of change as a result of various flow and non-flow related pressures including:

- Dam construction has resulted in a reduction in base flow and floods to the system, with a shift in the onset of the high flow period and increase in the duration of the low flow period.
- Artificial breaching.
- Loss of tidal flows and habitat as result of bridge construction (e.g. old N2, Railway bridge).
- Infilling of estuary channel and mouth area as a result of loss of floods and artificial breaching.
- A significant reduction in water quality as a result of Mossel Bay WWTW and urban runoff.
- Development in the EFZ.
- Alien vegetation.
- Limited bait collection and fishing effort, and
- Human disturbance (which influences bird abundance).

The **Ecological Reserve Category** that was signed off for this desktop assessment was a **C Category**. Mitigation of the negative trajectory of change and reaching the required EC will require significant improvement in the water quality of the system (linked to the wastewater treatment works discharge). An increase in base flow to the estuary should also be investigated to restore connectivity with the marine environment. Improved mouth management and rehabilitation of riparian areas/wetlands will contribute to reversing the negative trajectory of change.

12.9.5 Piesang Estuary

The Piesang Estuary is a small estuary situated in the warm temperate region in Plettenberg Bay. The following key pressures are contributing factors to the PES of a D Category:

- A reduction in base flows and floods to the system, with a shift in the onset of the high flow period.
- Direct abstraction of water from the mouth region for the reverse osmosis plant causing increased mouth closure and low water levels.
- Loss of tidal flows and habitat as result of bridge construction (e.g. old and new N2 bridge, Railway bridge).
- A decline in water quality as a result of urban runoff;
- Significant development in the EFZ and related loss of habitat.
- Limited fishing effort; and
- Human disturbance (which influence bird abundance).

The desktop assessment signed the **Ecological Reserve Category** off as a **B/C** as the estuary has a very high diversity of fish for such a small system and is considered an important supporting nursery area for surrounding estuaries, e.g. Keurbooms Estuary. The system also forms part of the core set of priority estuaries (i.e. desired protected area) in need of protection to achieve biodiversity targets in the National Estuaries Biodiversity Plan. The NBA 2011 also recommended that the Piesang Estuary be partially protected, and that 50% of the estuary margin be undeveloped.

The present flow regime should be maintained as a minimum. To improve the health of the system and achieve the B/C Category, additional flows (through base flow and less abstraction for reverse osmosis plant) would be required to keep a longer open mouth state during low flow periods. The reverse osmosis plant that is abstracting water in the lower reaches of the estuary significantly contributes to the current state of the system as it withdraws water to such low water levels that the mouth of the estuary closes more often. Improvement in water quality from adjacent urban areas should also be investigated, as well as the degree to which baseflow can be returned to the system in low flow periods.

12.9.6 Groot (Wes) Estuary

The Groot (Wes) Estuary is a small to medium size (39 ha) temporarily open/closed estuary. The following key pressures have contributed to the slight modification in ecological health in this system, with the PES being a B Category:

- Some reduction in base flow and floods to the system as a result of forestry in the catchment and abstraction by adjacent town, with a shift in the onset of the high flow period.
- Loss of tidal flows and habitat as result of bridge construction.
- Some development in the EFZ and related loss of habitat; and
- Limited bait collection and fishing.

This study is of **very low** confidence as it was done at a desktop level assessment with limited to no data being available. The Groot (Wes) Estuary is situated in the Tsitsikamma National Park, hence the system forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets. The NBA 2011 (Van Niekerk and Turpie, 2012) recommends that the estuary be fully protected, and that 50% of the estuary margin be undeveloped. The REC is therefore an A Category which can be achieved by improved mouth management practices, as well as returning base flow during low flow periods. The latter can, for example, be achieved through investigating alternative practices to supply water to the adjacent town (i.e. not drawing from the river during low flow periods). Reducing fishing effort and bait collection will also contribute towards achieving the REC.

As a minimum, the present flow regime needs to be maintained, and the extent to which base flows can be returned to this system needs to be investigated. The **Ecological Reserve Category** was signed off as a **B**.

12.9.7 Bloukrans Estuary

The Bloukrans Estuary is a small (4 ha) permanently open estuary. The estuary has a strongly tidal mouth that opens to the sea between steep valley sides. This study is of very low confidence as it was done at a desktop level assessment with limited to no data being available. A categories were assigned for both the PES and REC as the estuary is situated in the Tsitsikamma National Park and should be fully protected. The estuary is relatively resilient to flow reduction, with the **Ecological**

Reserve Category signed off as an **A**. About 1 - 5% of the present flow regime may still be available for abstraction, but this figure will need to be verified.

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APPENDIX A: CAPACITY BUILDING

This Section of the report briefly discusses training opportunities provided during the GRDS study to DWS staff, as well as feedback from DWS staff regarding training opportunities offered.

A.1 BACKGROUND

Although listed as an objective in the Terms of Reference (TOR), the budgetary constraints imposed by the project did not allow for sufficient training opportunities. Training is therefore included as the participation of DWS trainees in workshops and field trips. All training opportunities presented focussed on DWS personnel from both the main and regional offices. Other trainees that attended workshops or field surveys did so at their own cost.

In addition to the attendance of field trips and workshops, three training sessions were undertaken.

Information sharing was also provided by circulating progress reports and extending invitations to attend meetings and workshops to the DWS Regional Office (RO) and the DWS CD: RDM Project Coordinator (Ms Machaba). Ms Machaba coordinated training events for DWS in liaison with Dr Scherman and Ms Wilna Kloppers and Dr Andrew Gordon from the Western Cape DWS RO.

The capacitation of stakeholders in the study area was undertaken through the inclusion of selected and invited individuals onto the Project Steering Committee, and two Stakeholder Meetings held at the beginning (October 2013) and end (October 2015) of the study. A Background Information Document (2013) and two progress reports (2014 and 2015) were also prepared.

A.2 IDENTIFIED DWS TRAINEES: 2013

The trainees that were identified at the beginning of the study, and identified specialist areas for which training has been identified are are indicated below:

Head office, DWS CD: Water Ecosystem personnell

Team member	Field of Training
Vuledzani Muthelo	Wetlands, macroinvertabes and hydrology
Gladys Makhado	Hydrology, hydraulics and estuaries
Happy Maleme	Estuaries, hydrodynamics and water quality (rivers and estuaries)
Thapelo Machaba	Hydrodynamics and water quality (rivers and estuaries
Lawrence Maluleke	Groundwater
Netshiendeulu Ndivhuwo	Groundwater
Khoza Philani	Groundwater
Kutama Rotondwa	Groundwater
Tichatonga Gonah	Groundwater

Western Cape Regional office personnell

Team member	Field of Training
Pumza Buwa	Estuary field survey
Richard Phaiphai	Estuary field survey
Xolelwa Bhele	Estuary field survey
Rafieka Johaar	Estuary field survey
Earl Herdien	River survey 1
Fezeka Daniel	River survey 1
Caroline Tlowana	River survey 1
Thembela Bushula	River survey 2
Andrew Gordon	River survey 2
Shaddai Daniel	Wetland survey

A.3 TRAINING OPPORTUNITIES

The table below shows training opportunites provided during the study - in the form of attendance of field surveys, specialist workshops and three training workshops held specifically for the GRDS. The agenda for each training workshop is attached as Appendix B of this report. Attendance registers were taken and are shown below.

GRDM CAPACITY BUILDING OPPORTUNITIES		ATTENDED BY
1. ESTUARIES		
Estuary field survey: Goukou, Duiwenhoks, Gouritz, Klein Brak, Wilderness, Keurbooms	3 to 9 December 2013	**DWS:** Gladys Makhado, Happy Maleme, Thapelo Machaba, Nolu Jafta. **Other attendees:** Nompumelelo Thwala (DEA), Alexis Olds (CapeNature), Corne Erasmus + Carlo Williamson (DAFF).
Estuary specialist workshop 1 (CSIR Stellenbosch): Duiwenhoks, Klein Brak, Touw/Wilderness, Hartenbos, Blinde, Groot, Piesang, Bloukrans	17 to 21 November 2014	**DWS:** Gladys Makhado, Happy Maleme, Thapelo Machaba, Nolu Jafta, Esther Lekalake, Gerhard Cilliers, Sibusiso Majola. **Other attendees:** Nompumelelo Thwala (DEA), Corne Erasmus (DAFF). Chantal Petersen, Christo Rautenbach, Hellen Mpe, Janine + Marileen (interns) (CSIR), Alexis Olds (CapeNature).
Estuary specialist workshop 2 (CSIR Stellenbosch): Goukou, Gouritz, Keurbooms, EcoSpecs and monitoring	16 to 29 January 2015	**DWS:** Gerhard Cilliers, Sibusiso Majola, Nolu Jafta, Wilna Kloppers, Thembela Bushula, Pumza Buwa, Thapelo Machaba, Barbara Weston. **Additional attendees:** Jean du Plessis + Alexis Olds (CapeNature), Chantel Petersen (CSIR), Angus Paterson (SAIAB: reveiwer/advisor), Jill Slinger (TU Delft).
2. RIVERS		
River field survey 1: Gouritz, Doring, Touws, Buffels, Gamka	8 to 12 April 2014	**DWS:** Thembela Bushula, Andrew Gordon, Earl Herdien, Fezeka Daniel, Caroline Tlowana, Gladys Makhado, Gloria Muthelo, Happy Maleme, Thapelo Machaba.
River field survey 2: Duiwenhoks, Kammanassie, Goukou, Olifants, Keurbooms	23 to 26 June 2014	**DWS:** Thembela Bushula, Andrew Gordon, Gladys Makhado, Gloria Muthelo, Happy Maleme, Thapelo Machaba. **Other attendees:** Khaya Mgaba + Nkosinathi Mazangula (IWR, Rhodes University).
River specialist workshop 1, Rapid sites (East London): Duiwenhoks, Doring, Goukou, Kammanassie	28 July to 1 August 2014	**DWS:** Thembela Bushula, Andrew Gordon. **Other attendees:** Khaya Mgaba + Mzwanele Mkatali (IWR, Rhodes University).
River specialist workshop 2, Intermediate sites (East London): Touws, Buffels, Gamka, Gouritz, Keurbooms	8 to 12 September 2014	**DWS:** Thembela Bushula, Andrew Gordon.

GRDM CAPACITY BUILDING OPPORTUNITIES		ATTENDED BY
3. GROUNDWATER		
Groundwater field survey	28 to 30 May 2014	**DWS:** Ndima Manelisi, Netshiendeulu Ndivhywo, Philani Khoza.
4. WETLANDS		
Wetlands field survey	17 to 19 December 2014	**DWS:** Vuledzani Muthelo, Shaddai Daniels, Manelisi Ndima.
5. TRAINING WORKSHOPS		
Workshop 1: Overview and River Reserve training (Belville DWS RO)	30 September 2014	**Resource Protection section:** Thembela Bushula, Bentley Engelbrecht, Graeme Williams, Poppy Bhele, Shaddai Daniel, Andrew Gordon, Pumza Buwa, Rafieka Johaar, Earl Herdien, Searle Korasie, Fezeka Daniel, Richard Phaiphai, Bheki Cele, Wilna Kloppers. **Berg section:** Neels du Buisson. **Gouritz section:** Bonelwa Mabovu, Nkosinathi Mkonto, Tshiliszi Manavhela, Hester Lyons. **Geo-hydrology section:** Vuyi Tumana. **BGCMA:** Zama Mbunquka. **RDM HO (SWRR):** Thapelo Machaba.
Workshop 2: Estuary and Wetland Reserve training (Belville DWS RO)	1 October 2014	
Workshop 3: Groundwater, Economics and Yield Modelling Reserve training (Belville DWS RO)	29 to 30 September 2015	See attendance register on next page

Vule and Gladys at the Duiwenhoks EWR site (June 2014)

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Gouritz Reserve Determination Study

Training Session 3: Groundwater, Economics and Yield Modelling

Spectrum Building, Bellville

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Busisiwa Matyolo	DW - WQ	matyolob@dws.gov.za		[signature]
Mashudu Murovhi	DWS: B/O Protocol	murovhim@dws.gov.za	—	[signature]

A.4 FEEDBACK ON CAPACITY BUILDING: OVERVIEW

This section of the appendix on Capacity Building includes feedback from DWS and was compiled by the Project Co-ordinator, Thapelo Machaba. Feedback from staff members involved in training follow in Sections A.5 to A.8.

A.4.1 INTRODUCTION

Capacity Building is defined as the planned development of knowledge, output rate, management, skills and other capabilities of an organization through acquisition, incentives, technology and/or training. Capacity Building must be well designed and executed in order to produce sustainable effects. It is only successful when built on a clear vision, a broad-based commitment and active stakeholder participation.

The DWS considered it fundamental that there should be a skills transfer and capacity building for its personnel as part of the GRDS. The departmental personnel included those personnel involved in the study project as well as personnel from the DWS Regional offices and the proto Catchment Management Agency (CMA; now the Breede-Gouritz CMA).

A.4.2 IMPORTANCE OF TRAINING THROUGH CAPACITY BUILDING AND SKILLS TRANSFER

Training presents a prime opportunity to expand the knowledge base of all employees within an organization. Although employees miss out on work time while attending training and capacity building sessions there is a long term benefits for both the organisation and the employees. Some of the identified benefits are outlined below in **Section A.4.2.1** to **A4.2.3**.

A.4.2.1Addressing weaknesses and skills shortage of employee

Most employees have some weaknesses in their workplace skills. A training programme allows them to strengthen those skills that each employee needs to improve. Providing the necessary training creates an overall knowledgeable staff with employees who can take over for one another as needed, work on teams or work independently without constant help and supervision from others.

A.4.2.2Improved employee performance

An employee who receives the necessary training is better able to perform his/her job. The training may also build the employee's confidence. The confidence may push the employees to perform even better and think of new ideas that help excel in their area of speciality. When the employees are well-skilled there will be reduction of the dependency of the Professional Service Provider’s (PSP) as the employees will be able to carry-out projects in-house.

A.4.2.3Employee satisfactio

The investment in training that an organisation makes shows the employees that they are valued. Training creates a supportive workplace. Employees who feel appreciated and challenged through training opportunities may experience a greater sence of work satisfaction and hence will stay longer in the company, assisting in building the company’s technical profile and reduce costly staff turnovers.

A.4.3 PROCESS OF TRAINING UNDERTAKEN DURING THE STUDY

During the Inception Phase relevant personnel were identified with their areas of interest for capacity building. The task of the PSP was to develop the capacity building programme and submit it to DWS for approval. The nominated officials were invited to actively participate in all the activities during the study programme. Capacity building opportunities offered are shown in **Section A3**.

A.4.4 GAPS IDENTIFIED

- No proper training programme was in place thus it was difficult to measure the effectiveness of the training provided.
- No proper direction from the Department on the requirements for the capacity building and skills transfer.
- Specific tasks were not given to the trainees and this resulted in trainees moving from one activity to the other without building up the required knowledge base and developing neccesary skills.
- Not sufficient time during the field surveys to train DWS personnell on how to use the instruments and explanation the interpretation of methodology used for assessment during the site surveys. This resulted in the objectives of the capacity building program not being met.
- The PSPs were concerned about their time schedule and meeting the deadlines, thus sufficient time to provide the requird “in depth” training was not provided for; and
- Due to budget constrains within the Department, the personnell were not able to attend the sequential activities as specified in the Reserve methodologies and that resulted in a gap in continued skills development at all levels.

A.4.5 EXPECTATIONS

- Proper measurable capacity building objectives and transfer of skills to DWS personnel.
- Knowledge sharing during the site surveys and the field surveys.
- DWS personnell to be able to carry out tasks related to the Intermediate Reserve Determination on their own.
- Practical application of the methodology for the Intermediate Reserve Determinations for the different types of water resources.
- DWS personnell to be able to use the skills acquired and knowledge to implement in their line functions such as in-house Rapid Reserve determination. The latter will also assist with the review of technical report and proposals for future Reserve studies.
- Dedicated capscity building “specialist” Workshops to be arranged. This time and budget must be build in properly in the proposal and the capacity building section should not be seen as an area where costs can be cut when required.
- Training workshops need to be designed specifically for training and conducted for that purpose, and not be squeezed in as part of the Specialist workshops, were the main aim is to reach deliverables within the time constraints provided. And hence the latter does not provide adequate time and opportunities for trainnees to ask questions and experiment with the models and method to internalise the information obtained. A basic assessment should be done as part of the capacity building program to assess to what extent the training has reached its objectives

and to provide management with the relevant information to implement corrective action where required.

A.4.6 CONTRIBUTIONS DURING THE FIELD SURVEYS AND/OR TRAINING WORKSHOPs

Attached as **Sections A.5 to A.8** are the contribution from the personnel who attended the training and the workshops.

A.4.7 RECOMMENDATIONS

- The TOR must clearly stipulate what it is that is epected from the client related to capacity building and skills transfer (Note from Technical Team Leader: A training budget should be allocated or assigned so training with clear deliverables can be conducted).
- The appointed PSP must commit to capacity building and skills transfer properly and not just add it on paper because it has been required as per the TOR.
- Clear capacity building programme with key indicators to be discussed and agreed upon between the appointed PSP and the DWS at the Inception Phase.
- A 360° assessment criteria should be drafted to evaluat the trainnees in terms of what has been learnt and assess the trainers to evaluate if they have complied with all their capacity building.
- Commitment from DWS trainees for the entire study programme.
- The trainees must be given relevant and applicable tasks during the study that could be implemented practical and to indicate that the information that was provided as part of the capacity building sessions have been internalised by the traiineed and implemented in their line functions.
- Support from DWS Management ensuring that capacity building takes place in terms of providing the time; and
- Trainnees must provide proper scientific feedback in the form of presentations and reports which will be used for their quarterly assessements.

A.4.8 CONCLUSION

With the high and growing skills shortage in South Africa training provides an opportunity to develop scarce skills and build capacity. Despite the potential drawbacks, training provides both the organisation as a whole and the individual employees with benefits that make the cost and time spent a worthwhile investment. For the DWS to improve its performance and service delivery, training through Capacity Building must form part of its strategic objectives.

A.5 FEEDBACK ON TRAINING: VULEDZANI MUTHELO

A.5.1 FIELD SURVEYS ATTENDED

- Estuary field survey and workshop: The estuary field survey was conducted from the 2 - 5 December 2013. Duiwenhoks, Goukou and Gouritz estuaries were assessed. Microalgae, invertebrates, and water quality samples were collected. The survey was useful and informative and all the critical aspects and protocols were explained by the specialists. The general workshop was held on 1 October 2014 in order to present on the estuary Reserve determination. Susan Taljaard and Lara van Niekerk presented on the procedures of Reserve determination for estuaries. The workshop was very informative and most of the gaps were identified. The specialist workshop on the field survey results was also held from 17 - 21 November 2014. Due to cost cutting measures one was able to attend for two days, i.e., 17 - 18 November 2014. The Ecoclassification results were presented for each estuary per specialist field.

- River field surveys and workshop: The first river survey for the Reserve determination study in the Gouritz WMA was held from 7 - 10^{h} of April 2014. The Gouritz, Doring and Touws rivers were assessed during the site visit. The second river survey was held on the 23rd to 26th June 2014. Duiwenhoks, Goukou, Kammanassie, Olifants and Keurbooms rivers were assessed. The surveys were conducted under the management of Delana Louw (Water for Africa). The PSP team that was involved in the field survey were:
  - Delana Louw- Hydrology and Hydraulics.
  - James Mackenzie – Riparian Vegetation assessments.
  - Dr Anton Bok – Fish assessments.
  - Dr Mandy Uys – Macroinvertebrates assessments.
- The general rivers workshop was held on 30 September 2014. General procedures on Reserve determination were presented and also according to each specialist field.

A.5.2 TRAINING AND CONTRIBUTIONS DURING FIELD SURVEYS ATTENDED

- SASS 5: During the two field surveys, SASS 5 and RHAM were conducted. The expectations from the PSPs were that a specialist will conduct the training with the people who are interested in that specific field to show how it is done. Samples were collected from three different types of habitats, i.e., vegetation, GSM (Gravel Sand Mud), and stones. Different types of species were identified and the results were recorded on the SASS sheet for further analysis and interpretation of data.
- RHAM: A stretch of a river is chosen and different types of flow (pool, riffle, rapids, run etc) are identified. A sketch is drawn to show how the reach looks like. The survey extended from bank to bank, and measurements are made at every metre (depending on the wideness of the river) incorporating all significant changes in slope along the profile. The depth and the flow are measured and the type of substrate is recorded.
- Diatom samples: Diatom samples were also collected for water quality assessments. This is done through scrapping the rocks from the river with a toothbrush. Then the samples are taken to the laboratory for analysis.

Some of the EWR sites surveyed:

Duiwenhoks EWR 1

Goukou EWR 2

Kammanassie EWR 10

Olifants EWR 9

A.5.3 WETLANDS FIELD SURVEY

The wetlands field survey was conducted from the 8th until the 10th of December 2014 and led by Mark Rountree. The Duiwenhoks, George Rex (alongside George Rex Drive in Knysna), and Bitou wetlands were assessed. The critical aspects that were assessed were Ecoclassification of the wetlands. The PES and EIS were assessed.

A.5.4 CHALLENGES AND RECOMMENDATIONS

- Cost cutting measures.
- The car we were driving was small (vivo 1.3) and we were driving for hours from one site to the other in a gravel road and in mountainous area. A 4X4 is required for field surveys as we always travel in remote areas.
- One of the challenges that have always been experienced when attending the capacity building with the PSPs is that the PSPs have little time with trainees to clearly explain concepts and allow trainees to conduct tasks themselves.
- During the workshop (rivers), some of the questions could not be addressed because one presenter presented all the special fields, instead of each presenting on their specific specialty field.

A.6 FEEDBACK ON TRAINING: ANDREW GORDON

Three training events were attended, which are described separately below. This report was dated December 2014.

A.6.1 SECOND GOURITZ RIVER SURVEY

Training undertaken / specialist field

General Reserve process used in the field and also applicability of RHAM.

Duration of the training

- 23 - 26 June 2014.

Expectations

- Applicability of RHAM in monitoring ecological Reserve compliance.

Contributions during the field survey / training

- Undertook RHAM at EWR sites.

Learning experiences

- Possible applications and weaknesses of RHAM in Reserve monitoring.

Gaps identified

- Limited opportunity to discuss Reserve determination methodology and subsequent Reserve monitoring approaches with experts.

Challenges

- Experts had little time available on the field visits to adequately provide detailed training in Reserve field methods.

Recommendations for future studies

- More time should be budgeted for experts on field visits to allow for more in-depth training.

A.6.2 SPECIALIST WORKSHOP FOR DETERMINATION OF INTERMEDIATE RESERVES FOR GOURTIZ SUB-WMA

Training undertaken / specialist field

- General Reserve determination process; contribution of fish and diatom components to the determination process.

Duration of the training

09 - 11 September 2014.

Expectations

To gain an understanding of how the biological components and ecosystem drivers are used to develop the ecological Reserve.

Contributions during the field survey / training

Participation.

Learning experiences

General, but superficial, understanding of Reserve determination process.

Gaps identified

Need for training to occur separate from the time allocated for experts to determine Reserves for EWR sites. In this case the focus would be on one EWR site and training would methodically proceed through the Reserve determination process regarding this site.

Challenges

The costs of budgeting for experts to allocate more time to provide more thorough training.

Recommendations for future studies

More time should be budgeted for expert's skills transference.

A.6.3 GOURTIZ RESERVE TRAINING WORKSHOP

Training undertaken / specialist field

General Reserve determination process.

Duration of the training

30 September – 01 October 2014.

Expectations
Overview of general Reserve determination process.

Contributions during the field survey / training
Participation.

Learning experiences
Increased understanding of the general Reserve determination process/

Gaps identified
Presence of less experienced regional Water and Sanitation officials meant that the Reserve process was not covered in great depth.

Challenges
As above.

Recommendations for future studies
Should be held earlier in the study so as to set the scene for the Reserve determination process.

A.7 FEEDBACK ON TRAINING: HAPPY KHUMALO

A.7.1 BACKGROUND TO THE STUDY

The NWA (Act No. 36 of 1998) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without seriously affecting the functioning of the natural environment. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources, including groundwater resources, through the determination and implementation of the Reserve for these resources.

The Reserve is one of a range of measures aimed at the ecological protection of water resources and the provision of basic human needs. The Reserve is defined in terms of the ecological water requirements of the resource and assurance of supply provided at a defined spatial and temporal distribution. This is needed to provide in basic human needs and to protect the template and functioning of ecosystems to ensure ecologically sustainable development and utilisation of a water resource.

The CD: WE is tasked with the responsibility to co-ordinate all Reserve determination studies. These studies include the surface water, groundwater, estuarine and wetland components of water resources. The Reserve have priority over other water uses in terms of the Act, and should be determined before license applications are processed, particularly in stressed and over utilised catchments.

A.7.2 OBJECTIVES

The following are the objectives this study was seeking to achieve in order to ensure capacity building of DWS staff, junior personnel and other Historically Disadvantaged Individuals (HDIs):

- The involvement of local specialists and other stakeholders e.g. Local Authority, Environmental Groups, etc. in the project. Through their participation, these groups will develop an understanding of water resource protection through the Reserve determination methodologies and its relevance. This will also assist in the enhancement of their understanding of the concepts of integrated water resource management and sustainable development;
- Participation of DWA officials (RQIS, RDM Chief Directorate, Western Cape Regional Office) will ensure active sharing of ideas and contribute to the broadening of the RDM skills base

A.7.3 DISCUSSIONS AND TRAINING ACTIVITIES

Estuary surveys

The Estuary survey was held 7 - 9 December 2013. The following water resources that were surveyed:

- Klein Brak
- Touw
- Wilderness

Contributions during the field survey / training

Assisted in sampling for the following components:

- Flow dynamics
- Sediments
- Water Quality

Challenges experienced

No challenges per se. The PSPs were willing to share information. It was quite an interesting experience sampling some of the variables assessed for determining the PES of an estuary.

Gaps identified

Running of models and interpretation of results.

River surveys

The first River survey was held during **7 - 10 April 2014**. The following water resources that were surveyed:

- EWR site 3- Touws,
- EWR site 6- Gouritz
- EWR site 7- Doring River

The second River survey was held during **23 - 26 June 2014**. The following water resources that were surveyed:

- Duiwenhoks
- Olifants
- Keurbooms
- Goukou
- Kammanassie

Contributions during the field surveys / training

- **RHAM:** RHAM is a process of collating relevant habitat information in a cost-effective manner for Ecological Water Requirements Monitoring. Although I didn't get the chance to be hands-on when measurements were taken, I however, got an opportunity to see how the measurements are being taken and recorded on the RHAM sheet and what to consider when doing so. Depth measurements are firstly taken from the either the left or the right edge of the channel to the other one. Depending on how broad the width of the channel is. For example, if the channel is 5m wide then 1m intervals can be considered. The stretch of a river that is selected must have different geomorphic habitats (riffles, pools and runs). Then using a plank facing upstream of the river, the maximum and minimum water level are recorded at a particular interval from one water edge to the other.

Gaps identified in RHAM

I would like to have an opportunity to participate on site but conducting measurements myself. I would also like understand how RHAM measurements link with hydraulics and subsequent modelling.

- **Macroinvertebrates assessment:** I did not do sampling for different biotopes. Assisted with the identification of macro-invertebrates sampled.

Challenges experienced

Most of the time, PSPs were running a race against time. DWS personnel did not get a chance to ask enough questions.

Reserve training

The Reserve training was held in Stellenbosch, Cape Town from 30 September -1 October 2014.

Expectations

The presentation was mainly on what the Reserve is according to the NWA and on which water resources the Reserve needs to be determined in order to sustain their health and integrity.

Rivers

Concepts that are known were mainly covered and I had expected to learn more about the interpretation of the Reserve results especially when it comes to the outputs of models used (e.g. the rule and tab table from SPATSIM) for Rivers.

Estuaries

I learnt a lot about the Estuary Reserve. Concepts such as how to determine the PES and the Ecological Importance of estuaries were thoroughly covered. I left with a better understanding of how the Reserve is determined.

Workshops

Estuaries EWR workshop was held at CSIR in Stellenbosch, Cape Town from the 20 - 21 November 2014.General discussions on various estuaries, including overviews of hydrological scenarios were covered. The Touws Estuary was discussed together with the desktop assessment of Hartenbos, Blinde, Groot (Wes), Piesangs and the Bloukrans estuaries.

Expectations

See Gaps identified under Section A.7.3.

A.7.4 GENERAL RECOMMENDATIONS FOR FUTURE STUDIES

- It must be clearly emphasized to the PSPs that capacity building (especially for DWS personnel) is equally as important as other activities in the study. Most of the time it seems as if DWS personnel are there as helpers. They did not make an effort of explaining thoroughly why is something done and how to actually go about doing it. As a result DWS personnel end up grabbing bits and pieces making it difficult to confidently say you have learnt something.
- DWS personnel to be capacitated must be involved from the beginning of the study to the end in order to achieve the objectives of capacity building. That includes *inter alia* attending meetings, attending workshops and field surveys. Attending field surveys from beginning to the end will give each person to grasp as much as possible since the same assessments are conducted at each site. Further to this, one would get an idea how the results to be obtained at the end correlate with what was observed on site.
- For field surveys, a person must identify an area of interest e.g. water quality, hydrology, wetlands studies etc. and he/she must shadow a specialist in the field every time surveys are done. This will ensure that persons are fully capacitated and they can come back and conduct similar assessments specialising in that particular area during in-house studies.
- Workshops are mainly conducted with results interpretations done already. PSPs should invite DWS personnel back at their offices when various models are being ran after sampling and when the results are interpreted. Whatever area one chose, there must be a continuation to results analysis and interpretation. This will enable DWS personnel to follow the various steps applied during the specialist workshops and also allow the trainees to ask questions of aspects that are not clear.
- The duration of training (e.g. one and half day) is not enough. Most of the time the facilitators are rushing through their presentations just to finish instead of explaining thoroughly to the attendees.

A.8 FEEDBACK ON TRAINING: GLADYS MAKHADO

Ms Makhado’s input is provided in tabular format – see next page.

	Estuaries Survey	First River Survey	Second River Survey
Date attended	7- 8 December 2013.	7 – 10 April 2014.	23 – 26 June 2014.
Activities	Three estuaries were assessed, i.e Klein Brak, Touw and Wilderness.	Three rivers where visited for assessment, i.e Touws, Gouritz and Doring.	Several rivers were assessed during this period, like; Duiwenhoks, Goukou, Kammanassie & Olifants.
Expectation/objective	To gain knowledge on estuaries and be able to do the survey.	To be able to conduct fish survey and be able to do it without the assistant of the PSP.	A specialist will conduct the training in that specific field to show how it is done and trainees will perform the function with the supervision of the specialist.
Knowledge gained	Involved in water quality sampling, that's where a syringe is used to collect water sample. Sediment sampling using a specific instrument that is dropped in the water to grab sediment. Once the sample was collected, it is taken to the laboratory to be analyzed.	Involved in fish assessment. This involved shocking, catching and identifying various fish species. Once the fish were captured they were identified and measured. Being exposed to this practical experience has provided me with the opportunity to learn how to hold the fish, to look for the specific characteristics to identify the fish with the help of a fish identification book.	Involved in RHAM and SASS. **RHAM** - Several cross-sections were made at the reach were the EWR site is found. These cross-sections are put in different types of flow (pool, riffle, rapids, run etc) in the reach. A sketch is drawn to show how the reach looks like. The survey extended from bank to bank, and measurements are made at certain interval depending on the width of the river. The depth and the flow were measured and the type of substrate recorded. **SASS** – This involve kicking the substrate with your feet and sweeping a finely meshed SASS net. Samples were collected from three different biotopes each; stones, vegetation and gravel sand and mud. Samples were then identified and recorded on the SASS sheet.
Challenges	No challenge, just that there'll be no involvement when specialists analyze the sample at the lab.	PSPs had little time with trainees to explain clearly the whole concept and to let trainees do the work.	Same as before especially in SASS.

	Reserve Workshop	Estuary Specialist Workshop
Date attended	30 September – 01 October 2014.	20 – 21 November 2014.
Activities	Specialists from the Gouritz Reserve study were presenting the different steps of the Reserve process related to Surface water (Wetlands, Rivers and Estuaries) and Groundwater.	The following estuaries were discussed: Touws, Hartenbos, Blinde, Groot (Wes), Piesangs and the Bloukrans estuaries.
Expectation/objective	To see if there is a difference between the ways the department determine the Reserve and the way the PSP determine the Reserve. Also to understand the process of determining a wetland Reserve.	Expectations - The running of models and the interpretation of the results collected from the estuary survey. I had limited contribution to this workshop, since i don't have much knowledge and experience in estuaries.
Knowledge gained	The expectations were met. The main objective of attending this training was to understand what parameters are assessed, how they interact to make up the PES and to understand how wetlands are assessed and score their importance in order to determine the REC.	The different discipline applied in a scoring system to score the present health of the estuary to determine the PES and assess the importance of the estuary to determine the REC of different estuaries.
Challenges	No challenge.	It would have been beneficial if the workshop was attended from the first day. This helps in understanding the introduction to the whole concept.

A.8.1 RECOMMENDATIONS

- Trainees must be allowed to be fully involved in the study, provided with the opportunity to attend all the components (estuary, rivers and wetlands) related to the Reserve studies and attend the site surveys and workshops from the first day till the end.
- The PSP must explain the process in detail when doing the assessment and allow the trainees to be able to practically perform the function.

APPENDIX B: TRAINING WORKSHOP AGENDAS

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

GOURITZ RESERVE DETERMINATION STUDY

TRAINING SESSIONS 1 AND 2

Aims: (1) General dissemination of information regarding Reserve process for rivers, estuaries and wetlands; (2) discussion around the use of Reserve data in Classification, and (2) disccussion regarding implementation and monitoring.

Learning outcomes: Training Sessions 1 and 2 will provide a general understanding of the process and methods used in the river, estuaries and wetland components of the Reserve.

Subject	Time	Time allocation (mins)	Presenter
SESSION 1, 30 September 2014: RESERVE PROCESS + RIVERS			
WELCOME + BACKGROUND	**10:30**	**5**	**PS**
1. PURPOSE OF THE RESERVE + PROCESS	**10:35**	**60**	**PS**
1.1 Steps of the Reserve process			
1.2 Levels of the Reserve + confidence			
1.3 Reserve, Classification + River RQOs			
		5 MIN BREAK	
1.4 Templates	**11:40**	**20**	**PS**
1.5 Monitoring + operationalization			
2. GOURITZ RESERVE DETERMINATION STUDY	**12:00**	**30**	**PS**
2.1 Progress to date			
2.2 Future activities			
	12:30	**30**	**LUNCH**
3. RIVERS	**13:00**	**90**	
3.1 EcoClassification: An introduction			**MU**
3.2 Hydrology + hydraulics			**MU**
3.3 Geomorphology			**PS**
3.4 Water quality + diatoms			**PS**
	14:30	**30**	**TEA**
3.5 Riparian vegetation	**15:00**	**60**	**MU**
3.6 Fish			
3.7 Macroinvertebrates			
CLOSURE	**16:00**		

SESSION 2, 1 October 2014: ESTUARIES + WETLANDS			
4. ESTUARIES	**09:00**	**60**	
4.1 An introduction to estuaries			**ST**
4.2 Delineation of estuary boundaries			**LvN**
4.3 Overview of EWR methods for Estuaries			**ST, LvN**
	11:00	**30**	**TEA**
4.4 Confidence of EWRs: Importance of long-term data sets	**11:30**	**60**	**LvN**
4.5 Linking EWRs to other uses in estuaries			
	12:30	**60**	**LUNCH**
5. WETLANDS	**13:30**	**90**	**MR**
5.1 Catchment overviews and wetland resource units			
5.2 Quaternary scale EcoStatus assessments of wetlands			
5.3 Priority wetlands within the WMA			
5.4 Field assessments of priority wetlands			
5.5 Wetland RQOs			
DISCUSSION + CLOSURE	**15:00**		**MR**

Presenters

PS: Patsy Scherman
MU: Mandy Uys
LvN: Lara van Niekerk
ST: Susan Taljaard
MR: Mark Rountree

3. YIELD MODELLING	**10:45**		**EvN/GdJ**
3.1 Basic principles of hydrology			
3.2 Hydrology and the Reserve			
		5 MIN BREAK	
3.3 Principles of yield modelling			
3.4 Examples of yield models			
3.5 Modelling questions, discussion points and closing comments			
DISCUSSION + CLOSURE	**12:55**		**TM**
	13:00		**LUNCH**

Presenters

TM: Thapelo Machaba, DWS
RG: Reuben Grobler, Exigo
WM: William Mullins, Conningarth
EvN: Estelle van Niekerk, AECOM
GdJ: Gerald de Jager, AECOM

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

GOURITZ RESERVE DETERMINATION STUDY			
TRAINING SESSION 3: GROUNDWATER, ECONOMICS + YIELD MODELLING			
Aims: (1) General dissemination of information regarding the following tasks which are currently undertaken as part of an Intermediate and Comprehensive Reserve process: Yield modelling and Economics; and (2) General dissemination of information regarding Reserve processes for groundwater, using the Gouritz study as an example.			
Learning outcomes: Training Session 3 will provide a general understanding of the process and methods used for groundwater, macro-economics and yield modelling as part of the Reserve process.			
Subject	**Time**	**Time allocation (mins)**	**Presenter**
SESSION 1+2, 29 September 2015: GROUNDWATER + AN INTRODUCTION TO ECONOMICS			
WELCOME + BACKGROUND	10:00	5	TM
1. GROUNDWATER	10:05		RG
1.1 Introduction to groundwater (GW) and the GW Reserve			
1.2 Thinking logically about components that use groundwater			
		5 MIN BREAK	
1.3 Groundwater balances, the Reserve & GRDM method			
	12:30	45	LUNCH
1.4 Integration of groundwater Reserve with other components	13:15		
1.5 GW Questions, discussion points and closing comments			
	14:30	30	TEA
2. ECONOMICS	15:00		WM
2.1 Difference between resource economics and macro-economics			
CLOSURE		16:00	
SESSION 2+3, 30 September 2015: ECONOMICS + YIELD MODELLING			
2. ECONOMICS cont.	09:00		WM
2.2 Principles of macro-economics: Opportunity costs			
2.3 Value of Water: Theoretical Approach and Practical Application			
2.4 Evaluation of Scenarios			
2.5 Economics questions, discussion points and closing comments			
	10:15	30	TEA

APPENDIX C: COMMENTS AND RESPONSE REGISTER

Section	Report Statement	Comments	Addressed in Report?	Author Comment
Comments: Barbara Weston – DWS, 8 December 2015				
Report		Grammar and syntax errors	Yes	Corrected.
Acronyms	Integrated Environmental Importance	Ecological importance or does this relate to the NFEPA if it refers to the PES/EI/ES then it is ecological.	No	IEI is derived by integrating the EIS, SCI and the PES. This is discussed in detail in the Desktop EcoClassification Report.
Figure 1.1		This map is not legible at all please increase the size so that it can printed on an otherwise it is pointless to put it in.		The map will be provided as an A3 figure.
Section 1.3	The manufacturing and transport sectors in that town are also supported by the harbour, which is important to the region as the only harbour in this WMA.	What about the economic contribution from the coastal towns ito property due to the amenity value of water either coastal view/location or next to estuaries. Wilderness, Knysna, Plet etc.	Yes	
Figure 1.2		Increase size.	Yes	
Section 1.3.3	Irrigation area The irrigation data used was obtained from a number of sources. The total irrigated hectares were sourced from Water Resources of South Africa, and the economic contribution was calculated using the Mosaka Economic Consultants internal database and production budgets updated to 2013 prices. The final areas were brought in line with the data received from the Water User Associations.	These different components must refer to a proper map especially when you refer to where it is and the % coverage the different economic activities take up like there should be a map related to for instance forestation that indicates the different types of forestation and the same for irrigation etc. Date of report. Is this a known economic term should we define this for the non-economic guys.	No	Maps: Tables (for example, Table 2.1) shows areas for a range of crops per ER as summarized information. The data was sourced from the WR2012 database, and not from mapped sources. Reference of economic term: All figures were sourced from an internal database (referred to as *Mosaka Economists internal database*) which are 2005 figures updated to 2013 prices for the GRDS assessment. This phrase therefore refers to the source of the data and is not an economic term.
Section 1.4.1		Include a comment on the BHN and the Water Quality aspect on how/what was considered.	Yes	Surface water BHNR line included. Note water quality was not assessed for BHNR, as not ever requested.
Table 1.4	Tourism	Does these bed numbers also include the investment made in house bought there for people planning to retire there or live there or is it counted as part of tourism?	Yes	Clarification added to indicate that bed nights refer to occupancy and tourism only.

Section	Report Statement	Comments	Addressed in Report?	Author Comment
Section 2.2 and 2.4		Include maps which indicate water resource and SCI importance.	No	These kinds of maps were not produced as part of the GRDS study as in these tables contribute directly to the Hotspot identification.
Section 2.5	K1 (Hartenbos, Klein Brak)	We have had various complaints of water quality being a major problem in this water resource due to the WWTs discharges into the river/estuary. It was also discussed at various PMC meetings were it not considered as a scenario as well in terms point source pollution.	No	Scenarios considered are large-scale developments, and not normally inputs of existing WWTWs. Water quality scenarios were never requested and therefore not considered as part of the scenario process.
2.5.5	K5 (Knysna catchment)	What about the dams/ weirs there that impact the base flow isn't it?	No	Although there are three streamflow gauging weirs in the Knysna River catchment (at the Gouna commonage (Gouna River), at the Millwood Forest (Knysna River) and at Charlesford (Knysna River)), and five registered dams (three farm dams and two municipal dams), reduced low flows (small change) are primarily due to forestry and not instream impediments.
2.5.8	There are no Category A or A/B SQs and only a single E Category (J12B-08656) reach are present.	What is this rivers name? And why?	Yes	It is an unnamed stream. Reasons for the E category are provided in the paragraph.
2.5.10	Water quality impacts from the return flows will also be severe.	The impacts are already severe based on the D/E category. What is the main water quality problem, nitrification??	No	Eutrophication exacerbated by low flows – see Rivers Rapid Report for a water quality assessment.
2.6		Provide hotspot map.	Yes	
		Where is the criteria that was used to get to the hotspot areas?	Yes	
Table 2.3	WRUI scores	Why is this only one to four and is the meaning the same as the 1-5 for IEI.	Yes	Added additional text.
Section 2.6 and 2.7		Why is the Bitou not included under List of rivers with hotspots?	Yes	The Desktop report indicated that the Bitou is a hotspot; however the impact of proposed dam will be felt in the estuary and wetland - no river assessment necessary. The Bitou wetland was identified as a priority.
Table 4.1	Highest scoring metrics in the EIS model were unique species (new record and distribution for *Redigobius dewaali*).	Why then a low importance if it is a new species and sensitive to change?	No	Not a new species, but new species distribution. Remember that not only fish is taken into consideration when determining the

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				EIS. Species sensitive to WQ change is PBUR.
Section 7		Refer to a map and a table with the estuaries addressed in this study.	Yes	A list of estuaries assed were included, however a map was excluded as the assessed estuaries are provided as part of the study area map – Figure 1.1. A Google map and co-ordinates are provided for each Estuary.
7.1.1	Instead a "best attainable" approach was …..	Where is this process/criteria explained	No	This is explained in the Duiwenhoks Estuary report. The main report focuses on results and not methodology per se.
7.6.2	Limited bait collection and fishing.	Limited fishing ?? Why is the Fish score so bad?/	Yes	Currently the Fish is in an E category.
7.6.2	Ecological Importance	There is a lot of repetition can't you put this statement that applies for all the estuaries just put it at the top of this section say it ones and refer to all the estuaries listed in a table.	Yes	Report has been amended as requested.
Table 7.27		The table does not match text.	Yes	
7.9.3		Replace REC with EMC	No	*Our understanding is that the term EMC (Estuary Management Class) and RQOs can only follow after classification. These sets of reports represent the preliminary* ***Ecological Water Requirements*** *on the estuaries where we set RECs, EcoSpecs and TPCs. We understand that DWS decision on "allocated ECs" is outside these sets of reports, i.e. DWS can override, but this stands as the preliminary EWR.*
Section 7.10.2	The NBA 2011 (Van Niekerk and Turpie, 2012) recommended that the Piesang Estuary be partially protected, and that 50% of the estuary margin be undeveloped.	Do we mean that there is still 50% that is current not developed and that we need to put a restriction on development or do we need to implement management action rehabilitate some of the areas that are in the estuarine zone so that our objective of 50% in the long-term can be met. Clarify.	Yes	Clarified.
	REC	Is there not an issue around the breaching of this mouth and that it should be done according to a proper breaching management plan. Has an EMP been developed for this estuary if not we need to recommend that.	No	EMPs / mouth management is not a DWS mandate. Therefore we are of the opinion that this issue does not fall within the setting of preliminary EWRs. This issue falls under the ICM Act with the DEA as implementer. That is why the Western Cape (DEAP) is busy with EMP roll outs which

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				include the Piesang Estuary and could include mouth management.
7.13.2	Referring to the estuarine importance rating system (DWAF, 2008), the importance score of the Bloukrans Estuary – a score of 51 – indicates that the estuary is of "Average importance".	Does the fact that it is in a national park not automatically > the importance status of the estuary, the gorges (habitat type) don't see why it is so low in importance.	Yes	Clarified.
Table 8.1		Refer to a map that shows the area with the highest concentration of people that are reliant on run off river water. Make a statement maybe about the estuaries that there is not really subsistence use there.	Yes	Maps included.
Comments: Andrew Gordon - DWS WC: Resource Protection, received 13 November 2015				
Report		Grammar and syntax errors.	Yes	Corrected.
Figure 2.1		ER4 and ER 5 are labelled incorrectly.	Yes	Map labels have been corrected.
Table 2.2		There is no figure for commercial forestry for ER 4 in Table 2.2. For consistency it would be good to have 27 square km converted to ha.	Yes	Text corrected.
3.5.8	Buffels and tributaries up to Floriskraal Dam: Most of these streams occur in mountainous areas and have low impacts. Overall, the PES of this area is in a Category B or higher, with only four of the 32 SQs in a C Category (Roggeveld and Buffels – J11F-08427 and J11F-08460).	Are these part of the four SQs in C category? But only 2 SQs and associate drivers are mentioned – it's a bit confusing.	Yes	
Table 5.1		The table on the right suggests the EcoStatus is a C? I checked Intermediate Reserve Report 10 and the same situation occurs there. If a change has to be made then it will need to be made in that report too.	Yes	
Table 7.3; 7.12; 7.20; 7.24	Description of Present Scenario.	Is this meant to say 2014 in order to represent present day? 2004 is also mentioned in Table 7.3 and 8.3, but no date is specified in Table 11.3 and 12.3.	Yes	The WR2005 base year is the year 2004. Therefore The Present Day Scenario is based on 2004 water use. Standardized the Present Day scenario description.
7.11.2	The PES of the Groot (Wes) Estuary - assessed in terms of the degree of similarity to	Table below indicates PES as B. Table 17.34 in next chapter lists PES as A/B. – Will probably	Yes	Corrected the report. This was a typo and the Estuary report is correct.

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	the reference condition for various abiotic and biotic components are presented in Table 7.30, resulting in an overall PES of Category C.	need to correct report DWS 2015d to ensure the correct PES and REC are reflected in that report too.		
7.11.2; 7.11.3	The REC was set as a Category A	In the next section the REC is listed as B.	Yes	Corrected report. This was a typo. Should be an A Category.
11.1		I found this explanation confusing and often repetitive. The Monitoring report gives a much better version of this text extract which I think should just be copy-and-pasted in here to replace the highlighted text.	Yes	Extract provided by reviewer was included in report.
Table 11.1	2. Institute bi-monthly monitoring at EWR sites with no water quality gauging weir in place.	Bimonthly usually means every two months (although sometimes used to mean twice monthly). What is meant in this instance? Best to be explicit in this regard.	Yes	Rephrased.
Comments: Thapelo Machaba – DWS: CD: SWRR, received 4 December 2015				
Report		Grammar and syntax errors.	Yes	Corrected.
Exec summary; Section 1.3.1	Provide CD: WE with the information required to prepare the Reserve templates, including draft templates, for authorization by the Director-General of the DWS.	Please note that the function has been delegated to CD:WE.	Yes	
Figure 1.1		Map is unclear.	Yes	A3 map now inserted.
Section 2		Is there any particular reason. Why the Report starts with the Economic Overview?	Yes	The report has been restructured. There is no particular reason why. However this is a component that was assessed and provides a good overview of the study area.
	Project Plan and Approach	I think this section should be the first one before the Economic section as it outlines the whole approach of the Project.	Yes	The report has been restructured to reflect this.
Table 6.2		Explain colour coding.	Yes	
Figure 10.2		Figure unclear.	Yes	Changed page set up to A3 and enlarged figure.
Chapter 12		I think this info is the duplication of the Sections/ Chapters above which makes the report to long. Is it not possible that the conclusion be added on the Chapters above including the signoff by DWS? And on this section indicate that the	No	One needs a Final chapter which summarises the results. This was a big study. A well written conclusion summarises the results and readers, looking for quick results can go directly to this chapter instead of wading

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		results were presented to DWS management and the Stakeholders.		through the report – especially if they were not part of the study and were not familiar with the associated study tasks. Presentation of results is stated in the first paragraph.
12.4.1 and 12.4.2 and other similar sections		There are inconsistencies on the information given for rivers, e.g. other system the PES is given but others not given but just indicating the EIS and the REC signed off. This Section has been discussed above i really think that it is not necessary to repeat this.	No	Once again a well written conclusion is essential. No inconsistencies were noted. Level of detail is provided based on the Reserve assessment level. Sites were done at Rapid and Intermediate levels so detail regarding information provided in the report would differ.
Comments: Aldu le Grange - AECOM SA (Pty) Ltd, received 11 November 2015				
Report		General editorial comments and suggested changes.	Yes	