
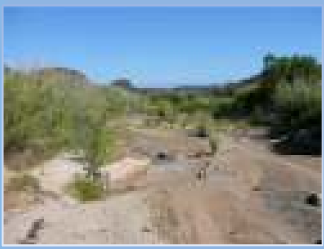



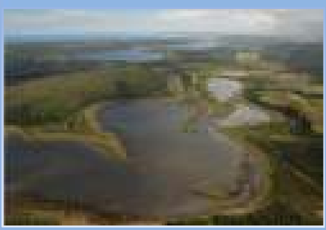
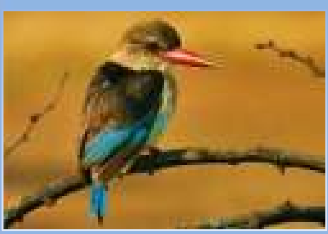

WP 10543

REPORT NO. RDM/WMA16/00/CON/0313, Volume 1

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

PROJECT TECHNICAL REPORT 3

DELINEATION REPORT, VOLUME 1

April 2014

Department of Water Affairs

Chief Directorate: Resource Directed Measures

Published by

Department of Water Affairs
Private Bag X313
PRETORIA, 0001
Republic of South Africa

Tel: +27 (12) 336 7500
Fax: +27 (12) 323 0321

This report should be cited as:

Department of Water Affairs (DWA), 2014. *Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area*: Delineation Report, Volume 1. Prepared by Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/0313, Volume 1.

Compiled by:
Scherman Colloty & Associates cc
22 Somerset Street
Grahamstown
6139

In association with:
AECOM SA (Pty) Ltd
Waterside Place
South Gate
Tyger Waterfront
Carl Cronje Drive
Bellville
7530

DOCUMENT INDEX

Reports as part of this project:

INDEX NUMBER	REPORT NUMBER	REPORT TITLE
Report Number 01	RDM/WMA16/00/CON/0113	Inception Report
Report Number 02	RDM/WMA16/00/CON/0213	Desktop EcoClassification Report
Report Number 03, Volume 1	**RDM/WMA16/00/CON/0313, Volume 1**	**Delineation Report, Volume 1 (Groundwater, Estuaries and Wetlands)**
Report Number 03, Volume 2	RDM/WMA16/00/CON/0313, Volume 2	Delineation Report, Volume 2 (Rivers)
Report Number 04	RDM/WMA16/02/CON/0413	Groundwater Report
Report Number 05	RDM/WMA16/03/CON/0513	Wetland Report
Report Number 06	RDM/WMA16/04/CON/0613	Estuaries RDM Report – Desktop Assessment
Report Number 07, Volume 1	RDM/WMA16/04/CON/0713, Volume 1	Estuaries RDM Report – Rapid Assessment, Volume 1 (Klein Brak Estuary)
Report Number 07, Volume 2	RDM/WMA16/04/CON/0713, Volume 2	Estuaries RDM Report – Rapid Assessment, Volume 2 (Wilderness System)
Report Number 08, Volume 1	RDM/WMA16/04/CON/0813, Volume 1	Estuaries RDM Report – Intermediate Assessment, Volume 1 (Duiwenhoks Estuary)
Report Number 08, Volume 2	RDM/WMA16/04/CON/0813, Volume 2	Estuaries RDM Report – Intermediate Assessment, Volume 2 (Gouritz Estuary)
Report Number 08, Volume 3	RDM/WMA16/04/CON/0813, Volume 3	Estuaries RDM Report – Intermediate Assessment, Volume 3 (Goukou Estuary)
Report Number 09	RDM/WMA16/00/CON/0913	Scenario Report
Report Number 10	RDM/WMA16/01/CON/1013	Rivers RDM Report – Intermediate Assessment
Report Number 11	RDM/WMA16/01/CON/1113	Rivers RDM Report – Rapid Assessment
Report Number 12	RDM/WMA16/00/CON/1213	Monitoring Report
Report Number 13	RDM/WMA16/00/CON/1313	Main Report

Bold indicates this report.

APPROVAL

TITLE:	Reserve Determination Studies for the Selected Surface Water, Groundwater, Estuaries and Wetlands in the Gouritz Water Management Area: Delineation Report, Volume 1
DATE:	April 2014
AUTHORS:	CSIR: Lara van Niekerk; AGES: Reuben Grobler and Koos Vivier; Fluvius Environmental Consultants: Mark Rountree
EDITOR:	Scherman Colloty & Associates
REVIEWERS:	Project Management Team
LEAD CONSULTANT:	Scherman Colloty & Associates
REPORT NO:	RDM/WMA16/00/CON/0313, Volume 1
FORMAT:	MSWord and PDF
WEB ADDRESS:	http://www.dwa.gov.za

Approved for Scherman Colloty & Associates cc:

Dr Patsy Scherman
Technical Team Leader

Approved for AECOM SA (Pty) Ltd:

Dr Aldu le Grange
Study Leader

Approved for the Department of Water Affairs by:

Ms Nancy Motebe
Deputy-Director: Groundwater
Reserve Requirements

Ms Barbara Weston
Deputy-Director: Surface Water
Reserve Requirements

Mr Yakeen Atwaru
Director: Reserve Requirements

Ms Ndileka Mohapi
Chief Director: Water Ecosystems

ACKNOWLEDGEMENTS

The following individuals are thanked for their contributions to this project:

Project Co-ordinators

Yakeen Atwaru	Department of Water Affairs	Project Director
Barbara Weston	Department of Water Affairs	Project Manager: Surface Water
Nancy Motebe	Department of Water Affairs	Project Manager: Groundwater
Thapelo Machaba	Department of Water Affairs	Project Co-ordinator

Project Management Team

Aldu le Grange	AECOM SA (Pty) Ltd	Professional Service Provider Study Leader
Patsy Scherman	Scherman, Colloty & Associates	Technical Study Team Leader
Simon von Witt	AECOM SA (Pty) Ltd	Professional Service Provider Study Co-ordinator

Members of Project Steering Committee

Names	Affiliation
Ndileka Mohapi	CD: Water Ecosystems (WE)
Yakeen Atwaru	D: Reserve Requirements (RR)
Barbara Weston	D: Surface Water Reserve Requirements (SWRR)
Nancy Motebe	D: Groundwater Reserve Requirements (GWRR)
Thapelo Machaba	D: SWRR
Vuledzani Muthelo	D: RR-SWRR
Gladys Makhado	D: RR
Happy Maleme	D: RR
Wietsche Roets	D: Water Abstraction and Instream Use
Shane Naidoo	D: Water Resources Classification
Vusi Mema	D: Resource Directed Measures Compliance (RDMC)
Boitumelo Sejamoholo	D: RDMC
Manelisi Ndima	D: GWRR
Isa Thompson	DWA: National Planning
Pieter Viljoen	DWA: Water Quality Planning
Mennard Mugumo	DWA: Options Analysis
Fanus Fourie	DWA: Planning Groundwater
Nadene Slabbert	DWA: Resource Quality Services (RQS)
Neels Kleynhans	DWA: RQS
Gerhard CillIers/Nolu Jafta	DWA: RQS
Rashid Khan	DWA Western Cape (WC): Regional Director
Wilna Kloppers	DWA WC: Resource Protection
Andrew Gordon	DWA WC: Resource Protection
Bertrand van Zyl	DWA WC: Operations
John Roberts/Hester Lyons	DWA WC: Gouritz Catchment Manager
Frans Mouski	DWA WC: Hydrology
Mike Smart	DWA WC: Geo-Hydrology
André Roux	Department of Agriculture Western Cape (DAWC)
Danie Swanepoel/ Francois Naude	Department of Environmental Affairs and Development Planning (DEADP)

Names	**Affiliation**
Ian Russell/ Dirk Roux	South African National Parks Board (SANParks)
Greg Palmer/ Andrew Turner/ Pierre de Villiers	CapeNature
Heidi Nieuwoudt	South African National Biodiversity Institute (SANBI)
Jannie van Staden	Breede Overberg Catchment Management Agency (BOCMA)
Vernon Gibbs-Halls	Eden District Municipality
Harold Basson	George Municipality
Alie Killian	Oudtshoorn Municipality
Roy Parry	Knysna Municipality
Johan du Preez	Mossel Bay Municipality
Pikkie Lombard	Bitou Municipality
Reggie Wesso	Hessequa Municipality
Louw Smit/Christopher Wright	Beaufort West Municipality
Richard Fransen/ Heinrich Mettler	Prince Albert Municipality
Jannie Venter	Laingsburg Municipality
Aldu le Grange	AECOM
Simon von Witt	AECOM
Patsy Scherman	SC&A
Cecilia Bester	Agricultural Research Council
Carl Opperman	Agri-Western Cape
Barry Levinrad	Department of Land Affairs
Alwyn Lubbe	Endangered Wildlife Trust
Connie Jonker	Jonkersberg Plantation
Ayanda Matoti	Marine and Coastal Management
Alan Boyd	Marine Protected Area and Estuary Management

AUTHORS

The following persons contributed to this report:

Authors	Company
Taljaard, Susan	CSIR
Grobler, Reuben	AGES
Vivier, Koos	AGES
Rountree, Mark	Fluvius Environmental Consultants

REPORT SCHEDULE

Version	Date
First draft	April 2014
Second draft	May 2014
Final draft	August 2014

EXECUTIVE SUMMARY

The National Water Act (Act No. 36 of 1998, Section 3)(NWA) 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 purpose of this report is to report on the delineation of resources in the study area, which is contained in the first two steps of the Reserve process. The Delineation Report is written as two volumes, with this document, Volume 1, covering groundwater, estuary and wetland delineation. Volume 2 will cover river delineation, and final river Ecological Water Requirement (EWR) sites will be presented. This report therefore covers the following:

- *Briefly describe the study area*
- *Define the groundwater Resource Units (RUs) and hotspots*
- *Define the wetland RUs*
- *Define the estuary RUs*

STUDY AREA

The study area encompasses the Gouritz Water Management Area 16 (WMA16), which 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.

GROUNDWATER

Fourteen Groundwater RUs and hotspots were selected for the hydrocensus and Intermediate Reserve determination to be conducted for the study. The RUs and hotspots need to be reviewed by the Department of Water Affairs (DWA) and finalised before field surveys at selected sites can be conducted. Other deliverables included in the groundwater section of the report are Rapid Reserve figures and Basic Human Needs outputs.

ESTUARIES

Twenty-one estuaries were delineated from the estuary mouth (downstream boundary) to the upstream boundary; and including the lateral boundary (5 metre contour above Mean Sea Level along each bank).

WETLANDS

The wetland study provides a description of the types of wetlands within the study area; and groups these into Wetland Resource Units (WRUs). The study builds upon the earlier work undertaken in selected coastal catchments of the Gouritz WMA (DWAF, 2009). The current study has been undertaken as a desktop-level assessment, relying on available information. Nine WRUs have been identified for the Gouritz WMA, viz.:

- *Nama Karoo*
- *Great Karoo*
- *Cape Fold Mountains (Swartberg)*
- *Klein Karoo*

- *South Cape Fold Mountains (Langeberg/Outeniqua ranges)*
- *South Coastal Belt*
- *South-East Coastal Belt*
- *Coastal Sediment Deposits, and*
- *Sedimentary Coastal Lakes unit.*

Field verification and descriptions of common wetland types, and threats and management recommendations, will be provided following a rapid assessment of the catchment in spring of 2014.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **vi**
TABLE OF CONTENTS ..... **viii**
LIST OF TABLES ..... **x**
LIST OF FIGURES ..... **xi**
ACRONYMS ..... **xiii**
GLOSSARY ..... **xiv**
1 INTRODUCTION **1-1**
1.1 PURPOSE OF THIS REPORT **1-1**
1.2 REPORT OUTLINE **1-2**
1.2.1 Study area (Section 2) *1-2*
1.2.2 Groundwater (Section 3) *1-2*
1.2.3 Estuaries (Section 4) *1-3*
1.2.4 Wetlands (Section 5) *1-3*
2 STUDY AREA **2-1**
3 GROUNDWATER **3-1**
3.1 INTRODUCTION **3-1**
3.2 METHODOLOGY **3-1**
3.2.1 Delineation approach *3-1*
3.2.2 Desktop study of existing literature *3-1*
3.2.3 Primary delineation: data comparison, GIS overlay analysis and catchments *3-2*
3.2.4 Geological and geohydrological resource unit delineation *3-2*
3.3 RESULTS **3-2**
3.3.1 Primary delineation: quaternary catchment rapid Reserve results *3-2*
3.3.2 Secondary delineation: Groundwater Resource Units (GRUs) based on geology *3-4*
3.3.3 Selected GRUs and hotspots for intermediate Reserve determination *3-8*
3.3.4 Acknowledgements *3-14*
3.3.5 Conclusions *3-14*
4 ESTUARIES **4-1**
4.1 INTRODUCTION **4-1**
4.2 INDIVIDUAL ESTUARY DELINEATION **4-2**
4.2.1 Duiwenhoks Estuary *4-2*
4.2.2 Goukou Estuary *4-3*
4.2.3 Gouritz Estuary *4-4*
4.2.4 Blinde Estuary *4-5*
4.2.5 Hartenbos Estuary *4-6*
4.2.6 Klein Brak Estuary *4-7*
4.2.7 Groot Brak Estuary *4-8*
4.2.8 Maalgate Estuary *4-9*
4.2.9 Gwaing Estuary *4-10*
4.2.10 Kaaimans Estuary *4-11*
4.2.11 Wilderness Estuarine Lake System Lakes *4-12*
4.2.12 Swartvlei Estuary *4-13*
4.2.13 Goukamma Estuary *4-14*
4.2.14 Knysna Estuary *4-15*
4.2.15 Noetsie Estuary *4-16*

4.2.16 Piesang Estuary 4-17
4.2.17 Keurbooms Estuary.. 4-18
4.2.18 Matjies Estuary... 4-19
4.2.19 Sout (Oos) Estuary... 4-20
4.2.20 Groot (Wes) Estuary.. 4-21
4.2.21 Bloukrans Estuary 4-22
5 WETLANDS 5-1
5.1 THE USE OF WETLAND RESOURCE UNITS... 5-1
5.2 OBJECTIVES OF THE STUDY.. 5-2
5.3 STUDY AREA 5-3
5.4 METHODS 5-12
5.5 PRIORITY WETLANDS IN THE GOURITZ WMA 5-12
5.6 WETLANDS IN THE STUDY AREA 5-14
5.6.1 General 5-14
5.6.2 Wetland Resource Units.. 5-14
5.6.3 Application of the data 5-17
6 REFERENCES.. 6-1
APPENDIX A: WETLAND TYPING/CLASSIFICATION A-1
APPENDIX B: PRIORITISATION PROCESS FOR SOUTHERN CAPE WETLANDS B-1
APPENDIX C: COMMENTS AND RESPONSE REGISTER....................................... C-1

LIST OF TABLES

Table 3.1: Summary table of geology, hydrogeology and groundwater resource units (GRUs) based on geology 3-6
Table 3.2: Initial groundwater hot spots – public stakeholder meeting October 2013 3-8
Table 3.3: All town reconciliation strategies: towns with higher risk of water supply failure 3-9
Table 3.4: Final list of WULAs and groundwater hot spots 3-13
Table 3.5: Final select quaternary catchments for intermediate Reserve 3-13
Table 4.1: RDM status of estuaries in WMA16 (as at 2011) 4-1
Table 5.1 HGM wetland types expected to be associated with the different Wetland Resource Units 5-16

LIST OF FIGURES

Figure 2.1: Map of WMA16 2-3
Figure 3.1: GRA2 data, new GRDM rapid Reserve and hot spots (preliminary) 3-3
Figure 3.2: Geological map showing the major groups, subgroups and formations underlying the Gouritz WMA 3-5
Figure 3.3: Groundwater Resource Units (GRUs) delineated based on geology shown in grouped colours 3-7
Figure 3.4: Example of one of the groundwater hot spots, namely Waboomskraal area which was delineated based on watersheds 3-11
Figure 3.5: Final selection of quaternary catchments for GRU delineation with GIS layers of interest 3-12
Figure 4.1: Geographical boundaries of the Duiwenhoks Estuary 4-2
Figure 4.2: Geographical boundaries of the Goukou Estuary 4-3
Figure 4.3: Geographical boundaries of the Gouritz Estuary 4-4
Figure 4.4: Geographical boundaries of the Blinde Estuary 4-5
Figure 4.5: Geographical boundaries of the Hartenbos Estuary 4-6
Figure 4.6: Geographical boundaries of the Klein Brak Estuary 4-7
Figure 4.7: Geographical boundaries of the Groot Brak Estuary 4-8
Figure 4.8: Geographical boundaries of the Maalgate Estuary 4-9
Figure 4.9: Geographical boundaries of the Gwaing Estuary 4-10
Figure 4.10: Geographical boundaries of the Kaaimans Estuary 4-11
Figure 4.11: Geographical boundaries of the Wilderness Estuarine lake system 4-12
Figure 4.12: Geographical boundaries of the Swartvlei Estuary 4-13
Figure 4.13: Geographical boundaries of the Goukamma Estuary 4-14
Figure 4.14: Geographical boundaries of the Knysna Estuary 4-15
Figure 4.15: Geographical boundaries of the Noetsie Estuary 4-16
Figure 4.16: Geographical boundaries of the Piesang Estuary 4-17
Figure 4.17: Geographical boundaries of the Keurbooms Estuary 4-18
Figure 4.18: Geographical boundaries of the Matjies Estuary 4-19
Figure 4.19: Geographical boundaries of the Sout (Oos) Estuary 4-20
Figure 4.20: Geographical boundaries of the Groot (Wes) Estuary 4-21
Figure 4.21: Geographical boundaries of the Bloukrans Estuary 4-22
Figure 5.1: The secondary catchments of the study area 5-5
Figure 5.2: Level I EcoRegions within the study area (after Kleynhans *et al*., 2005) 5-6
Figure 5.3: Level II EcoRegions within the study area (after Kleynhans *et al*., 2005) 5-7
Figure 5.4: The underlying broad-scale geology of the study area (geology information provided by DWA) 5-8
Figure 5.5: The extent and density of wetlands across the study area (displayed as blue/black dots and patches), as indicated by the SANBI Wetlands Probability Layer (SANBI, unpublished) 5-9
Figure 5.6: The extent and density of wetlands across the study area (displayed as blue/black dots and patches), as indicated by the SANBI FEPA wetland layer (Driver *et al*., 2011) 5-10

Figure 5.7: The extent and density of Level 1 FEPA (conservation priority) wetlands across the study area (Driver *et al.*, 2011)....5-11

ACRONYMS

AGES	Africa Geo-Environmental Services
AIP	Alien Invasive Plant
BHN	Basic Human Needs
CD: RDM	Chief Directorate: Resource Directed Measures
CMA	Catchment Management Agency
CSIR	Council for Scientific and Industrial Research
DAGEOS	Deep Artesian Groundwater Exploration for Oudtshoorn Supply
DM	District Municipality
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
FEPA	Freshwater Ecosystem Priority Areas
GIS	Global Information System
GRA2	Groundwater Resource Assessment Phase 2
GRDM	Groundwater Reserve Determination Methodology
GRDS	Gouritz Reserve Determination Study
GRUs	Groundwater Resource Units
GYMR	Groundwater Yield Model for the Reserve
ha	hectare
HGM	Hydrogeomorphic
k	permeability
K	hydraulic conductivity
KKRWSS	Klein Karoo Water Supply System
MAR	Mean Annual Runoff
MPA	Marine Protected Area
NSBA	National Spatial Biodiversity Assessment
NWA	National Water Act
ORDS	Outeniqua Reserve Determination Study
PES	Present Ecological State
RDM	Resource Directed Meaures
REC	Recommended Ecological Category
RU	Resource Unit
SANBI	South African National Biodiversity Institute
SC&A	Scherman Colloty and Associates
T	Transmissivity (m^2/d)
TMG	Table Mountain Group
WfWetlands	Working for Wetlands
WMA	Water Management Area
WPM	Wetland probability map
WR2005	Water Resources of South Africa, 2005 Study
WRUs	Wetland Resource Units
WULA	Water Use Licence Application(s)

GLOSSARY

Colluvium is a loose deposit of rock debris accumulated through the action of gravity at the base of a cliff or slope - non-fluvial (non-riverine) derived material.

EcoRegions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources, and are designed to serve as a spatial framework for the research, assessment, management and monitoring of ecosystems and ecosystem components. Several levels or scales of EcoRegions can be delineated (e.g. Level I low resolution/detail; Level III high resolution and detail). In South Africa, EcoRegions form the basis of the River Health monitoring assessments with Level II delineations available for use.

EcoStatus is the overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component EcoStatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

Endorheic means internally draining (e.g, most pans on the Highveld).

Floodplain refers to an inundated riparian zone – caused when a river overtops its banks during flood events. In areas where the soils are saturated or inundated for prolonged periods, longitudinal or riparian wetlands within the floodplain can develop.

Exorheic, referring to externally draining water bodies that have one or more points of outflow. Most lakes are exorheic, having some throughflow that prevents the accumulation of salts.

Gley is a soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but mottles (yellow, red, brown and black) may be present and indicate localised areas of better aeration.

Groundwater is subsurface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric pressure.

Groundwater table is the upper limit of the groundwater.

Hydric soil is soil that is saturated or flooded long enough during the growing season to develop anoxic conditions, which favour the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils).

Hydrogeomorphic refers to particular wetland typing ("classification") methods based on the landscape (morphological) setting and hydrological characteristics of different wetland types.

A ***HydroGeomorphic (HGM) Unit*** is a single "reach", segment or unit of a particular type of HGM wetland type.

Interflow relates to water moving downslope through the soil profile (i.e. below the surface, but not yet deep enough to be considered as true groundwater). This can be perched flows (where flows in the soil create locally perched water tables due to impervious layers in the soil or geology preventing seepage to deeper groundwater aquifers).

Lacustrine systems (e.g. lakes and dams) are wetlands that are situated in a topographic depression or a dammed river channel, have a total area greater than 8 ha and surface area coverage by mosses, lichens, trees, shrubs or persistent emergents of less than 30%.

Mottles are soils with variegated colour patters, described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles.

Palustrine (wetland) are all non-tidal wetlands dominated by persistent emergent plants (e.g. reeds) emergent mosses or lichens, or shrubs or trees (see Cowardin *et al*., 1979).

Peat is a brownish-black organic soil that is formed in acidic, anaerobic wetland conditions. It is composed mainly of partially-decomposed, loosely compacted organic matter with more than 50% carbon. The 50% carbon content is mostly applicable for the sphagnum peat moss peat deposits in the Northern Hemisphere. The South African soil classification uses a > 10% carbon content as a guideline. Inorganic soil particles are blown or washed into peatlands and also form part of the peat.

Perched water table is the upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater.

Plinthite is a redoximophic feature in highly weathered soil, generally occurring in a soil horizon that is saturated with water for some time during the year, and usually forms an impervious layer in the soil horizons. Plinthite changes irreversibly to an ironstone hardpan or to irregular soil aggregates on exposure to repeated wetting and drying. After such irreversible hardening, it is called ironstone.

Present Ecological State is a term for the current ecological condition of the resource. This is assessed relative to the deviation from the Reference State.

Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development.

Riparian includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas.

Seasonally wet soil is soil which is flooded or waterlogged to the soil surface for extended periods (>1 month) during the wet season, but is predominantly dry during the dry season.

Temporarily wet soil is the soil close to the soil surface (i.e. within 50 cm) which is wet for periods > 2 weeks during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.

Wetland delineation is the determination and marking of the boundary of a wetland on a map. The DWAF (2005b) guidelines should be employed to undertake this for field application.

A ***Wetland Resource Unit*** is an area of a catchment which has wetlands with similar characteristics, processes and also broadly similar sensitivities to particular developments and impacts.

Wetland in this report refers to the definition provided in the National Water Act; referring to "land that is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil" (National Water Act, Act 36 of 1998).

1 INTRODUCTION

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). The Chief Directorate: Resources Directed Measures (CD: RDM) within DWA 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 have been identified as part of the Outeniqua Reserve determination 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.

1.1 PURPOSE OF THIS REPORT

The purpose of this report is to report on the delineation of resources in the study area, which is contained in the first two steps of the Reserve process (as shown in **Figure 1.1**). The Delineation Report is written as two volumes, with this document, Volume 1, covering groundwater, estuary and wetland delineation. Note that Volume 1 for the groundwater component follows the most recent methods (Dennis *et al*., 2012), which includes delineation at a number of levels. Additional groundwater outputs include estimates of Rapid Reserves, hotspots and Basic Human Needs (BHN). Volume 2 will cover river delineation, and the location of final river Ecological Water Requirement (EWR) sites will be presented.

The purpose of this report is therefore to:

- briefly describe the study area,
- define the groundwater Resource Units (RUs) and associated deliverables,
- define the estuary RUs, and
- define the wetland RUs.

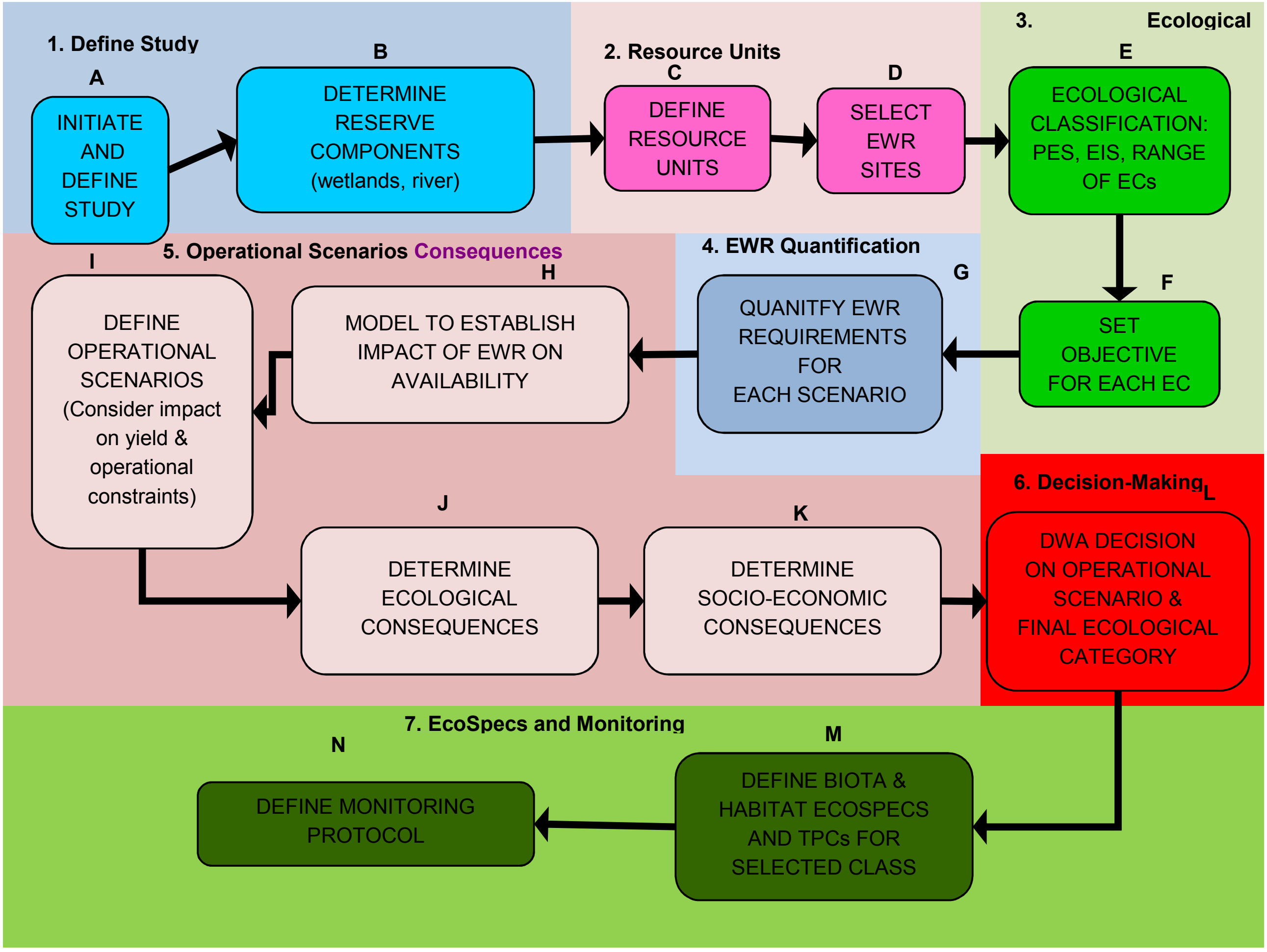

Figure 1.1: The Reserve process

1.2 REPORT OUTLINE

This report combines various aspects that relate to delineation of the RUs selection. The sections are summarised as follows:

1.2.1 Study area (Section 2)

This section provides an overview of the study area, namely the Gouritz WMA.

1.2.2 Groundwater (Section 3)

The groundwater RU delineation for the Gouritz WMA was done at a Desktop/Rapid level. This section provides detail on aquifer types and their groundwater potential and groundwater priority areas which formed the basis for groundwater delineation. Summary results are provided in map and table format.

1.2.3 Estuaries (Section 4)

Twenty-one estuaries were delineated from the estuary mouth (downstream boundary) to the upstream boundary; and including the lateral boundary (5 metre contour above Mean Sea Level along each bank). The results are provided in map format.

1.2.4 Wetlands (Section 5)

The wetland study provides a description of the types of wetlands within the study area; and groups these into Wetland Resource Units (WRUs). The study builds upon the earlier work undertaken in selected coastal catchments of the Gouritz WMA (DWAF, 2009). The current study has been undertaken as a desktop-level assessment, relying on available information. Nine WRUs have been identified for the Gouritz WMA, viz.:

- Nama Karoo
- Great Karoo
- Cape Fold Mountains (Swartberg)
- Klein Karoo
- South Cape Fold Mountains (Langeberg/Outeniqua ranges)
- South Coastal Belt
- South-East Coastal Belt
- Coastal Sediment Deposits, and
- Sedimentary Coastal Lakes unit.

Field verification and descriptions of common wetland types, and threats and management recommendations, will be provided following a rapid assessment of the catchment in spring of 2014.

2 STUDY AREA

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 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.

According to DWAF (2005a) regarding setting up a Catchment Management Agency (CMA) for the WMA, the area consists of five sub-areas, i.e. the (1) Groot River (secondary catchment J1), (2) the Gamka River (secondary catchment J2), (3) the Olifants River (secondary catchment J3), (4) the Western Coastal Rivers (secondary catchments H8, H9 and J4) and (5) the Eastern Coastal Rivers (Secondary Catchments K1, K2, K3, K4, K5, K6 and K7) (**Figure 2.1**).

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, 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.

Groundwater is of major importance as a source of water supply in the Gouritz WMA, particularly in the drier inland region where more than half of the water used in some sub-areas is abstracted from groundwater. Groundwater is the primary source of water for rural domestic supplies and stock watering, as well as for several towns. Most of the groundwater abstracted in the Gamka and Groot sub-areas, as well as a sizeable portion in the Olifants sub-area, is used for irrigation. Indications of overexploitation of groundwater has in the past been noted in the vicinity of Leeu Gamka Dam, with heavy utilisation of the resource in the Olifants River catchment. Little use is made of groundwater along the high rainfall coastal strip.

Limited verified information is available about the aquifer characteristics and the extent of inter-dependence between groundwater and surface water flows (including possible recharge by irrigation return flows). However, indications are that significant quantities of water could be abstracted from the deep, often confined, fractured rock aquifers of the Table Mountain Group (TMG) geological formations. These aquifers, which also extend westward to adjacent water management areas, drain directly to the ocean and have less connectivity to surface flows than the shallower aquifers. Refer to **Section 3**.

The study area includes 21 **estuaries** as indicated in **Section 4**.

Wetland delineation is discussed in **Section 5**.

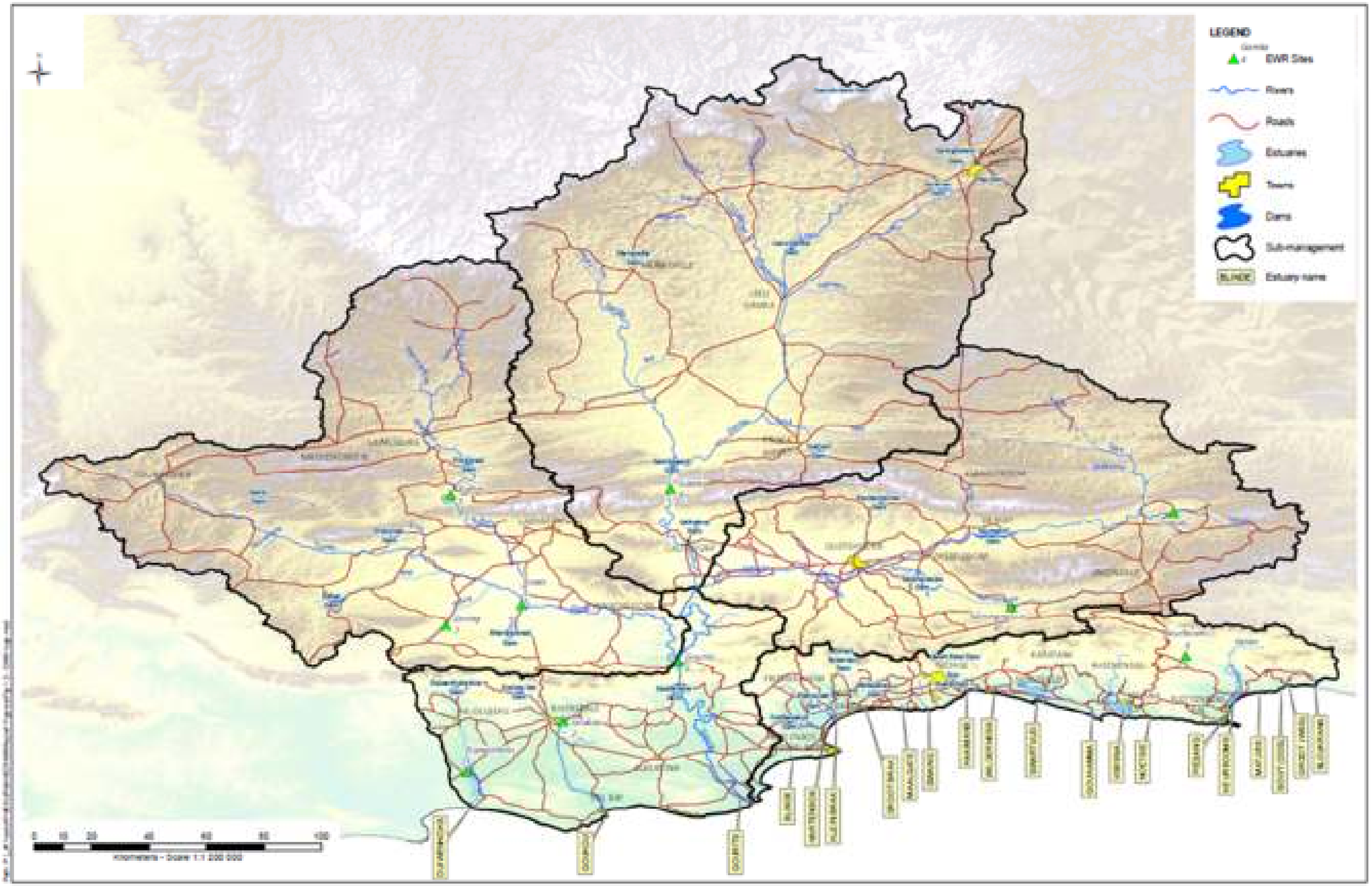

Figure 2.1: Map of WMA16

3 GROUNDWATER

3.1 INTRODUCTION

To provide more detailed groundwater Reserve determination assessments on selected/priority groundwater resource units (GRUs), a selection and delineation process is required. This section reports on the methodology followed, data used and results obtained from the selection of priority/hot spot locations for hydrocensus as well as determining selected GRUs.

3.2 METHODOLOGY

3.2.1 Delineation approach

There are two main approaches to GRU delineation:

- Surface water and watershed boundaries: This is the primary unit of analysis based on the most recent version of the Groundwater Resource Directed Measures manual since groundwater must also be considered in terms of an integrated water resource (Dennis *et al.*, 2012). Following this approach, it is important to make provision for the main geohydrological zones within the quaternary catchment as recharge can change substantially based on the geohydrology.
- GRU boundaries based on the geology and geohydrology: This approach assumes that hydraulic head (groundwater) follows the zones in the geology. Boundaries are thus based on contacts between the different geological formations/closed faults and differences between the permeabilities (k) / hydraulic conductivities (K) of the strata.

Most ideal is a combination of both approaches as well as taking possible groundwater hot spots into account. In most shallow aquifer cases, hydraulic head follows topography and as such the use of watersheds as GRU boundaries is acceptable. To this end, quaternary catchment boundaries are well suited for the purpose. The advantage of using the surface water boundary approach is that important input data such as rainfall, base flow, etc., is available from the WR2005/Groundwater Resource Assessment Phase 2 (GRA2) data sets. The GRU approach has an important disadvantage in that the inflows and outflows between different GRUs are not easily quantifiable on the scale of the assessment.

A three step delineation process was followed as described in the Outeniqua Reserve Determination Study (ORDS; DWA, 2010a) and the new Groundwater Reserve Determination Method (GRDM) manual (Dennis *et al.*, 2012).

3.2.2 Desktop study of existing literature

A desktop study of existing literature was performed to evaluate and obtain good first estimates of the inflow and outflow components as well as desktop/rapid level Reserves in the Gouritz WMA, based on a quaternary catchment and GRU approach.

Results from the ORDS groundwater study (DWA, 2010a) that obtained Reserve results for 19 quaternary catchments within the Gouritz WMA, were directly incorporated. The Reserve determined for the Peninsula Formation confined aquifer used in the Deep Artesian Groundwater Exploration for Oudtshoorn Supply (DAGEOS) project by Riemann and Blake (2010) was taken into account, with the results showing that the deep confined aquifer is unstressed according to the GRDM approach. The Reserve for the unconfined aquifer within the quaternary catchments above the confined aquifer is also important and these quaternary catchments have been flagged.

3.2.3 Primary delineation: data comparison, GIS overlay analysis and catchments

After evaluation of existing literature and data, a desktop/ rapid level Reserve was performed for the Gouritz WMA using primarily the Groundwater Resource Assessment Phase 2 (GRA2) raster datasets and the new GRDM software database. Vector overlay and raster extraction of the GRA2 data was performed and compared to the new GRDM software database reference values for flow balance components such as recharge, baseflow and groundwater abstraction.

Data from the newly improved GRDM (Dennis *et al.*, 2012) and GRA2 (DWA, 2006) was used to determine the groundwater use, recharge, Ecological Water Requirements (EWR) and Basic Human Needs (BHN) per quaternary catchment. EWR was assumed to be 60% of baseflow.

The recently completed National Spatial Biodiversity Assessment (NSBA) of formally protected areas GIS layer for the country was obtained from the South African National Biodiversity Institute (SANBI) website. Formally protected areas enjoy protection against any further abstraction as well as any reduction in baseflow, thus they cannot be included in further calculations of allocable groundwater. The formally protected areas were subtracted from the quaternary catchment areas and effective areas for the rapid Reserve determination obtained. Recharge and baseflows were scaled based on the new effective area.

These results were used in conjunction with known problem areas (as stated during October 2013 stakeholder meeting) as well as Reserve studies already performed in the Gouritz WMA, to identify groundwater hot spots and selected/priority GRUs.

3.2.4 Geological and geohydrological resource unit delineation

This methodology as mentioned is based on geological contacts between lithologically different rock types as well as major faults and other structural features. The methodology, as described in the new GRDM manual (Dennis *et al.*, 2012), and the ORDS groundwater study (DWA, 2010) was followed.

3.3 RESULTS

3.3.1 Primary delineation: quaternary catchment rapid Reserve results

Results from the evaluation of town hot spots and preliminary problem catchments are graphically portrayed and summarised in **Figure 3.1**.

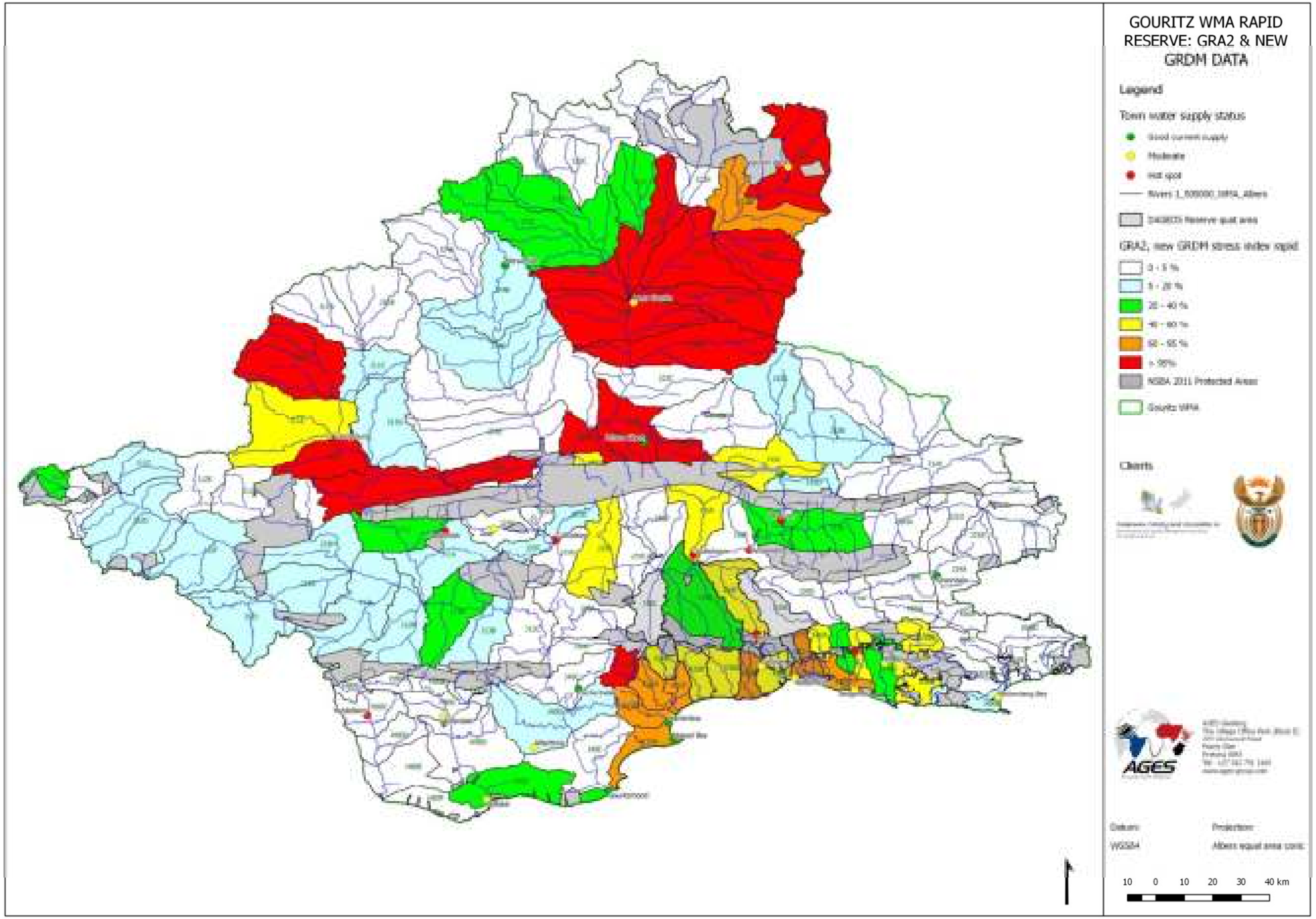

Figure 3.1: GRA2 data, new GRDM rapid Reserve and hot spots (preliminary)

Selection of final GRUs for intermediate GYMR and Goldsim Reserve determinations are based on known problematic or sensitive areas (hot spots), problematic rapid Reserves (stress index > 60%) and less to no groundwater availability after the Reserve has been taken into account.

Hot spots and selected GRUs are described in **Section 0**.

3.3.2 Secondary delineation: Groundwater Resource Units (GRUs) based on geology

The map in **Figure 3.2** below represents the geology of the study area at an appropriate scale, i.e. 1: 1000 000. For the intermediate Reserve and for priority areas 1: 250 000 geology can be digitized which is currently the highest resolution geological data available in raster format, without going to site and manually mapping geology.

Aquifers can be classified according to the lithological character of a group of formations as well as the transmissivity (T) of the formations or larger groups of formations. Within the Gouritz WMA study area, some geological units have already been defined as aquifers and aquitards in the ORDS (DWA, 2010a) as well as the Outeniqua Coast Water Situation Study (DWA, 2006b).

Table 3.1 describes the geology based grouping and basic GRU delineation with details of geological formations, groups and subgroups as well as lithology. Aquifer classification is also provided according to Parsons (1995).

Figure 3.3 provides a map of the basic delineation of the different aquifer types and main groundwater resource units in the study area based on geology. Colours show how the main geological units have been grouped.

The confined aquifer associated with the Peninsula Formation of the Table Mountain Group is delineated as a GRU based on geological boundaries for comparison with the Reserve and balances of the quaternary catchments it underlies.

The final quaternary catchments selected as GRUs for intermediate groundwater Reserve determination as well as geology defined GRUs are discussed in **Section 3.3.3**.

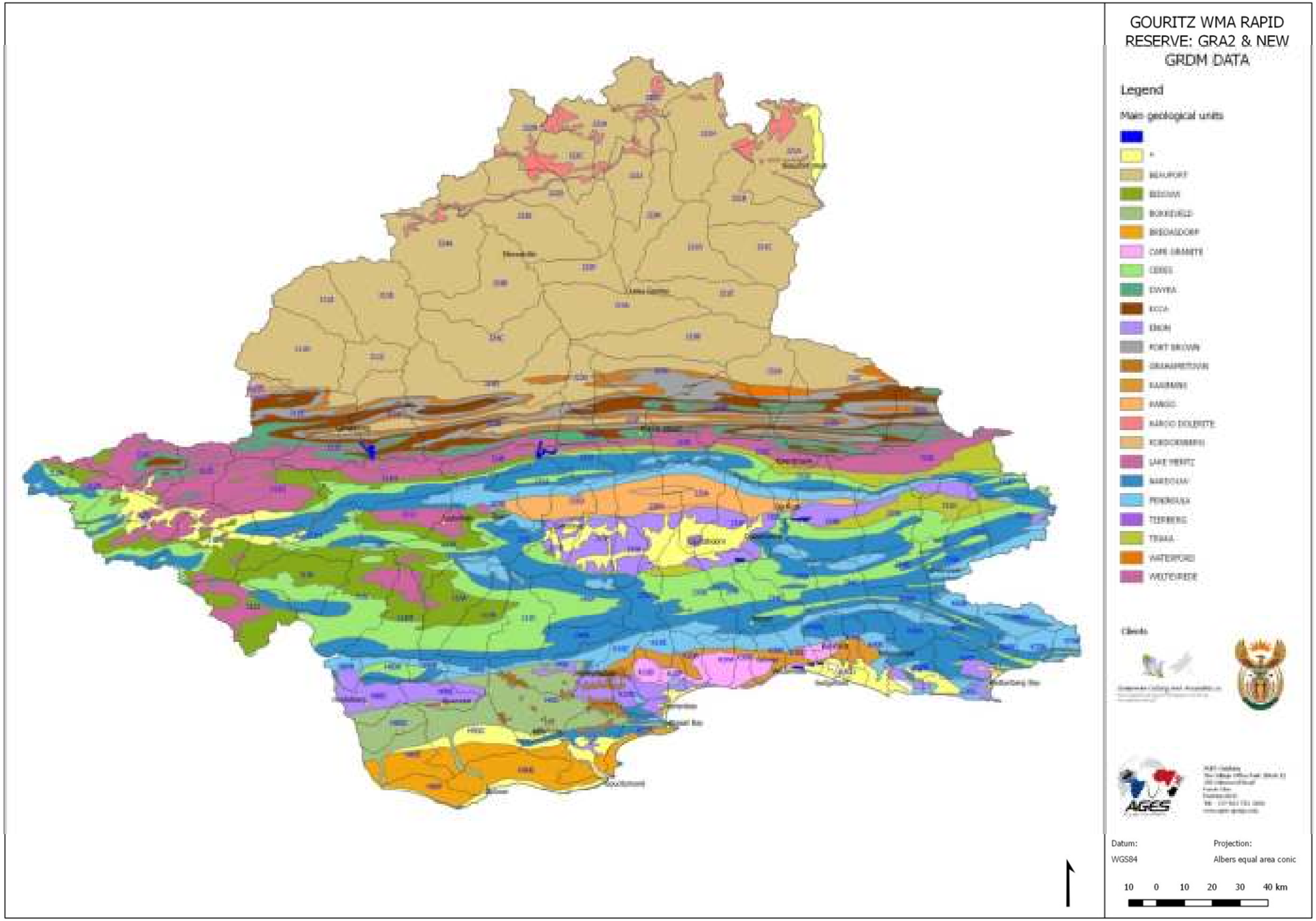

Figure 3.2: Geological map showing the major groups, subgroups and formations underlying the Gouritz WMA

Table 3.1: Summary table of geology, hydrogeology and groundwater resource units (GRUs) based on geology

Main Unit	Aquifer type	Unit in map	Lithology	GRU	Comments
Alluvium	Major	Alluvium	Coastal sands, quaternary sediments	GRU2b	The updated regional scale geology map shows larger areas of porous/ intergranular aquifers, but thickness is unknown and critical to sustainability
Bredasdorp Group	Major	Bredasdorp	Conglomerate, shelly limestones, calcarenites and calcrete	GRU2a	Essentially regarded as coastal aquifers
Grahamstown Fm	Minor	Grahamstown Fm	Silcrete	GRU11	Poor aquifer
Uitenhage Group	Minor	Enon	Conglomerate, sandstone and siltstone	GRU8	Poor aquifer
Karoo dolerite	Major/ Sole source	Karoo dolerite	Hypabyssal dolerite, igneous rock	GRU4	Dolerite and contact zones major groundwater targets in the Karoo
Cape Granite suite	Minor	Cape Granite	Plutonic igneous rock	GRU6	
Beaufort Group	Minor/ Sole source	Beaufort undifferentiated	Siltstone, mudstone and sandstone	GRU7	Karoo Sedimentary rocks with approximately similar groundwater characteristics
Ecca Group	Minor/ Sole source	Ecca	Shale, mudstone and minor sandstone		
	Minor	Tierberg	Predominantly argillaceous well-laminated dark grey to black shale		
	Minor/ Sole source	Waterford (previously Koedoesberg Fm)	Arenaceous very fine-grained lithofeldspathic sandstone and mudrock		
	Minor	Fort Brown	Rythmite and mudrock, minor sandstone intercalations		
	Minor/ Sole source	Koedoesberg	Fine- to medium-grained sandstone, siltstone, shale, rhytmite		
Dwyka Group	Minor	Dwyka	Diamictite	GRU11	Poor groundwater prospects; aquitard; ductile deformation
Witteberg Group	Minor	Lake Mentz Subgroup	Quartzites, mudrock and siltstone	GRU9	According to explanation abstract of 1:500 000 Port Elizabeth geohydrological map, poor aquifers in terms of quality
	Minor	Weltevrede Subgroup	Siltstone, shale and sandstone		
Bokkeveld Group	Minor	Bokkeveld undifferentiated	Feldspathic sandstone, shale and siltstone	GRU10	Generally poor aquifers due to abundant fine grained rock matrix
	Minor	Bidouw	Shale, siltstone and sandstone		
	Minor	Traka	Shale and siltstone		
	Minor	Ceres	Feldspathic sandstone, shale and siltstone		Borehole yields vary widely
Table Mountain Group	Major or minor	Nardouw Subgoup	Feldspathic sandstone and siltstone, fractured quartzite, sandstone, siltstone and shale, tillite	GRU1	Generally containing the major aquifer units in the WMA
	Major	Peninsula Formation	Fractured quartzite		
Cango Caves Group	Major	Kango	metasediments	GRU3	
Kaaimans Group	Major	Kaaimans	Low grade metasediments	GRU5	

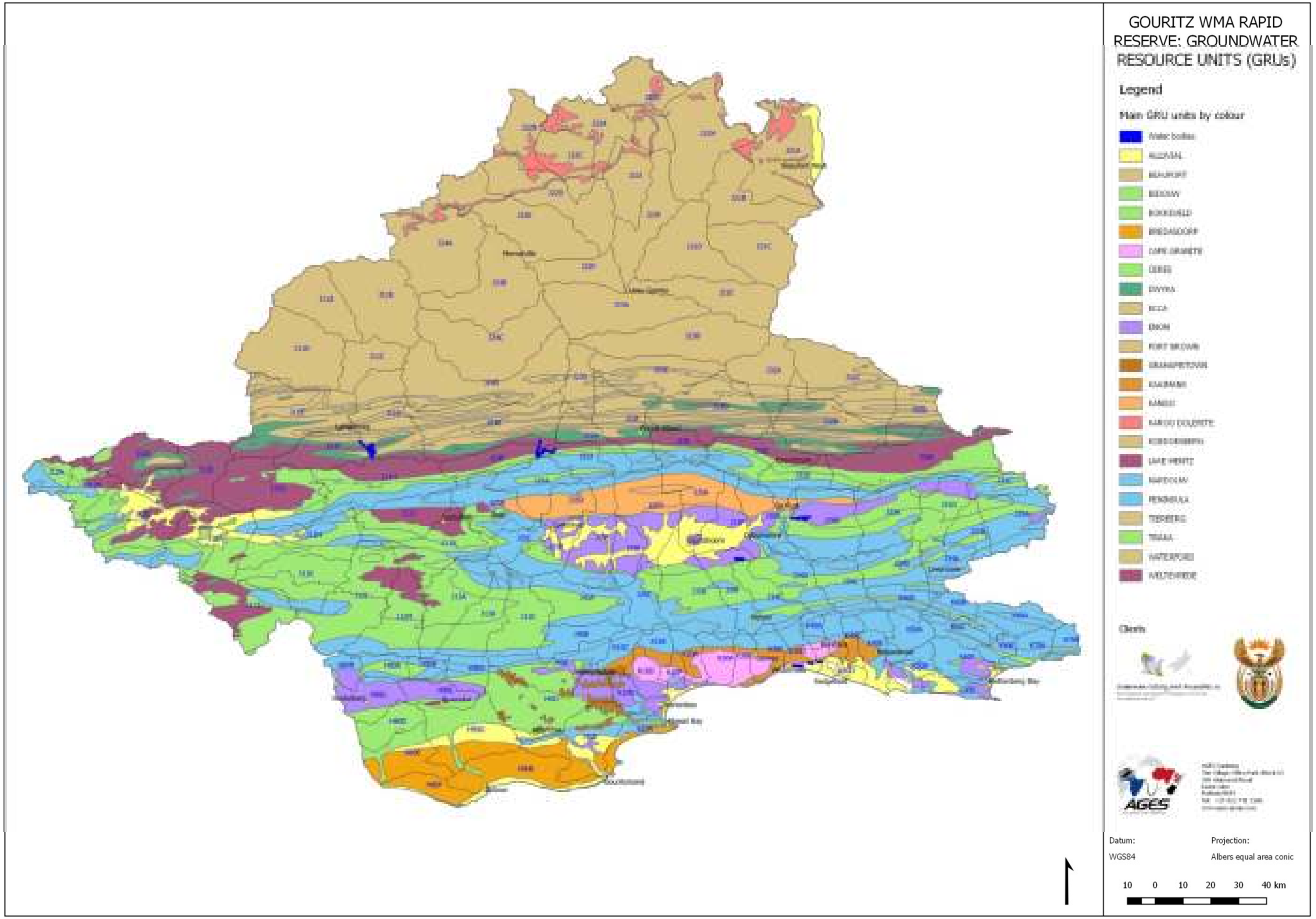

Figure 3.3: Groundwater Resource Units (GRUs) delineated based on geology shown in grouped colours

3.3.3 Selected GRUs and hotspots for intermediate Reserve determination

The following criteria were used to identify hot spots for hydrocensus as well as in final delineation of GRUs for intermediate groundwater Reserve determination:

- Desktop/Rapid groundwater Reserve determination results;
- Existing studies information;
- DWA Gouritz WMA stakeholder meeting held 3 October 2013 (**Table 3.2**);
- DWA All towns reconciliation strategies (DWA, 2014);
- Known aquifers of importance:
  - Vermaaks River catchment and Klein Karoo Rural Water Supply System (KKRWSS);
  - Peninsula Formation confined aquifer associated with DAGEOS;
- Water Use Licence Applications (WULAs) as received per DWA Excel sheet;
- DWA existing groundwater monitoring borehole data to steer hydrocensus;
- Wetlands from Freshwater Ecosystem Priority Areas (FEPA) GIS layer.

Table 3.2: Initial groundwater hot spots – public stakeholder meeting October 2013

Number	Name	Reason for hot spot	Source
1	Waboomskraal area	Intensive agricultural irrigation in the Waboomskraal area (Outeniqua mountain range north of George)	Mike Smart (DWA) - Gouritz Reserve Determination Public stakeholder meeting 3 October 2013
2	Western end of Kamanassie range	Groundwater abstraction for Klein Karoo scheme and agriculture	
3	Course of the Olifants River	Groundwater hot spot	
4	Ladismith groundwater abstraction	Groundwater abstraction	
5	Prince Albert groundwater abstraction	Groundwater abstraction	
6	Fracking north of Swartberge		Piet Lodder (Agri Klein Karoo) Public stakeholder meeting 3 October 2013
7	Peninsula Formation confined aquifer	Confined aquifer and associated unconfined aquifer/ Recharge areas	AGES and Umvoto: Groundwater specialist meeting: January 2014
8	Beaufort West	Historic droughts	Public knowledge
9	Albertinia		Henry Geldenhuys (Eden DM)
10	Swartvlei and flood lines		Henry Geldenhuys (Eden DM)
11	Reserve Determination for non-perennial systems	Select specific systems	Mike Smart (DWA) - Public stakeholder meeting 3 October 2013
12	Piesang River	Assess if only surface water issue	Christo Vlok (Plettenberg Bay Ratepayers)
13	Blinde River	Assess if only surface water issue	Benjamin Walton (CapeNature)
14	Keurbooms and Palmiet River systems	Assess if only surface water issue	Christo Vlok (Plettenberg Bay Ratepayers)

Figure 3.4 shows an example of one of the important hot spots, namely the Waboomskraal area, delineated based on watershed GRU boundaries. Intensive hops irrigation takes place supplied from groundwater abstraction in the unconfined aquifer.

Table 3.3 is compiled from the DWA All Town Strategies project (DWA, 2014) and from a summary map received from Dr Kornelius Riemann from Umvoto Africa (Riemann, *pers. comm.*, 16 Jan. 2014).

Table 3.3: All town reconciliation strategies: towns with higher risk of water supply failure

Number	Town hot spots	Water supply failure risk
1	Laingsburg	High
2	Ladismith	High
3	Calitzdorp	High
4	Oudtshoorn	High
5	De Rust	High
6	Dysselsdorp	High
7	Herold	High

8	Heidelberg	High
9	Karatara	High
10	Kurland	High
11	Beaufort West	Medium
12	Leeu Gamka	Medium
13	Zoar	Medium
14	Riversdal	Medium
15	Albertinia	Medium
16	Melkhoutfontein	Medium
17	Stilbaai	Medium
18	Rheenendal	Medium
19	George	Medium
20	Wilderness	Medium
21	Sedgefield	Medium
22	Plettenberg Bay	Medium
23	Nature's Valley	Medium

Quaternary catchments within the study area from the previous ORDS were not re-evaluated unless it is required for the Peninsula Formation confined aquifer intermediate Reserve determination.

The final GRUs and quaternary catchments for GRU delineation and intermediate Reserve determination are graphically illustrated in **Figure 3.5** and selected quaternary catchments are shown in **Table 3.5**.

Figure 3.4: Example of one of the groundwater hot spots, namely Waboomskraal area which was delineated based on watersheds

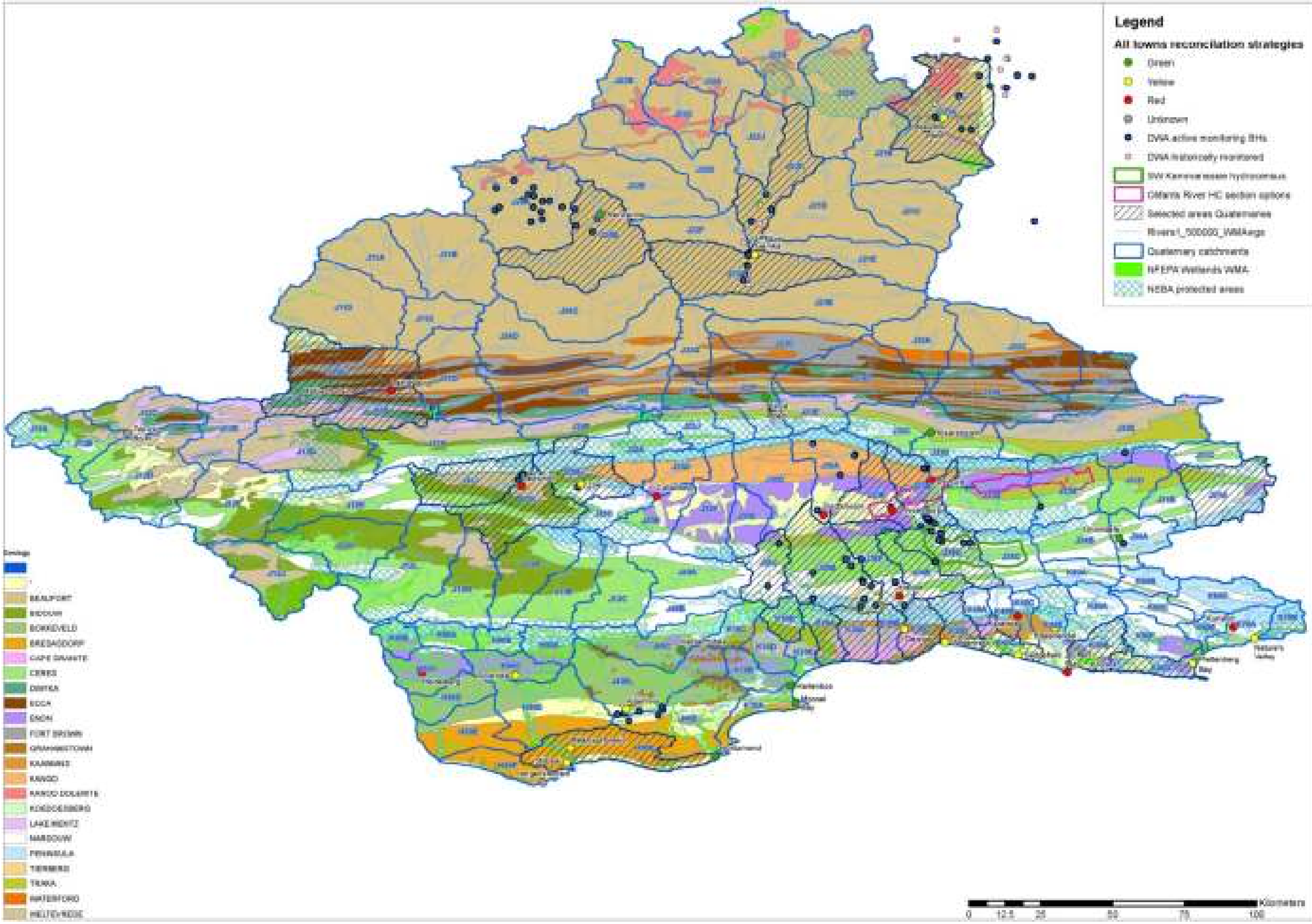

Figure 3.5: Final selection of quaternary catchments for GRU delineation with GIS layers of interest

Table 3.4: Final list of WULAs and groundwater hot spots

Town /area hot spots	Quaternary catchment/GRU
Water Use License Applications	
Beaufort West Municipality WULA GW; Sec 21(a); Hansrivier 196/Steenrots fontein 168	J21A
Knysna RO plant – according to WULA list GW implication; Sec 21 (a) & (f,h)&(e &g)	K50B
Plettenberg Bay municipality WULA Section 21 (g) GW?	K60G
Baviaans Municipality WULA GW sec 21(a); Wanhoop farm	J31A
Dreamworld Investments – WULA GW; Sec 21(a)	J21A
Knysna Municipality town wastewater treatment works (WWTW) WULA; Estuary. Sec 21(e, f, g) GW?	K50B
Beaufort West Municipality WULA; sect 21(a); Beaufort West 166	J21A
Oudtshoorn Municipality Blossoms wellfield; Sec 21(c,i)	J35B
Selected	
Dysselsdorp (KKRWSS), Vermaaks River catchment	J33E, J33F, J34D(hydrocensus)
Waboomskraal	J35B
Recharge areas of Peninsula aquifer applicable to DAGEOS confined aquifer	1: 250 000 geology maps; large area
DAGEOS Peninsula confined aquifer; Blossoms wellfield also sec. 21(c, i)	J35B,J35C,J34E,J34F,K10E,K20A, K30A,K30B,K30C,K30D - GRU
Ladismith recent groundwater development WULA	J11J, J11K
Zoar – Hoeko valley – contact GEOSS	J25B
Sedgefield – new wellfield development	K40D
Stillbaai-Melkhoutfontein springs situation	H90E
Laingsburg-contact municipality	J11E, J11F
Leeu Gamka – abstraction attrition; look at River catchment (s); check whether groundwater Reserve was done.	J23A, J22K
Complaints of groundwater stress	J24B (Merweville catchment)

The confined aquifer associated with the Peninsula Formation of the Table Mountain Group was also selected as a GRU based on geological boundaries for comparison with the Reserve and balances of the quaternary catchments it underlies. The Peninsula Formation confined aquifer GRU boundary, used by Umvoto for the first Peninsula Formation confined aquifer Reserve determination, will be used in the Intermediate Reserve determination.

Table 3.5: Final select quaternary catchments for intermediate Reserve

Number	Quaternary catchment
1	H90E
2	J11E
3	J11F
4	J11J
5	J11K
6	J21A
7	J22K

Number	Quaternary catchment
8	J23A
9	J24B
10	J25B
11	J31A
12	J33E
13	J33F
14	J34D
15	J34E
16	J34F
17	J35B
18	J35C
19	K10E
20	K20A
21	K30A
22	K30B
23	K30C
24	K30D
25	K40D
26	K50B
27	K60G
21%	of total (130) catchments

3.3.4 Acknowledgements

Gratitude is expressed towards Dr Riemann for providing data and a map of the All Towns Reconciliation Strategies project (DWA, 2014) in the Gouritz WMA and he is acknowledged for his contribution. Gratitude is also expressed towards Umvoto for fruitful discussions with them.

3.3.5 Conclusions

Priority GRUs and hotspots have been reviewed by the DWA and finalised and the hydrocensus was optimised based on GRUs and DWA actively monitored boreholes. This will provide accurate data for the current groundwater conditions in selected/priority areas as well as priority areas where gaps in groundwater data exist.

4 ESTUARIES

4.1 INTRODUCTION

The Gouritz WMA (WMA16) includes 21 estuaries. A summary of the Resource Directed Measures (RDM) status and estuary importance/protection status is summarised in **Table 4.1**.

Table 4.1: RDM status of estuaries in WMA16 (as at 2011)

System	Preliminary RDM completed	Importance/ protection status	Present Ecological State (PES)	Recommended Ecological Category (REC)
Duiwenhoks	-	Still to be confirmed		
Goukou	-	Marine Protected Area (MPA)		
Gouritz	-	Desired Protected (Partial)		
Blinde	-	Still to be confirmed		
Hartenbos	-	Still to be confirmed		
Klein Brak	-	Still to be confirmed		
Groot Brak	intermediate		D	D
Maalgate	desktop	Average importance	B	B
Gwaiing	desktop	Average importance	C	C
Kaaimans	desktop	Desired Protected(Full)	B	B
Wilderness (Touws)	-	National Park		
Swartvlei	rapid	Protected Area	A/B	A
Goukamma	rapid	Protected Area	A/B	A
Knysna	intermediate	National Park	B	B
Noetsie	desktop	Desired Protected	B	A
Piesang	-	Desired Protected (partial)		
Keurbooms	rapid	Local reserve	A/B	A
Matjies	intermediate	Average importance	B	B
Sout (Oos)	intermediate	National Park	A	A
Groot (Wes)	-	National Park		
Bloukrans	-	National Park		

4.2 INDIVIDUAL ESTUARY DELINEATION

4.2.1 Duiwenhoks Estuary

The geographical boundaries for the Duiwenhoks Estuary (**Figure 4.1**) are defined 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 4.1: Geographical boundaries of the Duiwenhoks Estuary

4.2.2 Goukou Estuary

The geographical boundaries for the Goukou Estuary (**Figure 4.2**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.2: Geographical boundaries of the Goukou Estuary

4.2.3 Gouritz Estuary

The geographical boundaries for the Gouritz Estuary (**Figure 4.3**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.3: Geographical boundaries of the Gouritz Estuary

4.2.4 Blinde Estuary

The geographical boundaries for the Blinde Estuary (**Figure 4.4**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.4: Geographical boundaries of the Blinde Estuary

4.2.5 Hartenbos Estuary

The geographical boundaries for the Hartenbos Estuary (**Figure 4.5**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.5: Geographical boundaries of the Hartenbos Estuary

4.2.6 Klein Brak Estuary

The geographical boundaries for the Klein Brak Estuary (**Figure 4.6**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 5'31.98"S, 22° 8'55.43"E
Upstream boundary:	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 Mean Sea Level (MSL) along each bank

Figure 4.6: Geographical boundaries of the Klein Brak Estuary

4.2.7 Groot Brak Estuary

The geographical boundaries for the Groot Brak Estuary (**Figure 4.7**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 3'22.53"S, 22°14'20.78"E
Upstream boundary:	34° 1'42.97"S, 22°13'19.81"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.7: Geographical boundaries of the Groot Brak Estuary

4.2.8 Maalgate Estuary

The geographical boundaries for the Maalgate Estuary (**Figure 4.8**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 3'15.60"S, 22°21'15.90"E
Upstream boundary:	34° 2'30.15"S, 22°21'9.03"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.8: Geographical boundaries of the Maalgate Estuary

4.2.9 Gwaing Estuary

The geographical boundaries for the Gwaiing Estuary (**Figure 4.9**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 3'22.69"S, 22°26'3.46"E
Upstream boundary:	34° 2'48.66"S, 22°25'43.54"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.9: Geographical boundaries of the Gwaing Estuary

4.2.10 Kaaimans Estuary

The geographical boundaries for the Kaaimans Estuary (**Figure 4.10**) are defined as follows:

Downstream boundary:	Estuary mouth 33°59'54.18"S, 22°33'26.36"E
Upstream boundary:	33°59'28.36"S, 22°32'56.85"E/ 33°59'13.20"S, 22°33'33.35"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.10: Geographical boundaries of the Kaaimans Estuary

4.2.11 Wilderness Estuarine Lake System Lakes

The geographical boundaries for the Wilderness Estuarine Lakes (also sometimes Touws Estuary when only referring to lower tidal section) (**Figure 4.11**) are defined as follows:

Downstream boundary:	Estuary mouth 33°59'45.56"S, 22°34'51.01"E
Upstream boundary:	Touws 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 Mean Sea Level (MSL) along each bank

Figure 4.11: Geographical boundaries of the Wilderness Estuarine lake system

4.2.12 Swartvlei Estuary

The geographical boundaries for the Swartvlei Estuary (**Figure 4.12**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 1'54.53"S 22°47'46.19"E
Upstream boundary:	33°58'26.50"S 22°43'19.78"E/ 33°58'9.67"S 22°48'2.03"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.12: Geographical boundaries of the Swartvlei Estuary

4.2.13 Goukamma Estuary

The geographical boundaries for the Goukamma Estuary (**Figure 4.13**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 4'36.11"S 22°57'0.18"E
Upstream boundary:	34° 0'11.95"S 22°55'54.77"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.13: Geographical boundaries of the Goukamma Estuary

4.2.14 Knysna Estuary

The geographical boundaries for the Knysna Estuary (**Figure 4.14**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 4'58.05"S 23° 3'37.82"E
Upstream boundary:	33°59'54.62"S 23° 0'11.90"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.14: Geographical boundaries of the Knysna Estuary

4.2.15 Noetsie Estuary

The geographical boundaries for the Noetsie Estuary (**Figure 4.15**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 4'48.76"S 23° 7'44.89"E
Upstream boundary:	34° 4'24.04"S 23° 8'20.90"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.15: Geographical boundaries of the Noetsie Estuary

4.2.16 Piesang Estuary

The geographical boundaries for the Piesang Estuary (**Figure 4.16**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.16: Geographical boundaries of the Piesang Estuary

4.2.17 Keurbooms Estuary

The geographical boundaries for the Keurbooms Estuary (**Figure 4.17**) are defined as follows:

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

Figure 4.17: Geographical boundaries of the Keurbooms Estuary

4.2.18 Matjies Estuary

The geographical boundaries for the Matjies Estuary (**Figure 4.18**) are defined as follows:

Downstream boundary:	Estuary mouth 34° 0'8.35"S 23°28'10.99"E
Upstream boundary:	33°59'49.42"S 23°28'10.69"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

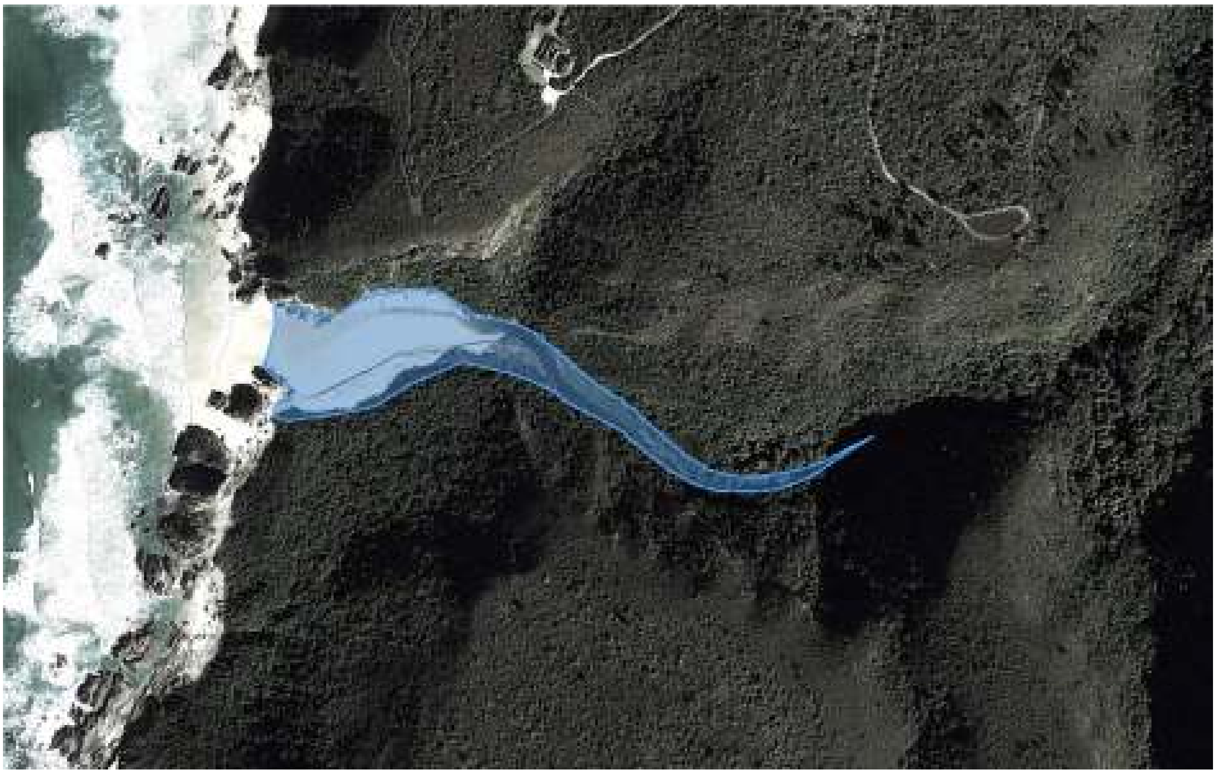

Figure 4.18: Geographical boundaries of the Matjies Estuary

4.2.19 Sout (Oos) Estuary

The geographical boundaries for the Sout (Oos) Estuary (**Figure 4.19**) are defined as follows:

Downstream boundary:	Estuary mouth 33°59'23.26"S 23°32'10.97"E
Upstream boundary:	33°59'6.96"S 23°31'47.76"E
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank

Figure 4.19: Geographical boundaries of the Sout (Oos) Estuary

4.2.20 Groot (Wes) Estuary

The geographical boundaries for the Groot (Wes) Estuary (**Figure 4.20**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.20: Geographical boundaries of the Groot (Wes) Estuary

4.2.21 Bloukrans Estuary

The geographical boundaries for the Bloukrans Estuary (**Figure 4.21**) are defined 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 Mean Sea Level (MSL) along each bank

Figure 4.21: Geographical boundaries of the Bloukrans Estuary

5 WETLANDS

Wetlands are amongst the most impacted and degraded of all ecological systems. Global assessments indicate that a large proportion of wetlands have been destroyed and the majority of remaining wetlands are degraded or under threat of degradation (Finlayson and Spiers, 1999).

South Africa is a contracting party to the Ramsar Convention on Wetlands and therefore has an obligation to promote their conservation and responsible use. Despite this, more than half of the country's wetlands are estimated to have been destroyed or converted into areas of lower functional importance (DEAT: State of the Environment, http://soer.deat.gov.za/themes.aspx?m=149). The assessment and monitoring of wetland condition is therefore an important component in managing the use of wetlands (Ramsar Convention, 2002).

In South Africa, the DWA is the custodian of the nation's water resources, including wetlands (see "What is a Wetland" below). The DWA is mandated through the NWA to ensure the conservation, protection and sustainable utilisation of wetlands. For effective implementation of the NWA, but also for a wider range of activities such as conservation planning and management, it is important that the ecological condition, and importance and sensitivity of wetlands be determined and managed.

What is a Wetland?

As defined by the South African National Water Act (Act 36 of 1998), a wetland is "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.*"

Wetlands are essentially an expression of the presence of surface or near-surface water in the landscape. This water can either be static (e.g. pans) or slowly moving through the landscape. The source of the water can include surface flow, interflow (water flowing through the soil profile), groundwater (including deep and/or perched groundwater), direct rainfall, or any combination of these. Whatever the source, the water must be present for long enough to influence both the soil properties and the vegetation. In practice, the wetland boundary is defined as the position in the landscape where hydric indicators occur in the soil within 0.5 m of the surface (DWAF, 2005). Where these hydric indicators are deeper than 0.5 m, they generally do not support wetland adapted plants. Thus, the 0.5 m measurement traditionally forms the boundary between terrestrial and wetland adapted plant species (DWAF, 2008).

5.1 THE USE OF WETLAND RESOURCE UNITS

There are thousands of wetlands in South Africa, and it would be difficult, if not impossible, to even map every single wetland as many are small (i.e. beyond a reasonable mapping scale), some are cryptic (i.e. not be easily identified) and others have been extensively modified, thus making their identification and delineation difficult. Even if all the wetlands within a region could be identified and mapped, their sheer number would preclude a site-specific approach to wetland management.

There is thus a need for an approach to classify wetlands with similar characteristics so that these can be grouped into Wetland Resource Units (WRUs). Such WRUs may then offer the opportunity to identify assemblages of wetlands rather than the many tens of thousands of individual wetland systems. Through the use of WRUs, DWA and other natural resource managers can manage wetlands on the basis of similar characteristics, driving processes, and sensitivities to developments and other impacts. Provided they are correctly classified and fairly well understood, WRUs can facilitate the implementation of the NWA as they allow for the management, conservation, protection and sustainable utilisation of wetlands, at a scale appropriate to available knowledge and resources. For instance, the information about wetland processes and sensitivities for a WRU can be used in low confidence (desktop) Reserve studies, which may be sufficient for many Water User Licence Applications (WULAs).

The use of WRUs does not, however, obviate the need for detailed Reserve studies for large, unique or highly-sensitive individual wetlands, particularly where potential developments are likely to have a significant impact upon water availability. In such situations, DWA and other managers could evaluate the anticipated impacts of the development against the general characteristics and sensitivities of wetlands within the relevant WRU to assess whether or not the impact is likely to be significant and if a detailed Reserve assessment is required.

The delineation of WRUs, and the understanding of underlying processes informing these delineations, may also provide important information for other studies, such as the buffer zone determination tool for rivers and wetlands, currently being prepared by MacFarlane *et al.* (*in prep.*), which relies on some basic information of wetlands in the areas being assessed.

5.2 OBJECTIVES OF THE STUDY

This study has the following objectives:

- describe the types of wetlands within the study area; and
- group these into Wetland Resource Units[1].

This study builds upon the earlier work undertaken (DWAF, 2009) in selected coastal catchments of this WMA. The current study has been undertaken as a desktop-level assessment, relying on available information. A later catchment-wide field verification trip (during spring when the wetlands will be most prominent) will be used to confirm and refine the findings of the desktop study. Subsequent tasks of this Reserve study will determine the quaternary catchment PES, EIS and Recommended Ecological Category (REC) for wetlands within the study area. The combination of quaternary scale EcoStatus information together with field-verified WRU characteristics will begin to provide for more effective understanding of wetland condition and processes which is important to the DWA in wetland-related WULAs and general wetland management.

[1] A Wetland Resource Unit is an area of a catchment which has wetlands with similar characteristics, processes and also broadly similar sensitivities to particular developments and impacts.

5.3 STUDY AREA

The study area encompasses the Gouritz Water Management Area, comprising drainage areas H, J and K (**Figure 5.1**). This Water Management Area (WMA) is situated along the southern coast of South Africa but extends inland across the Little Karoo and into the Great Karoo. The area covers about 53 000 km2 and includes the Gouritz River catchment, the bulk of the WMA, with its main tributaries, the Groot, Gamka and Olifants rivers as well as secondary tributaries, the Touws, Dwyka, Buffels, Koekemoers, Kamma, Leeu, Touws, Vals, Stink and Kammanassie rivers.

Along the coast to the east and west of the Gouritz River are several smaller coastal catchments. The Duiwenhoks and Goukou rivers drain the coastal belt west of the Gouritz River, while the Garden Route area to the east of the Gouritz consists of several smaller rivers including the Knysna and Keurbooms rivers. The catchments of the coastal belt also contain a number of important coastal lakes and wetlands. For instance, the Wilderness Lakes near Sedgefield are a designated RAMSAR wetland site and the Knysna Lagoon[2] is considered the largest and most important estuary in the country (Turpie, 2004).

Four main Level I EcoRegions characterise the study area (**Figure 5.2**), namely:

- the South Eastern Coastal Belt;
- the Southern Coastal Belt;
- Southern Cape Folded Mountains, and
- the Great Karoo EcoRegion.

Additionally, the northern extremities of the WMA extend in to the Nama-karoo EcoRegion, associated with the Great Escarpment which forms the northern boundary of the WMA. A small pocket of the Western Folded Mountains EcoRegion is present in the far west of the WMA (**Figure 5.2**). EcoRegions reflect a variety of biophysical factors which influence ecological processes and the distribution of biota, with the finer scale Level II EcoRegional distribution (**Figure 5.3**) reflecting to a large degree the underlying geological characteristics (**Figure 5.4**). Along the southern coastal belt, sections of granite, conglomerate and quartzite are dominant, whilst immediately adjacent to the coast old quaternary sediments (derived from fossil dunes and old sea beds) have been deposited in places (**Figure 5.4**). North of this lies an east-west deposit of the Table Mountain Group of sedimentary rocks, and this resistant feature has given rise to the Langeberge – a mountain range running from east to west separating the inland Klein Karoo from the coastal regions.

The Klein Karoo which lies to the north of the Langeberge and is about 10-15 km wide, and the Groot and Gamka tributaries arise here. This area belongs to the Bokkeveld Group and consists of sandstones and shales. A complex mix of geologies is associated with the folded mountainous regions, with an extensive deposit of the Adelaide Subgroup extending from the Swartberg Mountains north to the great escarpment which forms the northern boundary of the WMA.

---

[2] Estuaries are not evaluated in this report as the definition of wetlands in the National Water Act refers only to inland freshwater wetlands.

Further inland, north of the Swartberg Mountains, is the Great Karoo. The Great Karoo consists of flat plains and low hills formed by Karoo sediments and doleritic intrusions. Towards the south the terrain becomes mountainous consisting of the Dwyka Group diamictites and then sandstones and shales of the Cape Supergroup. In the Olifants River catchment, in the vicinity of Oudtshoorn, the geology consists of metasediments of the Cango Caves Group, sandstones and quartzite of the TMG, overlain by the younger Enon conglomerates and alluvial deposits in the valley floors. The great Karoo extends northward to the Great Escarpment.

Across this study area, large numbers of wetlands are present (**Figure 5.5** to **Figure 5.7**), many of which are regarded as conservation priorities (**Figure 5.7**).

Appendix A presents more information on the wetland typing or classification process.

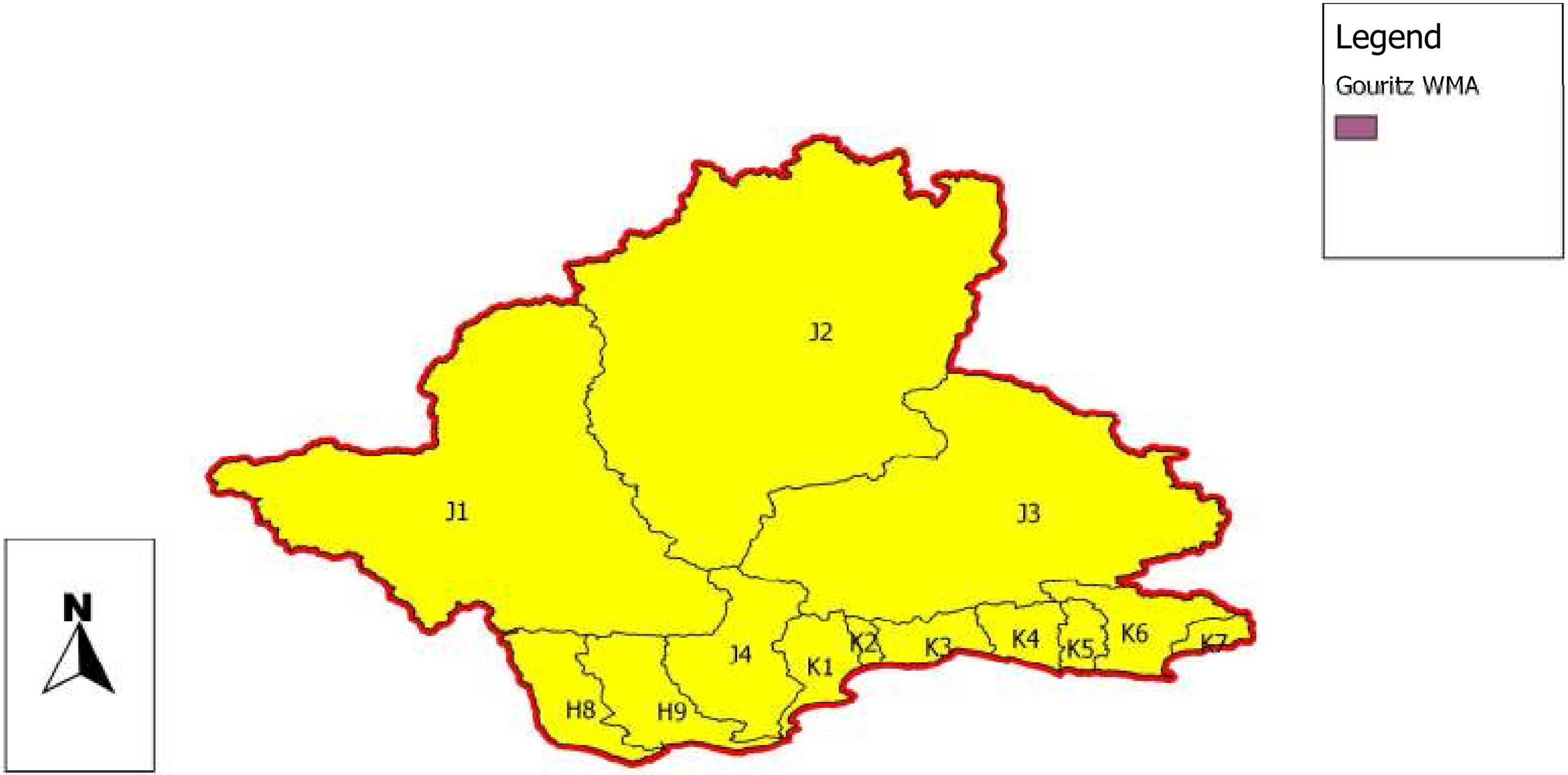

Figure 5.1: The secondary catchments of the study area

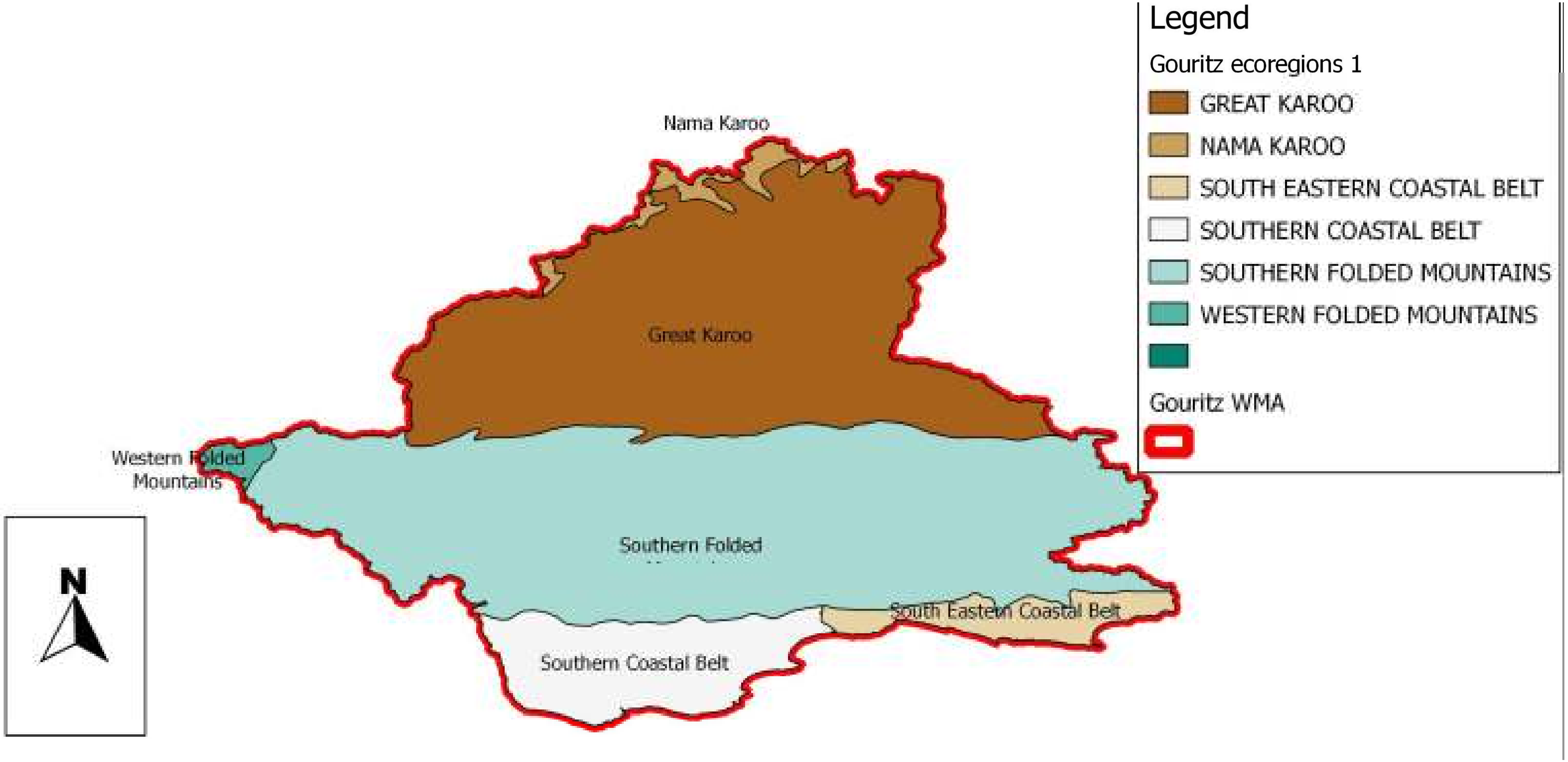

Figure 5.2: Level I EcoRegions within the study area (after Kleynhans *et al.*, 2005)

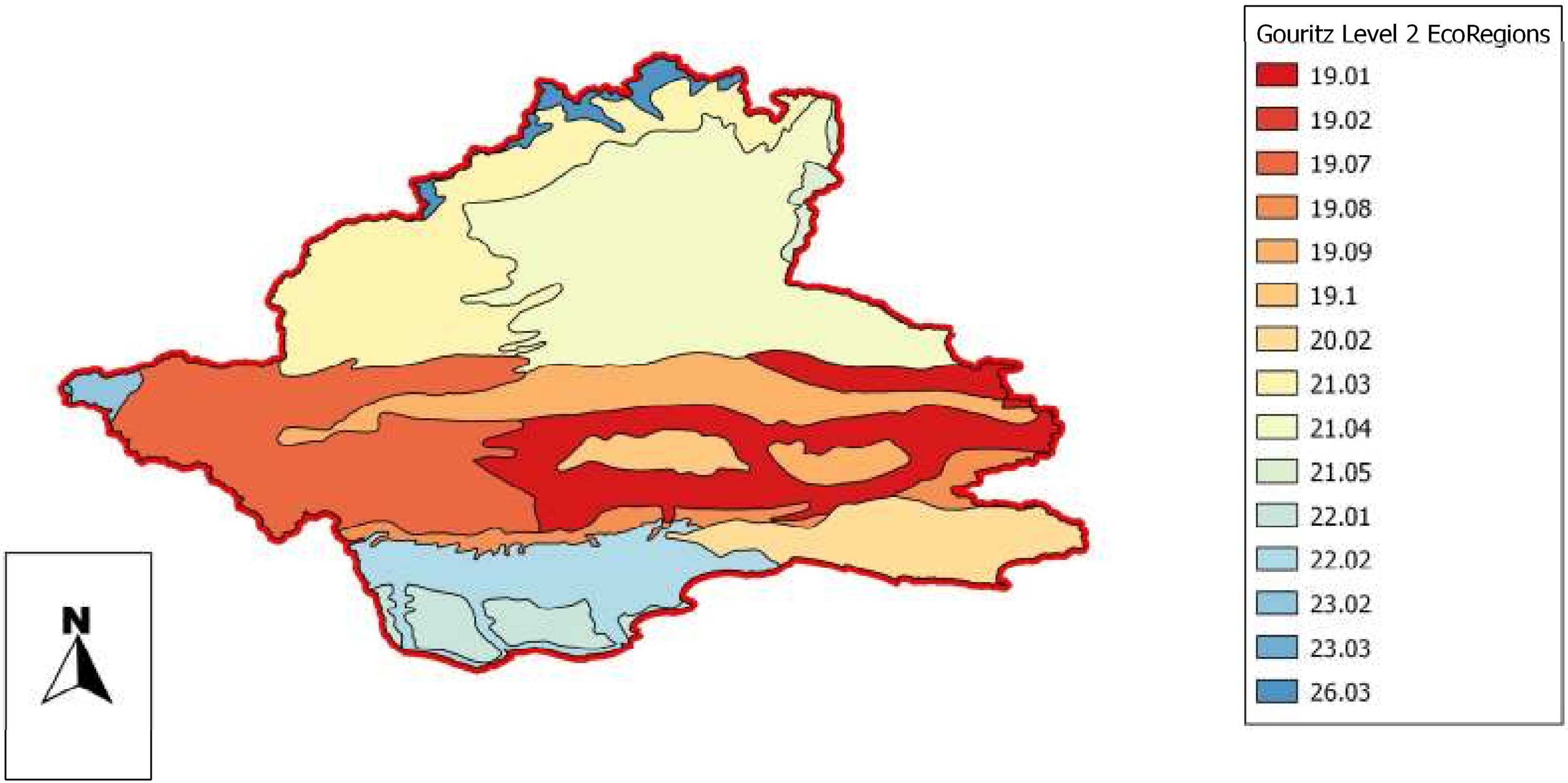

Figure 5.3: Level II EcoRegions within the study area (after Kleynhans *et al.*, 2005)

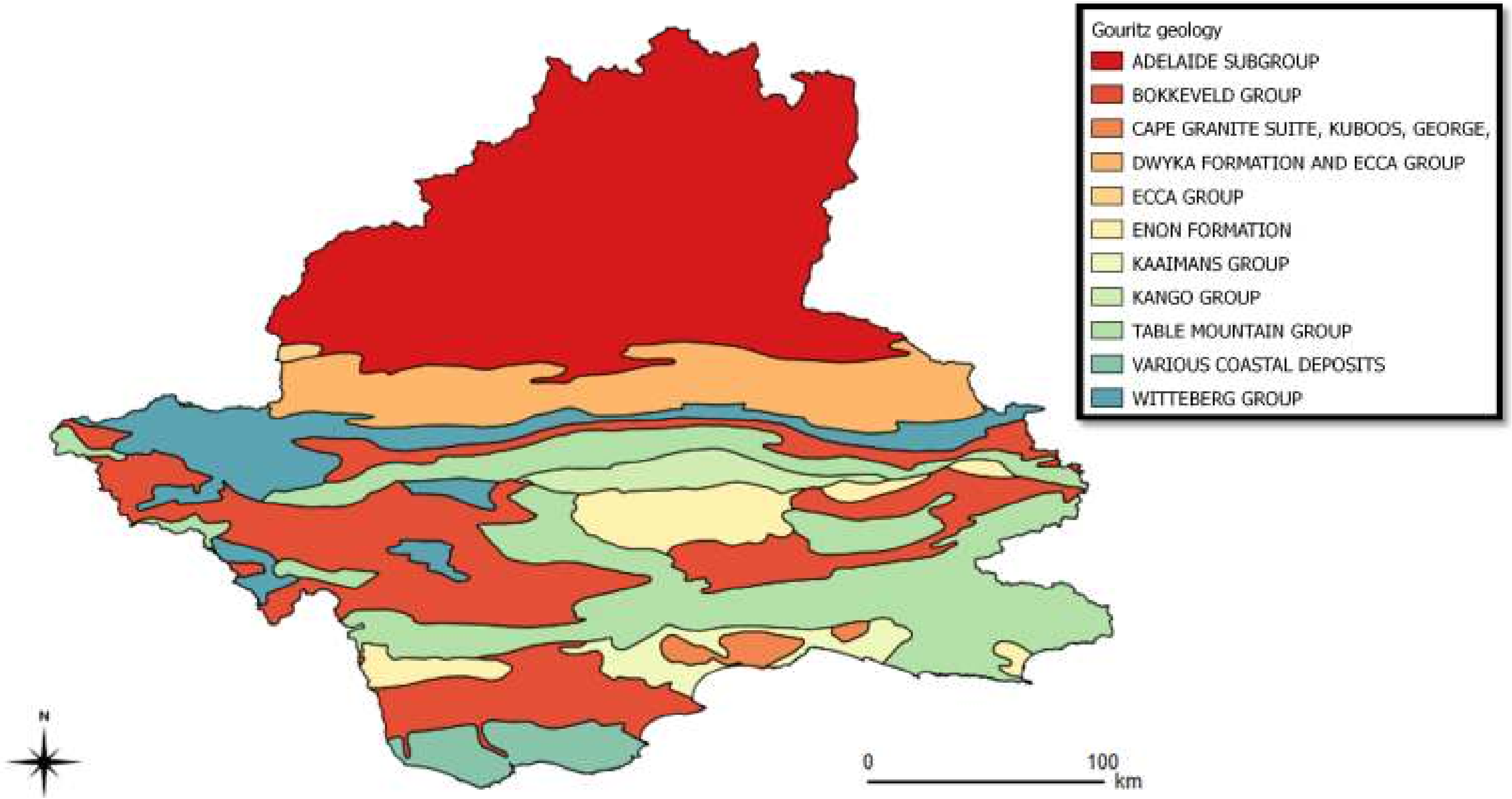

Figure 5.4: The underlying broad-scale geology of the study area (geology information provided by DWA)

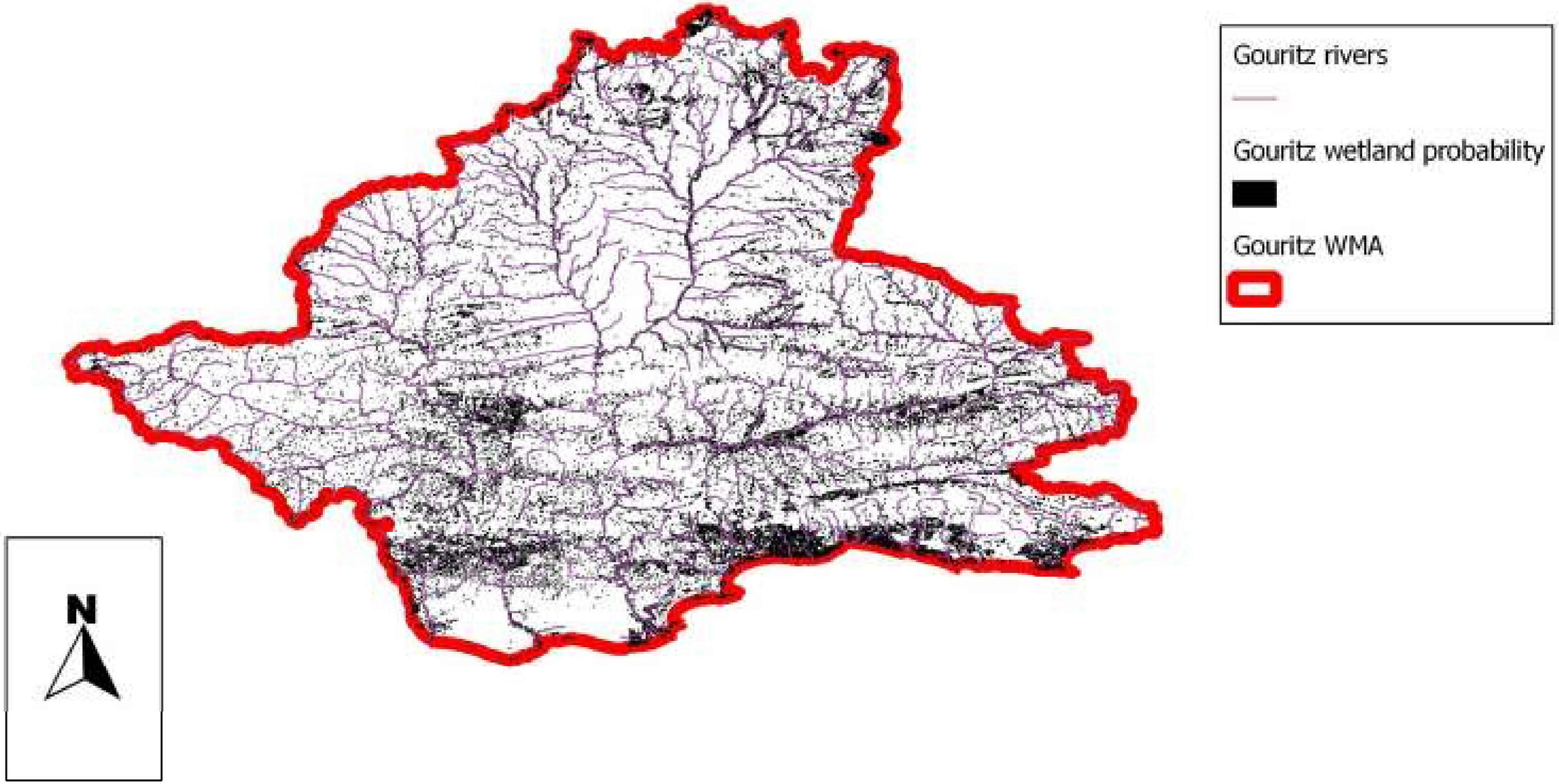

Figure 5.5: The extent and density of wetlands across the study area (displayed as blue/black dots and patches), as indicated by the SANBI Wetlands Probability Layer (SANBI, unpublished)

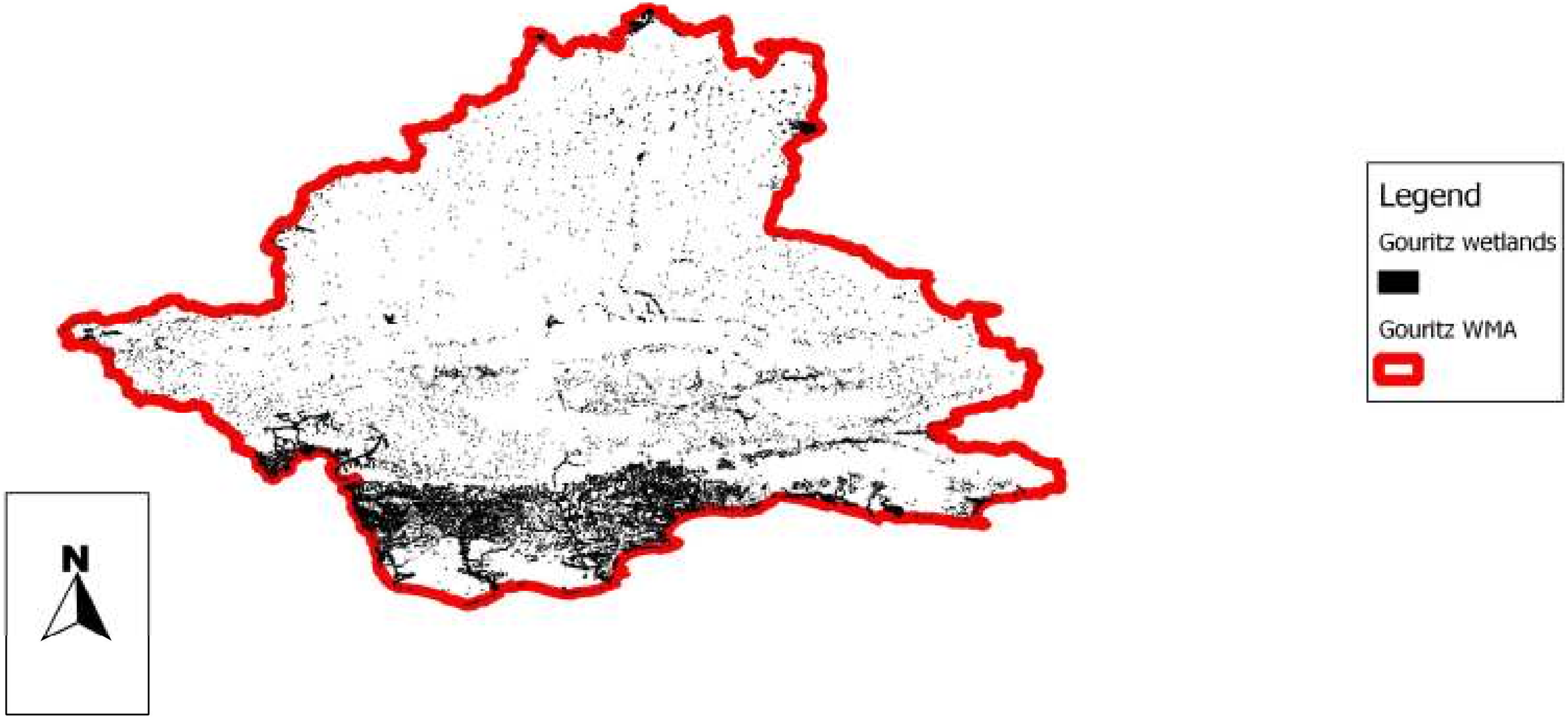

Figure 5.6: The extent and density of wetlands across the study area (displayed as blue/black dots and patches), as indicated by the SANBI FEPA wetland layer (Driver *et al.*, 2011)

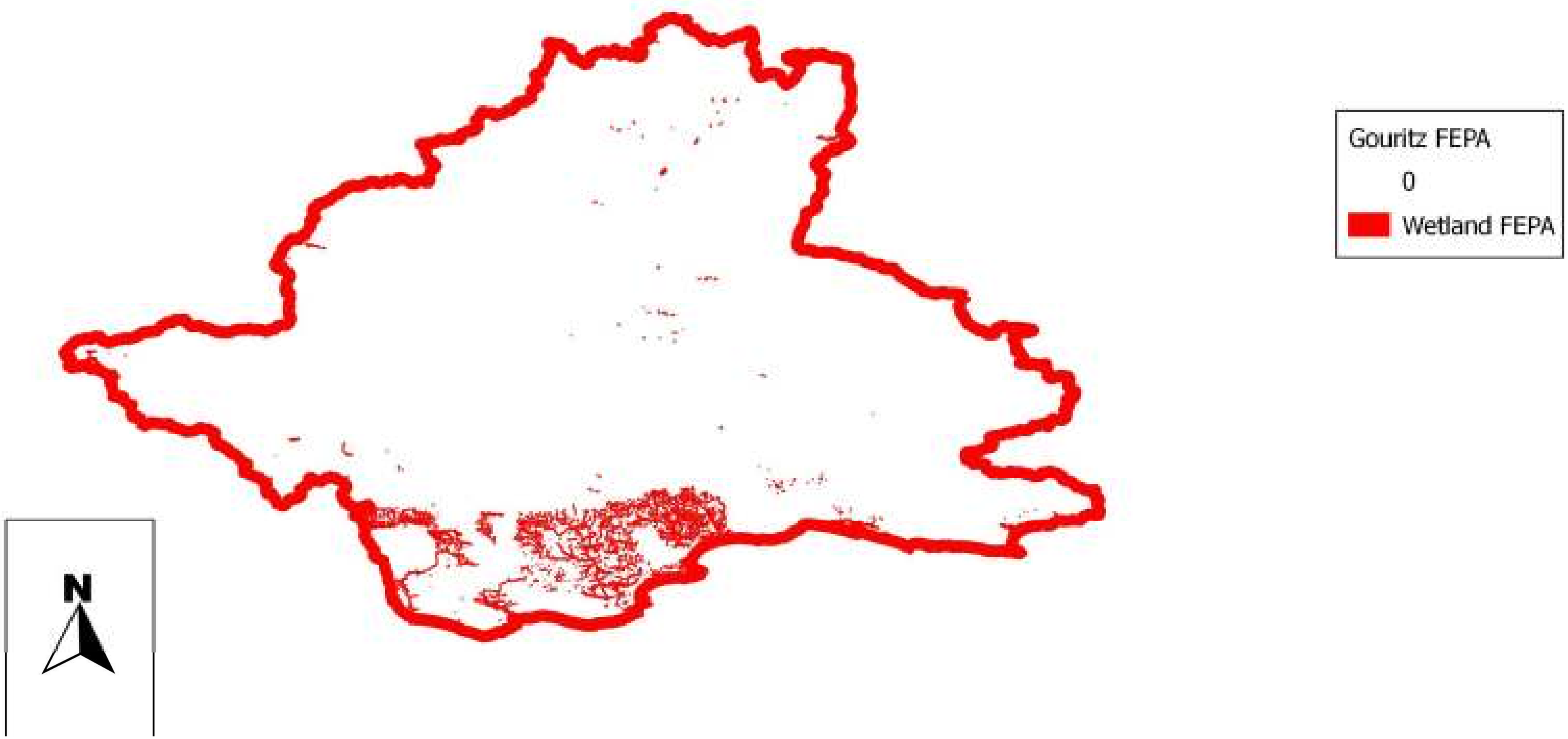

Figure 5.7: The extent and density of Level 1 FEPA (conservation priority) wetlands across the study area (Driver *et al.*, 2011)

5.4 METHODS

SANBI's Wetland Probability Map (WPM, **Figure 5.5**) and FEPA wetland maps (**Figure 5.6**, **Figure 5.7**) were used as a first-level assessment of wetland occurrence within the study area. These data are not ground-truthed, and should thus be treated with caution. It has been identified that many seepage wetlands are not mapped on the Wetlands Probability Map and farm dams are often included in the dataset. Although dams are artificial wetlands, many earth farm dams are located in seepage or valley bottom wetlands and can therefore be used to indicate likely locations (but not extents) of the wetlands. Despite the introduction of error through inclusion of farm dams, limited independent preliminary verification of the Wetland Probability Map suggests that these spatial data provide a significant underestimate of the actual occurrence and extent of wetlands; primarily due to the omission of many seepage wetlands.

Despite all these limitations, the SANBI Wetlands Probability Map (**Figure 5.5**) is thought to provide the best indication of true wetland distribution data for the country. Although it cannot be considered as definitive, it does provide an indication of relative wetland occurrence, size and density across the study area. The SANBI FEPA map provides a more conservative estimate and density of wetlands across the study area, but importantly denotes individual wetlands and clusters of wetlands (**Figure 5.7**) which are considered to be regionally or nationally important water resources.

The extent and density of wetlands and associated biophysical characteristics as were used to delineate the catchment in to regions of homogenous wetland groupings or processes, following the approaches of DWA (2009; 2010b) and Louw *et al.* (2010).

Priority wetlands within the catchment were identified from workshops and data derived from the Working for Wetlands (WfWetlands) programme in conjunction with the Southern Cape Wetlands Forum (**Appendix B**), from literature sources and consultations with WfWetlands, DWA and a large stakeholder meeting held in the study area in October 2013.

5.5 PRIORITY WETLANDS IN THE GOURITZ WMA

There are numerous small and large wetlands which, either individually or as part of wetland clusters, are denoted as Freshwater Ecosystem Priorities in the study area (**Figure 5.7**). The Southern Cape Wetland Forum in conjunction with the WfWetlands Programme undertook to identify and describe priority wetlands within the area as part of a prioritisation process to identify key areas for urgent rehabilitation needs and generated a short list of known important wetlands which are potentially under threat (**Appendix B**).

This list was reassessed to remove estuaries (which are not included in the scope of this study) and to focus on wetlands rather than river systems, as well as to incorporate additional wetlands identified, or highlighted with increased importance, by stakeholders. Priority wetlands in the WMA, based on size, rarity, threats and perceived biological importance have been tabulated below:

No.	Wetland System	Threats
1	Wilderness Lakes system	This RAMSAR site of interconnected lakes is threatened by continued development creep and effluent (water quality) risks.
2	Duiwenhoeks and Goukou systems	These very large wetland complexes are threatened by erosion and invasive vegetation, as well as flow abstractions.
3	Tshokwane wetland (lower Keurbooms)	The wetland is threatened by proposed development, drainage of the wetland and invasive alien plants, nearby mining and the impacts of roads.
4	Groenvlei	A highly unique endorheic lake, but threatened by alien fish (bass, carp, tilapia), groundwater use, pollution, hydrological changes and general development.
5	Bitou River (lower reaches)	This system has a unique mix of biodiversity – no alien fish occur here yet. The system is threatened by waste water return flows and proposed developments.
6	Hoëkraal	Threats include housing estate development and abstraction for inter-basin transfer.
7	Moordkuil River	The Palmiet wetlands are threatened by abstractions and alien invasive vegetation.
8	Vankankersvlei	There is a low risk posed by forestry and invasive plants to this unique wetland near Groenvlei.
9	Upper Knysna catchment (including Gouna)	High biodiversity and habitat diversity threatened by invasive alien plants, flow reductions from forestry
10	Touws (Wilderness) River	This system is threatened by increased abstractions (a 35% increase is predicted to be abstracted for Wilderness), as well as water quality risks from pollution, sewerage pipes etc.
11	Salt River system (Crags)	The threats to this system are high - sewerage and pollutants from housing estates, and possible plans to pipe water to Plettenberg Bay from this system will reduce flows. The threat is high because the system is pristine in lower reaches. Invasive alien plants in the upper catchments are increasing.
12	Keurbooms River (lower)	The high importance for biodiversity (linked to estuarine sea horse presence) is threatened by continued and possibly increased water abstraction and pollution from the town.
13	Karatara	High abstraction, with likely increases in future due to demands from Sedgefield. Alien invasive plants (AIPs) are widespread.
14	Kaaimans River system	A dam is being built for abstraction and this will reduce flows Although still in a good condition, invasive alien plants are present but management is difficult due to the steep, inaccessible areas.
15	Gwaing River system	A large number of wetlands are present in this urban (city of George) watercourse. Albeit that they are fairly degraded, threatened by development encroachment, pollution and waste water discharges, alien clearing should be considered.
16	Wolwe / Diep River	Threatened by development in the middle reaches, with risks to the riparian zone and threat of localised erosion.

The Knysna, Swartvlei, Noetsie (Kruisfontein) and Grootbrak Estuaries were excluded from consideration as the estuaries are being examined separately from this study.

5.6 WETLANDS IN THE STUDY AREA

5.6.1 General

Rainfall is a key determinant of wetland occurrence. High wetland densities are found along the wetter coastal catchment areas (**Figure 5.5**), but exceptions to this are in the porous coastal sediments and limestones on the coast in the extreme south of the WMA (**Figure 5.4**), where very few wetlands are present due to deeply draining soils and to limited surface water exposure.

In the drier interior of the WMA, wetland prevalence is not surprisingly far lower. The few Karoo wetlands found here however provide important grazing resources, as well as trapping flood flows and important water table recharge functions. Many wetlands are unfortunately scarred by erosive gullies (dongas) caused by overgrazing, large camp systems, tree removal and burning. Degradation is likely to have started with the intensive livestock operations of early European farmers (Smuts, 2012) which caused erosion and declines in forage productivity (Milton and Dean, 1995). Additional degradation of watercourses may also have been initiated by old access routes – wetlands in the area functioned as the roads for ox wagons carts that transported people and goods through the Karoo prior to the arrival of cars (Dean and Milton, 1999). Further impacts are caused by the presence of "thirsty" alien trees that reduce flow or even totally dry up springs and lower water tables.

5.6.2 Wetland Resource Units

EcoRegions and geology are key factors in the delineation of WRUs. The main geological formations in the study area are shown in

Figure 5.4. The Cape Folded Mountains tend to be dominated by Table Mountain Group sandstones. These sandstones weather to form steep valleys. The resultant steep topography and limited infiltration limits the development of extensive wetlands, although small aquifer dependent ecosystems (springs and seepage wetlands) are found where groundwater is forced to the surface (Colvin *et al.*, 2007).

In contrast, the coastal zones are characterised by a flatter topography. Consequently, the drainage lines are relatively flat with large expanses of very low energy areas. These conditions can favour the development of wetlands. The area is underlain by large areas of granites, quartzites and conglomerates. These different geologies result in differing potential for wetland formation, and the formation of different wetland types. Granites weather and tend to produce shallow sandy soils underlain by clays. This association of sandy upper and clay-rich lower soil horizons creates ideal conditions for perched subsurface water flows (interflow). Where the valley side and longitudinal gradients are sufficiently flat, granitic catchments can create extensive seepage and wide valley bottom wetlands. The conglomerate formations in comparison are relatively impervious, and these areas tend to have lower densities of wetlands than occurs in the granitic zones of the study area. The conglomerates also have the lowest yield for groundwater, whereas the quartzite formations are among the highest groundwater yielding formations within the study area (DWAF, 2009). The quartzite formations are likely to constitute a significant contribution to baseflow in these areas, and seepage wetlands are likely to develop where the groundwater is emerging.

Groundwater studies usually draw a distinction between deep groundwater reserves, mainly in secondary aquifers, and the more shallow, near-surface flows that occur in the primary aquifers. For most wetlands in the coastal zones, the shallow groundwater is critical for wetland formation and maintenance. However, due to regional aridity across the rest of the WMA, wetlands found in the arid Klein and Great Karoo, and in the drier areas of the Nama Karoo and Fold Mountains, are likely to be dependent on deep groundwater.

The relevance of understanding the underlying driving conditions maintaining different wetland types may become apparent when, for example, evaluating the impacts of proposed developments or water use license applications (WULAs). Wetlands that are maintained by interflow can be expected to have a relatively small catchment, but would be highly sensitive to developments within that immediate topographically-defined catchment area. Wetlands maintained by regional groundwater however could be expected to be less sensitive to individual developments in the immediate vicinity of the wetland, but to be more sensitive to cumulative impacts of regional development. Abstraction through boreholes several kilometres from an interflow-dominated wetland may not be expected to have a significant impact (since this is maintained by the immediate catchment), but if the wetland was groundwater-dependent, then abstraction, even if far from the wetland, may affect the regional groundwater aquifer and thus the “downstream” wetland; albeit that the impact point and groundwater-maintained wetland may not be connected by surface hydrological processes, nor located immediately adjacent to one another.

Nine wetland resource units have been identified for the Gouritz WMA (**Figure 5.8**), *viz.*:

- Nama Karoo
- Great Karoo
- Cape Fold Mountains (Swartberg)
- Klein Karoo
- South Cape Fold Mountains (Langeberg/Outeniqua ranges)
- South Coastal Belt
- South-East Coastal Belt
- Coastal Sediment Deposits, and
- Sedimentary Coastal Lakes unit.

Within each of the WRUs, broad hydrological and biophysical processes which maintain the wetlands would be broadly similar, and the main hydrogeomorphic (HGM) and ecological characteristics of the wetland types present within each WRU are likely to be similar **(Table 5.1)**. For example, the large coastal lake wetlands (Groenvlei, Wilderness Lakes) are all found within the Sedimentary Coastal Lakes WRU. Patches of small valley bottom wetlands are all located within South Coastal Belt WRU.

Field verification and descriptions of common wetland types, and threats and management recommendations, will be provided following a ‘bakkie window’ assessment of the catchment in the spring of 2014.

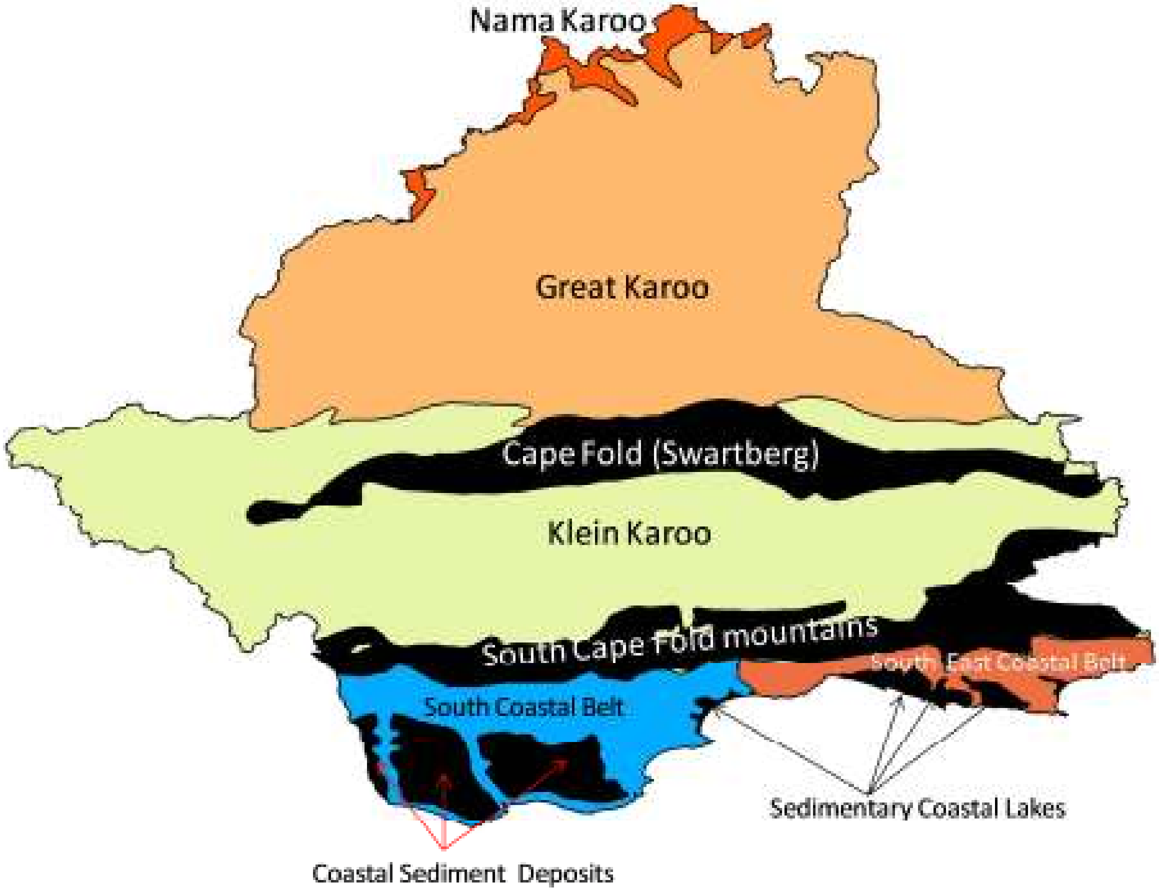

Figure 5.8: The Wetland Resource Units of the Gouritz WMA

Table 5.1 HGM wetland types expected to be associated with the different Wetland Resource Units

Level II: WRU		Level III: HGM wetlands
	Wetland Resource Unit name	**Common HGM wetland types within the WRU**
	Sedimentary (Coastal Lakes)	Lakes and wetland flats
	South Coastal Belt	Channelled and un-Channelled valley bottom wetlands; extensive seepage wetlands (especially in granitic areas)
	South Cape Fold Mountains	Small seeps associated with groundwater-fed springs
	Cape Fold Mountains (Swartberg)	Small seeps associated with groundwater-fed springs
	South-East Coastal Belt	Channelled and un-Channelled valley bottom wetlands
	Klein Karoo	Small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence respectively
	Great Karoo	Small seeps and river-linked wetlands with a likely high degree of direct and indirect groundwater dependence respectively
	Coastal Sedimentary Deposit	Desktop information suggests wetlands are nearly absent due to porous geology lack of shallow water tables/perched water. Isolated interdune depressional wetlands may be present.
	Nama Karoo	Seeps with a likely high degree of groundwater dependence

5.6.3 Application of the data

The classification and delineation of WRU and description of dominant wetland types within these can be used for reporting, assessment and monitoring purposes, as well as to provide some insight and understanding of wetland processes and predictions of likely impacts when WULAs are being evaluated. The WRUs can also be divided according to quaternary catchment areas if appropriate. For the purposes of extrapolation, it should be noted that there is a greater potential for effective extrapolation across catchments but within the same WRU type, than there is likely to be within the individual catchment areas and across WRU boundaries.

Whilst the WRU classification and descriptions provide some insight into the underlying processes of the different types of wetlands across the study area, the quaternary scale PES and EIS for wetlands provides a first step for managing wetlands. Although these data were derived from largely desktop information and are therefore very low confidence, the data could aid in low confidence Wetland Reserve studies associated with the WULAs of small-scale, low impact developments. When assessing the risk of activities on wetlands it is critical to identify underlying processes at the WRU scale. Desktop PES and EIS assessments provided for wetlands at the quaternary catchment scale could be used in conjunction with WRU characteristics to evaluate the potential risks of WULAs. Very low risk WULAs may be able to be evaluated at the desktop level; low to moderate risk WULAs may require at least a brief field-based assessment of the site; whilst moderate to high risk WULAs may necessitate a full wetland Reserve determination study to be initiated.

The PES and EIS of a catchment can additionally be used to inform how wetlands within that area should be managed. For example, high EIS scores in areas where the wetland PES scores are low or moderate would suggest that interventions (such as Working for Wetlands) could be considered to stabilise and/or improve the condition of the wetland. In such areas, developments that result in a net decline in wetland extent or condition would not enable the DWA to achieve the aims of the NWA. Thus developments which result in an overall decline in wetland condition should be discouraged from areas where the REC is to maintain or improve the PES.

The EcoStatus determination of the wetlands (per quaternary catchment) will be undertaken during later tasks of this study. A “bakkie window” assessment of the wetlands across the WMA will be used to confirm:

- HGM wetland types present within the WRUs;
- WRU boundaries and characteristics;
- Land use and threats to wetlands; and
- Desktop EcoStatus assessments of the WMA.

6 REFERENCES

Allanson, B.R., Hart, R.C., O'Keeffe J.H. and Robarts R.D. 1990. Inland Waters of Southern Africa: An Ecological Perspective. Kluwer Academic Publishers, London.

Brinson, M.M. (1993). A hydrogeomorphic classification for wetlands. Wetlands Research Program Technical Report WRP-DE-4. U. S. Army Corps of Engineers, Waterway Experiment Station. Vicksburg, MS: Bridgham and Richardson.

Colvin, C., le Maitre D., and Saayman I. 2007. Aquifer Dependent Ecosystems in Key Hydrogeological Typesettings in South Africa. Water Research Commission, South Africa. Report No. TT 301/07.

Cowardin, L.M., Carter, V., Golet, F.C. and LaRoe, E.T. 1979. Classification of Wetlands and Deepwater Habitats of the United States. FWS-OBS-79-31. US Fish and Wildlife Service, Washington, DC.

Dean, W.R.J. and Milton, S.J. 1999. The Karoo: Ecological Patterns and Processes. Cambridge University Press, 374 pages.

Department of Environmental Affairs and Tourism (DEAT). State of the Environment, http://soer.deat.gov.za/themes.aspx?m=149. Accessed February 2014.

Dennis, I., Withüsser K., Vivier J.J.P., Dennis R. and Mavurayi A. 2012. Groundwater Resource Directed Measures. WRC Report no. TT 506/12.

Department of Water Affairs (DWA). 2009. Resource Directed Measures: Reserve Determination studies for selected surface water, groundwater, estuaries and wetlands in the Outeniqua catchment: Ecological Water Requirements Study. Wetland RDM Report (K10-K50, K60G). Compiled by Rountree, M (Fluvius Environmental Consultants), for Scherman Colloty & Associates. Report no. RDM/K000/02/CON/0607.

Department of Water Affairs (DWA). 2010a. Resource Directed Measures: Reserve Determination studies for selected surface water, groundwater, estuaries and wetlands in the Outeniqua catchment. Groundwater Report. Edition 3. Compiled by Vivier, JJP (AGES), for Scherman, Colloty & Associates. Report no. RDM/K000/02/CON/0507.

Department of Water Affairs (DWA). 2010b. Intermediate Reserve Determination Study for the Surface and Groundwater Resources in the Mokolo Catchment, Limpopo Province: Wetland Report. Authored by Rountree, M.W. (Fluvius Environmental Consultants), for Rivers for Africa and Clean Stream Biological Services, edited by M. D. Louw. RDM Report no. 26/8/3/10/14/015.

Department of Water Affairs (DWA). 2014. All town reconciliation strategies – Strategy Portal: various reports. http://www.dwa.gov.za/projects.aspx Date of access: 15 March 2014.

Department of Water Affairs and Forestry (DWAF). 2005a. Proposal for the establishment of the Gouritz Catchment Management Agency. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (DWAF). 2005b. A practical field procedure for identification and delineation of wetland and riparian areas. Department of Water Affairs and Forestry, Pretoria.

Department of Water Affairs and Forestry (DWAF). 2006a. Department of Water Affairs and Forestry, July 2007, Report No. P WMA 16/000/00/0406. Outeniqua Coast Water Situation Study: Urban and Rural Water Requirements and Return Flows. Prepared by UWP Consulting /BKS.

Department of Water Affairs and Forestry (DWAF), 2006b. Outeniqua Coast Water Situation Study: Groundwater Resources: Report 5, Report No P WMA 16/000/00/047, Pretoria. Prepared by Parsons, R & Veldtman, S for UWP and BKS.

Department of Water Affairs and Forestry (DWAF). 2007. Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and Channeled valley bottom wetland types by M. Rountree (ed); CP Todd, CJ Kleynhans, AL Batchelor, MD Louw, D Kotze, D Walters, S Schroeder, P Illgner, M Uys and GC Marneweck. Report no. N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Department of Water Affairs and Forestry (DWAF). 2008. Resource Directed Measures for Protection of Water Resources: Methodologies for the determination of ecological water requirements for estuaries. Version 2. Pretoria.

Department of Water Affairs and Forestry (DWAF). 2009. Resource Directed Measures: Reserve Determination studies for selected surface water, groundwater, estuaries and wetlands in the Outeniqua (Knysna and Swartvlei) catchment. Draft Groundwater Report. Compiled by Vivier, JJP (AGES), for Scherman Consulting. Report no. RDM/K000/02/CON/0507.

Driver, A., Maze, K., Lombard, A.T., Nel, J., Rouget, M., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas Z., Reyers, B., Sink, K., and Strauss, T. 2004. South African National Spatial Biodiversity Assessment 2004: Summary Report. Pretoria: South African National Biodiversity Institute.

Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel ,J. and Funke, N. 2011. Atlas for Freshwater Ecosystem Priority Areas – Maps to support sustainable development of water resources. Water Research Commission, WRC Report No. TT 500/11.

Ellery, W.N., Kotze, D.C., McCarthy, T.S., Beckedahl, H., Quinn, N., and Ramsey, L. 2005. The Origin and Evolution of Wetlands. Water Research Commission Report, (draft).

Ewart-Smith, J.L., Ollis, D.J., Day, J.A. and Malan, H.L. 2006. National Wetland Inventory: development of a wetland classification system for South Africa. WRC Report No. KV 174/06.

Finlayson, C.M. and Spiers, A.G. (eds). 1999. Global review of wetland resources and priorities for wetland inventory. Supervising Scientist Report 144, Supervising Scientist, Canberra.

Finlayson, C.M, Begg, G.W., Howes, J., Davies, J., Tagi, K. and Lowry, J. 2002. A Manual for an Inventory of Asian Wetlands: Version 1.0. Wetlands International Global Series 10, Kuala Lumpur, Malaysia.

Jones, M.G.W. 2002. Developing a Classification System for Western Cape Wetlands. M.Sc. thesis, University of Cape Town.

Jones, M.G.W. and Day J.A. 2003. A Field Classification System for the Wetlands of the Western Cape. Freshwater Research Unit, University of Cape Town.

Kleynhans, C.J, Thirion C and Moolman J. 2005. A Level I EcoRegion classification system for South Africa, Lesotho and Swaziland. Report No: N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. and Collins, N.B. 2005. A rapid assessment procedure for describing wetland benefits. Mondi Wetland Project.

Louw D, Kotze P, Mackenzie, J. 2010. Scoping study to identify priority areas for detailed EFR and other assessments. Produced for WRP as part of Support to Phase II ORASECOM Basin Wide Integrated Water Resources Management Plan.

MacFarlane, D. (ed) (in prep). River and Wetland Buffer Zone Guideline. Report for the Water Research Commission, WRC, Pretoria.

Marneweck, G.C. and Batchelor, A. 2002. Wetland inventory and classification. In: Ecological and economic evaluation of wetlands in the upper Olifants River catchment. (Palmer

RW, Turpie J, Marneweck GC and Batchelor (eds.). Water Research Commission Report No. 1162/1/02.

Milton, S. and Dean, R.J. 1995. South Africa's arid and semiarid rangelands: why are they changing and can they be restored? Environmental Monitoring and Assessment, 37: 245-264.

Parsons, R. 1995. South African Aquifer system management classification. WRC report no.: KV 77/95.

RAMSAR. 2002. The Ramsar Strategic Plan 2003-2008, Ramsar Convention on Wetlands http://www.ramsar.org/key_strat_plan_2003_e.htm.

Riemann, K. & Blake, D. 2010. Groundwater Reserve determination for the current and potential wellfield development of the TMG aquifers. WRC Report No TT506/12, Pretoria.

Roets, W.Y., Xu, L., Raitt, M., El-Kahloun, P., Meire, F., Calitz, O., Batelaan, C., Anibas, K., Paridaens, T., Vandenbroucke, N., Verhoest, E.C. and Brendonck, L. 2008. Determining discharges from the Table Mountain Group (TMG) aquifer to wetlands in the Southern Cape, South Africa. Hydrobiologia: 607 (1), p 175-186.

Rountree, M.W. and Batchelor, A.L. (in prep). A proposed wetland classification system for Southern Africa.

SANBI. 2009. Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Draft report prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI), Pretoria.

Semeniuk, C.A. and Semeniuk, V. 1995. A geomorphic approach to global classification for inland wetlands. Vegetation 118: 103–124.

Shaw, K.A. and de Villiers, R. (2001). Sensitive Wetlands GIS coverage. 1:50 000 scale. CapeNature, Jonkershoek, Western Cape.

Smuts, T.N. (2012). An archaeological perspective on the nineteenth century development of land, landscape and sheep farming in the Karoo. Thesis submitted for the Degree of Master of Science in the Department of Archaeology, Science Faculty, University of Cape Town.

South African National Water Act; Act 36 of 1998.

Turpie, J.K. 2004. South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 3: Estuary Component. Pretoria: South African National Biodiversity Institute.

APPENDIX A: WETLAND TYPING/CLASSIFICATION

A modification of a hierarchical system for the classification of South African wetlands (Ewart-Smith *et al.*, 2006, with updates by SANBI, 2009) was used in to classify the wetlands in this study. The wetland typing system (DWAF, 2007) uses the underlying contemporary hydrological processes and formative geomorphological setting as the basis of classification.

At the broadest spatial level (Level I), all inland wetlands are classified in a single unit (**Table A.1**). Nested within Level I are two classification systems that operate at smaller spatial scales, *viz*:

Level II: Broad geological groupings of wetlands based on, *inter alia*, underlying dominant geology and/or EcoRegions, which are referred to as Wetland Resource Units (WRUs) in this study.

Level III: Groups of wetlands based on geomorphological and hydrological criteria, referred to as hydrogeomorphic (HGM) wetland types in this study.

In this study, Level II: WRUs were identified using the following information:

- Level I EcoRegion information
- Regional geological series
- Vegetation distribution data
- 1:50 000 topographical maps.
- GIS layers specifically relating to the Western Cape wetlands as follows:
    - Sensitive wetlands (Shaw and de Villiers, 2001).
    - SANBI: Ecosystem status for the Western Cape (Driver *et al.*, 2004).
    - SANBI: Western Cape Wetlands Directory Data (Driver *et al.*, 2004).
- Information on relative wetland size and density.

Table A.1 The nested hierarchical classification system, whereby the HGM wetland types (Level III of the classification) are nested within a larger scale (Level II) of classification units (after DWAF, 2007, and Rountree and Batchelor, in prep.)

Level I: ***System***	**Level II:** ***Wetland Resource Units***		**Level III:** ***Wetland HGM Types***
INLAND	Geomorphic Province/EcoRegion (as defined by the Driver *et al.*, 2004)	Dominant Geology (from 1:250 000 maps)	River
			Lake
			Meandering Floodplain
			Channeled Valley Bottom
			Unchanneled Valley Bottom
			Hillslope seepages (connected)
			Hillslope seepages (isolated)
			Pan
			Flat

The common HGM wetland types within each WRU were then identified and described. The HGM wetland typology (**Section 3.2.1**) is based on the underlying hydrological processes that create and sustain wetlands. The likely sensitivities to particular types of activities, and thus recommendations for future management, can be determined, albeit at low confidence, from this information.

Underlying geology proved to be an important determinant of the HGM wetland types in the study area and also correlated well with the observed wetland densities found within a region. Geology alone accounted for much of the variation in wetland densities and characteristics across the study area. This is to be expected since the underlying geology influences the resultant topography and soils that are derived, which in turn influences the slopes and hydrological characteristics of the water courses that subsequently develop.

Description of HGM Wetland Types

Landform (geomorphological setting or landscape position) and wetland hydrology (the way water flows into, through and out of a wetland system) are commonly acknowledged as the fundamental determinants of the existence of wetlands (Brinson, 1993; Semeniuk and Semeniuk, 1995; Finlayson *et al*., 2002; Jones, 2002; Kotze *et al*., 2005, Ellery *et al*., 2005), and are the foundation for hydrogeomorphic (HGM) classification systems for wetlands (e.g. Brinson, 1993; Semeniuk and Semeniuk, 1995).

Wetland classification systems based on geomorphic and hydrologic aspects are regarded as more robust and consistent than those based on other criteria (Finlayson *et al*., 2002) – because they describe the fundamental reason for the existence of a wetland in a landscape and, accordingly, provide the primary point of departure for wetland classification.

The HGM classification systems described above have previously undergone some adaptations for application in South African Palustrine wetlands (Marneweck and Batchelor, 2002; Jones and Day, 2003; Kotze *et al*., 2005; Ewart-Smith *et al*., 2006). For a review of these adaptations refer to DWAF (2007). The classification system proposed here should be robust and simple enough to allow for application by DWA and DEAT technicians and regional staff. Correct identification of the wetland type is expected to carry a number of consequences for management decisions (for instance, such as how, and at what level, WULAs are to be handled).

Thus on the basis of desktop information and interpretation thereof, it is possible to distinguish a number of different wetland types according to the landscape position in which they are found, and on the assumed flow patterns or hydrological characteristics that typify those HGM wetland types (**Table A.2**).

Table A.2 A wetland typing system for inland wetlands of South Africa (DWAF, 2007)

Landscape setting		Flow pattern within wetland	HGM Wetland Type
Valley Bottoms	*Confined*	Channeled	*River*
		Standing water	*Lake*
	Unconfined	Diffuse	*Unchanneled Valley Bottom*
		Channeled (parallel to valley)	*Channeled Valley Bottom*
		Channeled (meandering across valley; Sinuosity Index > 1.5)	*Meandering Floodplain*
Slopes		Diffuse => diffuse	*Seepage (isolated)*
		Diffuse => surface/channel	*Seepage (connected to channel)*
Crests		Diffuse flow => standing water	*Seepage (connected to pan)*

Landscape setting	Flow pattern within wetland	HGM Wetland Type
	Standing water	*Pan*
Flats	Standing water	*Wetland flat*

This typing system identifies 8 groupings of wetland types (seepage wetlands are grouped into a single unit), which can be identified at a broad desktop level. These eight HGM wetland types are described below.

Rivers

Linear fluvial, eroded landforms that carry channelised flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorges) or within an incised macro-channel. The "river" includes both the active channel (the portion which carries the water) as well as the riparian zone. For the purposes of this wetland report, no further focus has been placed upon the rivers of the study area.

Meandering floodplain

Linear fluvial, net depositional valley bottom surfaces that have a meandering channel which develop upstream of a local (e.g. resistant dyke) base level, or close to the mouth of the river (upstream of the ultimate base level, the sea). The meandering channel flows within an unconfined depositional valley, and ox-bows or cut-off meanders - evidence of meandering – are usually visible at the 1:10 000 scale (i.e. observable from 1:10 000 orthomaps). The floodplain surface usually slopes away from the channel margins due to preferential sediment deposition along the channel edges and areas closest to the channel. This can result in the formation of backwater swamps at the edges of the floodplain margins.

Channelled valley bottoms

Linear fluvial, net depositional valley bottom surfaces that have a straight channel with flow on a permanent, seasonal or ephemeral/episodic basis. The straight channel tends to flow parallel with the direction of the valley (i.e. there is no meandering), and no ox-bows or cut-off meanders are present in these wetland systems. The valley floor is, however, a depositional environment such that the channel flows through fluvially-deposited sediment. These systems tend to be found in the upper catchment areas.

Un-channelled valley bottoms

Linear fluvial, net depositional valley bottom surfaces that do not have a channel. The valley floor is a depositional environment composed of fluvial but may also have some colluvial sediment. These systems tend to be found in the upper catchment areas.

Lakes

These are depressions in the valley bottoms that may be temporarily, seasonally or permanently inundated. Unlike pans, they are not deflationary erosional features, but instead they have, or would have had, an outlet at the downstream end of the valley (a low point); which has been variously blocked or otherwise restricted by dune deposits (e.g. Kosi Bay), terminal moraines (e.g. Lake District; United Kingdom.) or landslides (Lake Fundudzi) or other depositional features across the valley bottom. Within this study area, sand dunes had blocked previously eroded river valleys and when sea levels rose, these interdune depressions have become drowned as the regional water table rose (Allanson *et al*, 1990). The shape of lakes is therefore determined by the surrounding slopes/higher ground rather than deflational processes creating the typical circular or oval pan shape.

Seepage wetlands (isolated or connected)

Hill-slope seepage wetlands are the most common type of wetland (in extent and number), but are also probably the most overlooked. Hillslope seepage wetlands are located on the mid- and footslopes of hillsides, and are connected to valley bottom wetlands or riparian zones. Hillslope seepage wetlands occur where springs are decanting into the soil profile near the surface, causing hydric conditions to develop; or where throughflow in the soil profile is forced up to/near the surface due to impervious layers (such as Plinthite or other impervious layers; or where large outcrops of impervious rock force subsurface water to the surface). Seepage wetlands can also occur connected to (fringing, or surrounding) pan wetlands.

Isolated hillslope seepage wetlands can occur in the hillslope or crest positions of the landscape. As with the other hillslope seepage wetlands, these occur where springs are decanting into the soil profile near the surface, or where throughflow in the soil profile is forced up to/near the surface due to impervious layers.

Pans

Small (deflationary) depressions that are circular or oval in shape; usually found on crest positions in the landscape. The topographic catchment area can usually be well-defined (i.e. a small catchment area following the surrounding watershed). Although often apparently endorheic (inward draining), many pans are “leaky” in the sense that they are hydrologically connected to adjacent valley bottoms through subsurface diffuse flow paths.

Flats

Wetland flats could be expected to occur in specific geologies that have a significant groundwater component (i.e. very pervious rock) where the permanently or seasonally high water table intersects with low-lying portions of the landscape. These troughs in the topography become permanently or seasonally saturated due to the proximity of the water table and wetland conditions are able to develop at these points. Such conditions exist in areas like the Cape Flats; in low-lying sections of the northern KwaZulu-Natal coastal belt and in some low-lying areas of Dolomitic regions.

APPENDIX B: PRIORITISATION PROCESS FOR SOUTHERN CAPE WETLANDS

Prioritisation process

The Southern Cape Wetland Forum is required to provide input towards prioritising wetlands for funding and rehabilitation. Due to the knowledge gap surrounding wetlands in the region, wetlands needed to be identified, mapped and prioritised according to a list of criteria. As an initial step in this process, sixty four wetlands and catchments were identified as prominent in the region. This is by no means an exhaustive list of Southern Cape Wetlands, but probably includes the majority of well-known wetlands and catchments particularly in the lowlands. The initial identification of wetlands and catchments was undertaken in a workshop with members of the Southern Cape Wetland Forum. A small expert group subsequently gathered together to prioritise the identified wetlands according to the following criteria: biodiversity, hydrological intactness, socio-economic, threats, physical condition and strategic importance (i.e. opportunity costs associated with not rehabilitating, and return on investment for rehabilitation interventions).

Criteria (scored on a scale of 1-10):

Biodiversity: This score is based on diversity and/or uniqueness of species and habitats within the wetland, a high score is given if there is a combination of unique species, unique habitats, many different species and/or habitats. A high score is assigned to systems with high biodiversity. A wetland can however have a high score with just a few unique species.

Hydrological intactness: This score is based on the degree of functionality the wetland still has and the importance of its function to the larger drainage system (e.g. downstream). For example many wetlands and catchments are impacted by alien species, abstraction and infrastructure such as roads, weirs and dams, all of which alters the hydrology of the system. A high score is given if the system is still largely intact and/or is important to the hydrological functioning of the larger aquatic drainage system.

Socio-economic/poverty: This score is based on the importance, or potential importance of the system for local economies, and poverty alleviation opportunities. High scores are given if the system is currently providing water to towns and land users, is used for recreation and/or tourism; and/or has the potential to provide socio-economic benefits through poverty alleviation projects.

Threats: This score is based on the short to medium term level of threat on the system. This is in reference in particular to erosion, alien invasive species, water abstraction, pollution, and infrastructure (e.g. residential development) development that may impact the system. A wetland that faces a high degree of threat has a high score.

Physical condition: This score is based on the current physical condition of the wetland system, a system that is pristine will have a high score, and a highly degraded system will have a low score. A wetland system in good physical condition and with high level of hydrological intactness would not be in need of rehabilitation (unless to mitigate some imminent threat to that system).

Strategic importance of rehabilitation (opportunity cost / return on investment / likelihood of success): This score is based on the likelihood of success of undertaking strategic rehabilitation interventions, the opportunity costs of not intervening and the likely return on investment for undertaking the rehabilitation interventions required. Essentially it is based on a rapid costs benefit analysis, done with the knowledge among the experts that informed the scoring. A high score is awarded if a small investment would make a big difference to the rehabilitation of the wetland system, and which would have a high likelihood of success. Such wetland systems should be prioritised for rehabilitation investment. A low score was given where rehabilitation interventions would be very expensive, for very little or any meaningful benefit. In some cases a number of small interventions may be sufficient to solve the core problems, whilst in many cases nothing can actually be done practically in terms of rehabilitation.

Note: many of the scores were given in comparison to other similar systems.

Notes for each wetland:

The following are brief notes that indicate what was discussed in order to decide on the particular score for each aspect of each wetland. In some cases there was no discussion and a score was given intuitively.

Groot River (incl. Nature's Valley):
Biodiversity: this is quite a diverse and pristine system, there are two red data book fish species. The system does not really have wetlands upstream as it is a narrow steep system. There are fynbos seeps in the mountains. There are several systems that are similar systems in terms of biodiversity, so it is not unique. The Upper Groot River is mostly contained within a conservation area so it is fairly secure. A pristine area like this should be important as it has a high corridor function.
Socio-economic/poverty: socio-economic benefit/potential is low; there are not many houses there.
Threats: possible development and water abstraction. Sewage is only a minor problem in Nature's Valley.
Physical condition: the system is virtually pristine physically.
Strategic: a Strategic intervention could be to raise the road, and move three houses, this could solve the artificial breaching problem of the estuary system. A high input for a relatively low return, so a low score.

Salt River system (Crags):
Biodiversity: this is probably comparable to the Groot River, particularly in invertebrates, as it has no fish.
Hydrological intactness: there is more water going out of this river than the previous example; however there is still a fair amount flowing down it.
Socio-economic/poverty: it is providing water, there is the possibility of tours by local communities.
Threats: the threats to this system are high- Kurland Polo Estate in particular- sewerage and pollutants from the estates, the threat is quite high because it's pristine downstream, there are also plans to pipe water to Plettenberg Bay from this system.
Physical condition: it is currently still fairly pristine.

Strategic: alien removal in upper catchments could be done.

Upper Palmiet (Soetkraal/Keurbooms)
Biodiversity: this area was last burnt in 2005, so there is a large alien invasive problem. There is headway with removing aliens as 10 years ago it was completely degraded with wattle, hakea and pine. An important fish species is found here: *Pseudobarbus* - it is the only place where it does not co-occur with alien fish, it is also the most endangered fish in SANParks land.
Hydrological intactness: it flows into the Keurbooms River so it is important, however there are also alien invasive plants (AIPs).
Socio-economic/poverty: it is feeding into a big system where there is a lot of development. Plettenberg Bay is taking water from the Keurbooms River.
Threats: AIPs are a threat in the whole catchment, but it is being dealt with.
Physical condition: it seems fairly unmodified, AIPs may have changed it, it is eroded towards the east, but unsure.
Strategic: there is already an existing project here and it is also in a conservation area.

Keurbooms River catchment (upper)
Hydrological intactness: it is important as it feeds the entire Keurbooms area.
Socio-economic/poverty: it is an important area, score similar to Upper Palmiet- but slightly higher because it is bigger.
Threats: very high threat due to the amount of AIPs everywhere, there are also trout farms in this system.
Physical condition: in the upper areas there was a lot of erosion- there are also dams, but to get in there it would be very expensive.
Strategic: there are many small problems that can be dealt with.

Keurbooms River (lower)
Biodiversity: high- seahorses etc.
Hydrological intactness: there is a road that runs over it with drainage. It is also completely dependent on what happens upstream.
Socio-economic/poverty: recreation is high as it is linked to the whole Keurbooms Estuary.
Threats: water abstraction, the possibility of increased water abstraction and pollution from the town.
Physical condition: the road has impacted on the system.
Strategic: One intervention could be to move the car park which is in the way of the breech.

Tshokwane wetland (lower Keurbooms)
Threats: proposed development. Currently draining. Alien plants. Mining nearby and roads.
Strategic: road needs better drainage, change culverts.

Bitou River lower / estuary
Biodiversity: has a unique mixture of biodiversity. No alien fish occur here yet.
Hydrological intactness: waste water return flow
Threats: there is a lot of development planned, polo fields.
Strategic: the only intervention would be to try curb development, otherwise there is not much that can be done.

Piesang River
Biodiversity: very degraded.
Hydrological intactness: inter-basin transfer, dams.
Socio-economic/poverty: high value as the town relies on the water.
Threats: high from development (sewage, dumping, municipal dump seepage etc.)
Physical condition: physical condition is probably acceptable in terms of the estuary at the bottom of the system.
Strategic: Some rehabilitation potential at the Roodefontein Golf Estate. There are some opportunities in the upper catchment.

Robberg vlei
Not much was known about this vlei amongst the expert group, scoring was done intuitively.
Threats: are probably high from development and storm water etc.

Packwood (dairy farm)
The same as above, not much is known about this wetland.
Threats: From dairy farming effluent.

Noetsie River/estuary (Kruisfontein)
Biodiversity: not too special however there is an interesting mixture of habitats: forests, fynbos etc.
Socio-economic/poverty: important tourism attraction with a high amount of recreational use.
Threats: high threat from a number of sources: plantations, informal settlements, industrial areas, developments, abstraction demands, golf course etc. which are all found upstream. Comparable with the Salt river system.
Physical condition: estuarine section is still fine but the upper river is non-existent in some plantation areas.
Strategic: water demand management, there are some small opportunities- but it's a very steep system so it would be expensive, opportunities that exist around settlement and industrial area- good advice.

Bigai River (Knysna Golf Course)
Biodiversity: not much, it's an urbanised river system, presence of *Typha* is an indication that it is degraded, but this will help to filter the water before going into the Knysna Estuary.
Socio-economic/poverty: it is near to areas of poverty, it is important locally but not for tourism.
Threats: high effluent from Hornlee and Hunters Home, erosion etc.

Knysna estuary/floodplain
Biodiversity: important, number of special species etc.
Hydrological intactness: hydrology is influenced by the sea, but the hydrology may have changed over time due to bridges etc.
Socio-economic/poverty: it is a major tourism drawcard.
Threats: 90% of the flood plain is modified, there is also threat from abstraction, more development etc.
Physical condition: quite a lot could be done: there are a number of pipelines draining into it- these areas could physically be rehabilitated, more storm water control- purifying etc. these interventions would be expensive but it is a high profile area so it could be done.

Salt River system (Knysna)
Biodiversity:
Hydrological intactness: large quantities of siltation, there is an informal settlement above it.
Socio-economic/poverty: there is a large community of people living in poverty nearby. It is comparable to the Bigai River.
Threats: high threats particularly from sewerage.
Physical condition: not good, but probably better than the Bigai River, which also has alien species.
Strategic: education and clean-up exercises could be done, intervention measures would be expensive.

Upper Knysna catchment (including Gouna)
Biodiversity: high biodiversity: there is still a lot of Palmiet, Gouna- has high biodiversity, Knysna River has important invertebrates and there are a diversity of habitats (big pools, vleis, etc.) in this system which is very rare.
Hydrological intactness: mostly intact, 99% of water abstraction comes from lower parts of this system. There are some plantations in Gouna.
Socio-economic/poverty: It is important because it's feeding into the Knysna Estuary and providing water.
Threats: there are a number of threats such as erosion and AIPs, however this is being addressed. It's not as bad as the Palmiet, but no one has looked into it much.
Physical condition: Gouna is good, but there are plantations and dairy farms, Knysna is not in as good a condition but there is clearing going on.
Strategic: A lot of high altitude AIP removal work would have to be done which is expensive.

Goukamma estuary/floodplain
Biodiversity: into Marine Protected Area.
Threats: development in floodplain.

Goukamma/Homtini upper catchment
Biodiversity: the mountain catchment is fairly good. There are farmlands in the middle reaches, the system rejuvenates slightly towards lower reaches.
Hydrological intactness: the headwaters are not very impacted.
Socio-economic/poverty: a lot of people depend on it, but it's not that crucial.
Threats: aliens, agriculture.
Physical condition: there are some nice forested gorges.
Strategic: alien removal, erosion could be solved but it is steep terrain.

Vankerwelsvlei
(there is another small similar one higher up- and was impacted by trees- dried up-found by FSC-forest stewardship council)
Biodiversity: extremely unique aspargnum wetland (forms the peat). A plant survey has just been done.
Hydrological intactness: very intact, groundwater fed by the TMG aquifer - not affected by the plantations at all.
Socio-economic/poverty: it is not really benefiting anyone *per se*, but the plantation owners won't touch it- it's safe. It could have tourism potential.

Threats: TMG abstraction would be the only perceivable threat.
Physical condition: good.
Strategic: low cost for high return- tourism- signage etc.

Ruigtevlei
Biodiversity: very saline, mainly reeds, not a unique system, plantations surround it.
Hydrological intactness: there are a number of roads, it's possibly been fairly modified in the past 100 years- there may have been more links between this and Groenvlei.
Socio-economic/poverty: not a lot of value.
Threats: plantations- water level could have been affected by the plantations, it also in the aeolian sand dune system. Probably also groundwater fed.

Groenvlei
Biodiversity: It is the only endoheic coastal lake and the water level is about 3 meters above sea-level. Very unique.
Hydrological intactness: hydrology changed.
Socio-economic/poverty: it is important for recreation such as bass angling. Essentially all lakes in this area are fairly important for tourism, etc.
Threats: There are a number of threats: alien fish, bass, carp, tilapia etc, groundwater use, pollution, hydrological changes and development.
Physical condition: still good.
Strategic: interventions would include curbing groundwater use and development and control alien fish (carp- have decreased from fishing, which is good news). Some can be solved, could do more signage and interpretation.

Perdespruit
Hydrological intactness: it is completely altered, it used to be one of the temporary channels that was part of the bigger system when flooding. The connectivity with Swartvlei has been lost. There are culverts.
Threats: threats are getting worse- AIPs etc.
Physical condition: Road culverts etc.
Strategic: In order to restore this system- millions of rands would have to be invested, all the constrictions would have to be removed and the N2 would have to be moved. This is therefore not viable.

Swartvlei system estuary/floodplain
Biodiversity: the biodiversity is high, many species of fish, birds and plants etc. It is one of the few clear water systems in the country that has high plant diversity.
Hydrological intactness: flood plain is altered and breaching is altered, but 75% of its mean annual runoff still flows into it.
Socio-economic/poverty: it is important for recreation, boating, tourism etc.
Threats: high threats: golf estates- decision coming soon for rezoning- will abstract 1/3 of water, loads of development, ongoing and progressive threats.
Physical condition: condition still seems to be fairly good, there were physical changes from the rain. Bridge altered the flow but seems to have reached a new equilibrium.
Strategic: this is a water management issue.

Karatara
Biodiversity: similar to Diep and Wolwe river.
Hydrological intactness: the most modified of the three, abstraction is high.
Socio-economic/poverty: need water for Sedgefield from this system.
Threats: abstraction, AIPs, but there are two clearing programmes going on.
Physical condition: probably quite good, nor heavily eroded.
Strategic: not much that can be done, they are building a dam.

Hoëkraal
Threats: golf estate and Sedgefield inter-basin transfer.
Strategic: In the upper reaches there are possible exit areas, which could provide opportunities for erosion preventions mechanisms, etc.

Klein Wolwe
Hydrological intactness: highly modified, impounded by farm dams etc.
Socio-economic/poverty: important for industry.
Threats: dairy farming.
Physical condition: lowest in terms of the River Health Assessment.
Strategic: there have been effluent spills- milk by-products. could do artificial wetlands before it goes into the estuary to purify water- so there is opportunity.
Highly modified, lowest in terms of river health assessment.

Wolwe/Diep River
Threats: A possible threat is the reversal of the forestry exit decision – there could be reforestation pressure.
Physical condition: there is a lot of development in the middle reaches, with changes to the riparian zone, localised erosion, etc.

Wilderness Lakes system
Biodiversity: It is a national park and a RAMSAR site.
Hydrological intactness: it is modified, it does still get breached, the percentage of loss of flow is high.
Socio-economic/poverty: very important for recreation and tourism.
Threats: creeping development, effluent, etc.
Physical condition: there is a lot of modification, emergent vegetation because the flooding has been altered.
Strategic: there are some small interventions that could help, rehabilitate the vegetation, and do artificial flooding.

Duiwe River/Langvlei Spruit
Hydrological intactness: it is a perennial river that stops flowing- altered.
Socio-economic/poverty:
Threats: increased agricultural use.
Physical condition: August ’08 floods affected it severely in lower reaches, it is eroded.
Strategic: it is quite an inaccessible region so interventions would be costly.

Touw River
Biodiversity: this system extends to the top of Outeniqua, mostly falls into protected areas.
Hydrological intactness: only a small amount of abstraction.
Socio-economic/poverty:
Threats: Abstraction will increase, another 35% is predicted to be abstracted for Wilderness, there is also threat from pollution, sewerage pipes, etc.
Physical condition: the condition is still fairly good, it is not incised, AIP clearing has been ongoing.
Strategic: Can't stop development, but can sort out the AIPs.

Kaaimans River system
Socio-economic/poverty: extremely important for George.
Threats: high, a dam is being built.
Physical condition: still in good condition.
Strategic: alien control, but it is a very steep system.

Gwaing River system
Biodiversity: it is an urban river that runs through George, with a large number of wetlands throughout the area, it is fairly degraded.
Socio-economic/poverty: golf courses, etc., benefit.
Threats: very high: development, pollution, waste water discharge from Waste Water Plant.
Strategic: alien clearing, river rehabilitation, it would be a good investment to remove Alien Invasive Plants (AIPs) in these wetlands as they are easily accessible.

Maalgate River system
Hydrological intactness: there are numerous farm dams.
Socio-economic/poverty: many people benefit- farming.
Threats: AIPs, farming activities.
Strategic: AIP clearing, not much can be done about farm dams.

Outeniqua strand/Glentana
Not much was known about this system amongst the experts.
Physical condition: highly damaged in the August 2008 floods, probably not in good shape now.

Grootbrak estuary/floodplain
Hydrological intactness: there is a dam, they have increased the release from the dam, it is highly modified.
Threats: from development, 80% of Grootbrak is under the floodplain.
Strategic: water management.

Grootbrak plateau/Varings River
Threats: aliens and farming, there are a lot of applications for increased abstraction for farming.
Physical condition: abstraction.
Strategic: alien clearing.

Geelbeksvlei/Brandwag River
Threats: aliens, water abstraction.

Strategic: not much can be done.

Moordkuil River
Biodiversity: Palmiet wetlands in this system.
Hydrological intactness: still intact, mostly AIPs affect the flow, abstraction high.
Socio-economic/poverty: important.
Threats: heavy AIP infestation.
Strategic: alien clearing can be done- wattle.

Kleinbrak estuary
Biodiversity:
Hydrological intactness: hydrology is not great.
Socio-economic/poverty: recreation- boating and fishing.
Threats: flood plain has an informal settlement on it, abstraction, sewerage spills, and development and AIPs.
Physical condition: not in bad condition but affected.
Strategic: alien clearing higher up in the reaches.

Goukou River system
Biodiversity: Fairly pristine for a Palmiet system.
Socio-economic/poverty: supply of water, and farms depend on it.
Threats: farming, AIPs.
Physical condition: fairly pristine, lower down it is degraded. Two of the tributaries are degraded.
Strategic: Rehabilitation/operational/infrastructure costs high as one structure that needs to be built.

Duiwenhoks east (upper)
Socio-economic/poverty: it flows into the Duiwenhoks Dam which supplies a large amount of water.
Threats: major headcut and some farming.
Strategic: operational costs are high.

Duiwenhoks east (upper)
Hydrological intactness: degraded.
Physical condition: not much left, essentially just an erosion gully.
Strategic: could be rehabilitated slightly, the wetlands need to be rehydrated, but this will be very costly. However, in the long term it would save the entire system downstream.

Goukou estuary /lower reaches (Stilbaai)
Biodiversity: Palmiet wetland system, permanently open, nursery area for fish.
Hydrological intactness: marine system, lower part driven by the sea. Large quantities of sediment washing into the channel due to wattle infestation.
Socio-economic/poverty: town depends on it.
Threats: development, AIPs and farming.
Strategic: not much can be done in lower reaches.

Duiwenhoks estuary
Biodiversity: probably similar to the Goukou in terms of biodiversity.

Hydrological intactness: hydrology worse affected than Goukou though.
Socio-economic/poverty: not that important.
Threats: lower threats than Goukou, AIPs upstream.
Strategic: not much can be done.

Upper Groot Doring Seep zone (draining into the Karoo)
Biodiversity: high species diversity.
Hydrological intactness: fairly intact.
Socio-economic/poverty: feeds into the Doring River system, many farmers probably benefit.
Threats: severe groundwater abstraction in the area around Zebra railway station.
Strategic: not much can be done.

APPENDIX C: COMMENTS AND RESPONSE REGISTER

Page and/or Section	Report Statement	Comments	Changes Made?	Author Comment
Comments: Mike Smart, DWA - June 2014				
Page 2-1		Suggest "Indications of overexploitation of groundwater has in the past been noted in the vicinity of Leeu Gamka dam,"	Yes	
Page 2-2		,,,,,,,,,,,,,"abstracted form deep ,*often confined*, fractured rock…….. "	Yes	
Section 3.2.1		Since it has been "proven". Be careful of this statement and the basis on which it is considered to have been proven.	Yes	Checked and updated.
Table 3.1		Consider separating Witteberg group from GRU9.	Yes	
Table 3.3		Not necessarily indicative of aquifer stress	Yes	Wording corrected.
Table 3.4		Accompanying map needed; how calculated?	Yes	Map included and text updated.
Section 5		Consider more focus on groundwater dependant wetlands in identifying groundwater "hot spots"	No	This verification will be undertaken during the study.
Section 5.3		Geology section needs attention (Tillites in Cape Supergroup? Malmesbury Group/ Kango? Enon?)	Yes	Note that geology only briefly discussed as part of wetland delineation.
Section 5.6.2		TMS with shale intrusions???	Yes	