WP 10543

REPORT NO. RDM/WMA16/00/CON/0313, Volume 2

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 2

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

Copyright reserved

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 2. Prepared by Scherman Colloty & Associates cc. Report no. RDM/WMA16/00/CON/0313, Volume 2.

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 2
DATE:	April 2014
AUTHORS:	Rivers for Africa eFlows Consulting (Pty) Ltd: Delana Louw
EDITOR:	Scherman Colloty & Associates
REVIEWERS:	Project Management Team
LEAD CONSULTANT:	Scherman Colloty & Associates
REPORT NO:	RDM/WMA16/00/CON/0313, Volume 2
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 Cilllers/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 members of the study team authored this report:

Author	Company
Louw, Delana	Rivers for Africa eFlows Consulting (Pty) Ltd
MacFadyen, Sandra	Private (GIS analysis and maps)

REPORT SCHEDULE

Version	Date
First draft	April 2014
Second and final draft	September 2014

EXECUTIVE SUMMARY

INTRODUCTION

This document reports on the delineation of the river systems and selected Ecological Water Requirement (EWR) sites to be assessed during the Reserve study for the Gouritz Water Management Area.

RESOURCE UNITS (RUs)

Resource Units are required as it may not be appropriate to set the same numerical Reserve for the headwaters of a river as for the lowland reaches. Different sections of a river frequently have different natural flow patterns, react differently to stress according to their sensitivity, and require individual specifications of the Reserve appropriate for that reach. The approach adopted was to consider both Natural Resource Units (NRUs) and Management Resource Units (MRUs) and to take account of the following aspects:

- *EcoRegion classification of the river system*
- *Geomorphological zonation in which channel gradient has been found to be a dominant factor*
- *Land cover*
- *Management and operation of the river system*
- *Water quality considerations*
- *Local knowledge*
- *Desktop Present Ecological State (PES)*

*The MRUs selected are summarised in **Table 1**:*

Table 1: MRU summary table

MRU	*Rationale*
Duiwenhoks River	
MRU Duiwenhoks A	*The similar relief and land use with a distinct break at the Duiwenhoks Dam result in the selection of the MRU.*
MRU Duiwenhoks B	*The PES is a D/E due to the land use with the dominant impact being on the riparian zone. Heidelberg is at the end of the MRU with associated water quality problems. The end of MRU B is due to the change in relief with the river now in a steep valley (gorge) which results in a riparian buffer zone being present.*
MRU Duiwenhoks C	*Steep river valley with irrigation in the higher regions. End of MRU is at the estuary.*
Goukou River	
MRU Goukou A	*The mountainous area with limited use is included in the much more extensive irrigation area as the mountainous area cannot be operated differently from the downstream area. The break is at the Vet River tributary at Riversdale. This tributary is in an E category and this, with the Riversdale water quality impact, changes the situation downstream.*
MRU Goukou B	*See above. The riparian buffer zone is in a marginally better condition than upstream, but extensive alien vegetation occurs. End of MRU is at the estuary.*
Buffels River	
MRU Buffels A	*The MRU represents the area that is very similar to NRU A and is dominated by the mountainous area in good ecological condition. The downstream end of the MRU is situated at Floriskraal Dam as a logical management break. The most downstream section includes Laingsburg and some irrigation down to the*

MRU	Rationale
	Floriskraal Dam.
MRU Buffels B	*This area is different from upstream as it is dominated by irrigation.*
Touws River	
MRU Touws A	*The MRU A ends where the irrigation decreases and the river state improves. Most of the operational possibilities for managing the downstream MRU is situated in MRU A.*
MRU Touws B	*As there are no operational changes in this section and the land use is largely homogenous, this reach comprises the downstream MRU.*
Gamka River	
MRU Gamka A	*Similar land use with limited operational capability apart from Gamkapoort Dam which form the logical end point of the MRU.*
MRU Gamka B	*Releases from the dam for irrigation and extensive irrigation around Calitzdorp provide the rationale for delineating a MRU.*
Olifants River	
MRU Olifants A	*Unregulated and minimal use.*
MRU Olifants B	*Operation from Stompdrift Dam.*
MRU Olifants C	*Impacts from Oudtshoorn and the Grobbelaars and Kammanassie rivers.*
Kammanassie River	
MRU Kammanassie A	*Kammanassie Dam is the only operational breakpoint and was selected as the end of this MRU. PES is also better than the PES downstream of the Kammanasssie Dam*
MRU Kammanassie B	*See above.*
Gouritz River	
MRU Gouritz A	*Change from mountainous area to more open area (lowland), change in land use, change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.*
MRU Gouritz B	*See above. Open area, irrigation, slightly worse PES.*
Keurbooms River	
MRU Keurbooms A	*Change from mountainous area to more open area (lowland), change in land use, change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.*
MRU Keurbooms B	*See above. Open area, irrigation, slightly worse PES.*

EWR SITES

Well established criteria and processes (Louw et al., 1999) were adopted to select EWR sites for further analysis. EWR sites and summarised criteria is provided in ***Table 2****.*

Table 2: EWR site summary

EWR site name	SQ	River	EcoRegion Level II	Geomorphic Zone	Altitude (m)	MRU	Quat.
Duiwenhoks_EWR1	*H80E-09314*	*Duiwenhoks*	*22.02*	*E Lower Foothills*	*15*	*MRU Duiwehoks C*	*H80E*
Goukou_EWR2	*H90C-09229*	*Goukou*	*22.02*	*E Lower Foothills*	*87*	*MRU Goukou A*	*H90C*
Touws_EWR3	*J12M-08904*	*Touws*	*19.07*	*E Lower Foothills*	*271*	*MRU Touws B*	*J12M*
Gamka_EWR4	*J25A-08567*	*Gamka*	*19.09*	*E Lower Foothills*	*375*	*MRU Gamka B*	*J25A*
Buffels_EWR5	*J11H-08557*	*Buffels*	*19.09*	*E Lower Foothills*	*499*	*MRU Buffels B*	*J11H*
Gouritz_EWR6	*J40B-09106*	*Gouritz*	*19.08*	*E Lower Foothills*	*121*	*MRU Gouritz A*	*J40B*

EWR site name	SQ	River	EcoRegion Level II	Geomorphic Zone	Altitude (m)	MRU	Quat.
Doring_EWR7	*J12L-09895*	*Doring*	*19.07*	*E Lower Foothills*	*370*	*N/A*	*J12L*
Keurbooms_EWR8	*K60C-09882*	*Keurbooms*	*20.02*	*D Upper Foothills*	*161*	*MRU Keurbooms B*	*K60C*
Olifants_EWR9	*J31D-08592*	*Olifants*	*19.01*	*E Lower Foothills*	*621*	*MRU Olifants A*	*J31D*
Kammanassie_EWR10	*J34C-8869*	*Kammanassie*	*19.01*	*E Lower Foothills*	*445*	*MRU Kamma-nassie A*	*J34C*

Note: Quat. = quaternary

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

CD:WE	Chief Directorate: Water Ecosystems
CMA	Catchment Management Agency
DWA	Department of Water Affairs
EI	Ecological Importance
ES	Ecological Sensitivity
EWR	Ecological Water Requirement
MRU	Management Resource Unit
NRU	Natural Resource Unit
NWA	National Water Act
PES	Present Ecological State
RAU	Reserve Assessment Unit
RU	Resource Units
SQ	Sub Quaternary
WMA	Water Management Area
WWTW	Wastewater Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The National Water Act (Act No. 36 of 1998) (NWA), Chapter 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: Water Ecosystems (CD: WE) within the Department of Water Affairs (DWA) is tasked with the responsibility of ensuring that the Reserve is determined to enable the use in the assessment of water allocation and licensing applications.

The requirement for detailed Reserve determination 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.

1.2 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 (2005) 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).

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

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

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

1.3 PURPOSE OF THIS REPORT

The purpose of this report is to provide:

- The information used to define the river Resource Units (RUs).
- The delineation of the RUs in the study areas.
- Information on the Ecological Water Requirement (EWR) sites.

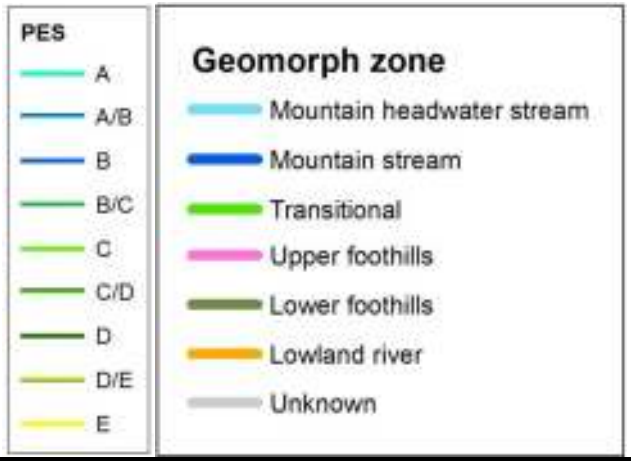
Note that this report only focuses on river Resource Units. The term Resource Units is also used within the wetland Reserve approaches as well as the groundwater component of the Reserve, but in a different context. The delineation of estuary, wetland and groundwater RUs are described in DWA (2014a).

1.4 STRUCTURE OF THIS REPORT

Please note for interpretation of all maps:

The Present Ecological State (PES) and geomorphic zone legends for standard colours are provided below and not repeated on maps further in this document. The purpose of different colours in all other maps (Natural Resource Unit (NRU), EcoRegions, Management Resource Unit (MRU), land use) ONLY illustrates the delineation changes from e.g. one land use to another). The colours are not specific to e.g. any type of land use.

Generic PES and geomorphic zone legends and standard colours:



The report structure is as follows:

- **Section 1**: Introduction
  - This section
- **Section 2**: River reach demarcation and delineation
  - Describes the approach to determining Resource Units and the selection of EWR sites
- **Section 3–11**: Resource Units: River name
  - Describes the NRUs and MRUs as well as the EWR sites for each of the rivers selected as hotspots and where EWR sites were selected

2 RIVER REACH DEMARCATION AND DELINEATION

2.1 APPROACH

If an Ecological Reserve determination is required for a whole catchment, it is necessary to delineate the catchment into RUs. These are each significantly different to warrant their own specification of the Reserve, and the geographic boundaries of each must be clearly delineated (DWAF, 1999, Volume 3).

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

2.1.1 Natural Resource Units

Based on the above approach, the breakdown of a catchment into RUs for the purpose of determining the Reserve for rivers is therefore done primarily on a biophysical basis within the catchment and called NRUs. EcoRegions and geomorphic zones are the major criteria that are considered.

2.1.2 Management Resource Units

Management requirements (DWAF, 1999, Volume 3) also play a role in the delineation. An example could be where large dams and/or transfer schemes occur. Furthermore, the type of disturbance/impact on a river plays a role to select homogenous river reaches from a biophysical basis under present circumstances. These are called MRUs.

The delineation process considers all of the above issues. Overlaying all the data does not necessarily result in a logical and clear delineation and therefore expert judgement, a consultative process and local knowledge are required for the final delineation. The practicalities of dealing with numerous reaches within one study must also be considered to determine a logical and practical suite of MRUs.

MRUs can be further delineated in even smaller assessment units and the approach for this is described in DWAF (2008).

The EWRs are determined for each MRU by means of the following (Louw and Hughes, 2002):

- An EWR site is selected within the MRU and represents a critical site within the relevant river section. Results generated at the EWR site will then be relevant for the MRU as a whole.
- If no EWR site can be selected within the MRU, extrapolated results from an adjacent representative MRU with an EWR site are used. The reasons for an EWR site not being selected within the MRU can be the following:
    - The characteristics of the river within the MRU do not meet the criteria for EWR sites.
    - Due to the number of MRUs within the study area, it is not practical and/or cost-effective to

address EWR sites within each MRU.

2.2 RESOURCE UNIT CONSIDERATIONS

2.2.1 EcoRegions (Level II)

The EcoRegion typing approach developed in the USA (Omernik, 1987) was applied and tested at a preliminary level in South Africa. EcoRegional classification or typing will allow the grouping of rivers according to similarities based on a top-down approach. The purpose of this approach is to simplify and contextualise assessments and statements on Ecological Water Requirements (EWRs). One of the advantages of such a system is the extrapolation of information from data rich rivers to data poor rivers within the same hierarchical typing context (eco-regional type).

The first more holistic step was to use available information to delineate EcoRegion boundaries at a very broad scale (i.e. Level I) for South Africa. Attributes such as physiography, climate, rainfall, geology and potential natural vegetation were evaluated in this process and 18 Level I EcoRegions were identified (Kleynhans *et al*., 2005). The next Level II (Kleynhans *et al*., 2007), used the same attributes but in more detail. Physiography can for example, be explored in more detail by considering terrain morphological classes, slopes, relief, altitude, etc. An EcoRegion map is included as Appendix A as an example.

2.2.2 Geomorphological zonation

Rowntree and Wadeson (1999) have developed a zonal classification system for Southern African rivers modified from Noble and Hemens (1978). In their classification an attempt was made to give each zone a geomorphological definition in terms of distinctive channel morphological units and reach types. After working in a number of different rivers around the country it has become clear that channel gradient is a good indicator of channel characteristics and that probable or expected difference can be identified from an analysis of gradients (**Table 2.1**).

Table 2.1 Geomorphological Zonation of River Channels (adapted from Rowntree and Wadeson, 1999)

Longitudinal zone	Characteristic channel features	
	Zone	Description
Mountain headwater	A	A very steep gradient stream dominated by vertical flow over bedrock with waterfalls and plunge pools. Normally first or second order Include bedrock fall and cascades.
Mountain stream	B	Steep gradient stream dominated by bedrock and boulders, locally cobble or coarse gravels in pools. Reach types include cascades, bedrock fall, step-pool, Approximate equal distribution of 'vertical' and 'horizontal' flow components.
Transitional	C	Moderately steep stream dominated by bedrock or boulder. Reach types include plain-bed, pool-rapid or pool riffle. Confined or semi-confined valley floor with limited flood plain development.
Upper Foothills	D	Moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plain-bed, pool-riffle or pool-rapid reach types. Length of pools and riffles/rapids similar. Narrow flood plain of sand, gravel or cobble often present.
Lower Foothills	E	Lower gradient mixed bed alluvial channel with sand and gravel dominating the

Longitudinal zone	Characteristic channel features	
	Zone	Description
		bed, locally may be bedrock controlled. Reach types typically include pool- riffle or pool-rapid, sand bars common in pools. Pools of significantly greater extent than rapids or riffles. Flood plain often present.
Lowland river	F	Low gradient alluvial fine bed channel, typically regime reach type. May be confined, but fully developed meandering pattern within a distinct flood plain develops in unconfined reaches where there is an increased silt content in bed or banks.

2.2.3 Land cover

The land cover was provided as part of the national PES and Ecological Importance (EI) – Ecological Sensitivity (ES) project (referred to as the national PES/EI/ES project) for WMA 16 (DWA, 2013a), but in this case was updated by extensive Google Earth viewing and ground-truthing.

2.2.4 System operation

After identifying NRUs, which are based largely on natural hydrology, EcoRegions and geomorphological zonation, MRUs must be defined. The overriding aspects in terms of identifying MRUs are the land cover (a surrogate for land use) and the closely related management and operation of the water resources within the study area. MRUs therefore have to consider the different operational structures, management and constraints regarding Reserve implementation. Mostly qualitative information is required to describe the operation and this is usually available at the onset of the Reserve study based on various previous studies.

2.2.5 Local knowledge

Any expert information that could contribute to the assessments are considered and used.

2.2.6 Present Ecological State

The desktop PES is also considered in the MRU delineation as it provides an indication of the response of the river to the operation of the system, land use and land cover. The PES is determined following the procedures in Kleynhans and Louw (2007). The Desktop PES has been provided at sub-quaternary (SQ) reaches (DWA, 2013a) and reviewed within this study.

2.3 RIVERS SELECTED IN THE GOURITZ WMA FOR RU DELINEATION

Hotspots have been defined in DWA (2013b). Hotspots used in this context are defined as areas that warrant detailed investigations. Logically, these are the rivers in which key biophysical nodes or EWR sites are to be selected. EWR assessments at these sites will follow a Rapid III, Intermediate or Comprehensive level of EWR assessment which implies that results should have confidence which is higher than desktop level.

The process on the selection of the hotspot rivers for MRU delineation and the results are described in detail in DWA (2014b); including maps showing hotspot areas. The rivers selected for detailed EWR assessment and that therefore requires RU delineation are:

- Duiwenhoks (Two SQ hotspots)
- Goukou and tributaries (Four SQ hotspots)
- Buffels/Groot (13 SQ hotspots)
- Touws (Three SQ hotspots)
- Doring (Three SQ hotspots)
- Gamka (20 SQ hotspots)
- Olifants (20 SQ hotspots) (upper section only)
- Kammanassie (Three SQ hotspots)
- Gouritz (11 SQ hotspots)
- Keurbooms (2 SQ hotspots)

The results of the assessment for each of these rivers are described in **Sections 3–11** in this report.

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

2.4 CRITERIA FOR EWR SITE SELECTION

EWR sites are selected through a multi-disciplinary process consisting of evaluating an aerial video (if available) or Google Earth images of the river to identify a range of possible sites, and ground-truthing to make a final selection from the various options. An EWR site consists of a length of river which includes one or various cross-sections for both hydraulic and ecological purposes (modified from Louw *et al*., 1999). The EWR site is nested within an RU.

EWRs are determined at each of the EWR sites, and it is therefore vital that:

- The sites are selected to provide as much information as possible about the variety of conditions in a river reach.
- The specialists that need to use these sites to set flow requirements for their discipline can relate to the habitat the sites represented.
- The persons involved in selecting the sites understand and are experienced in the use of sites in EWR studies.

The selection of EWR sites is guided by a number of considerations, including (modified from Louw *et al.,* 1999):

- The locality of hotspots.
- The locality of gauging weirs with good quality hydrological data.
- The locality of new proposed and existing developments.
- The locality and characteristics of tributaries.
- The habitat integrity or PES of the different river reaches.

- The boundaries of Level II EcoRegions within the study area.
- The reaches where people depend directly on a healthy river ecosystem and use of its goods and services for their day to day existence (Basic Human Needs Component).
- The suitability of the sites for follow-up monitoring.
- The locality of geomorphologically representative sites.
- The habitat diversity for aquatic organisms, marginal and riparian vegetation.
- **The suitability of the sites for accurate hydraulic modelling throughout the range of possible flows, especially low flows.**
- **Accessibility of the sites.**
- **An area or site that could be critical for ecosystem functioning. These are often represented by riffle units, where low flow conditions or the cessation of flow constitutes a break in the functioning of the river, and consequently, the biota dependant on this habitat and/or perennial flow are adversely affected. Pools are not considered critical habitats in perennial system since they are still able to function or at least maintain life during periods of no flow.**

The criteria in **bold** are the most important and carry more weight.

---

3 RESOURCE UNITS: DUIWENHOKS RIVER

3.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Duiwenhoks River are described in **Figure 3.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within one EcoRegion (Level II), i.e. 22.02 and is dominated by the Lower Foothills geomorphic zone. Within the first mountainous section, various geomorphic zones occur. The estuary falls within the Lowland river zone. The Lowland section as represented by the estuary falls largely outside of the river assessment. Due to the major difference between the mountainous zone (river flowing east to west) and the southeast flowing section in terms of geomorphic zones, two NRUs are selected. The NRUs are described as NRU Duiwenhoks A and B and the delineation information are provided in **Table 3.1**.

3.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 3.2**. The description of the MRUs and the rationale for selection is provided below and in **Table 3.2**.

System operation and land use:
The main storage dam in the H80 secondary catchment (Duiwenhoks River Dam (6 million m³)) supports irrigation activities (Duiwenhoks Government Scheme) and domestic supply to the town Heidelberg and to Duiwenhoks Rural Water Supply Scheme. Many farm dams that support irrigation are also found in this catchment. Current water requirements exceed supply and the catchment can be regarded as stressed.

Present Ecological State:
The upper reaches of the Duiwenhoks River (H80A-09154 and H80B-09149) are subjected to primarily non-flow related impacts (agriculture), with the Duiwenshoks Dam situated in the lower reaches of H80A-09154, resulting in an overall PES of C. The flow modification and water quality impact of the Duiwenhoks Dam are more significant in the next downstream reach of the Duiwenhoks River (H80C-09208) and, together with the agricultural impacts (including irrigation) and Heidelberg town result in a deteriorated PES of D/E. The Duiwenhoks River improves slightly in the lower reaches (H80D-9286 and H80D-9314) to a category D but is still impacted notably by flow modification (Duiwenhoks Dam and abstraction for irrigation) as well as non-flow related activities (farming).

MRU rationale:
The PES and land use provides the motivation for the MRU delineation. The operation of the system is different upstream and downstream of the Duiwenhoks Dam, therefore the river reach upstream of Duiwenhoks Dam forms the MRU A. Downstream of the Duiwenhoks Dam the land use is mostly irrigation with Heidelberg as the urban centre. The change in relief and change in water quality (downstream of Heidelberg) result in this reach being delineated into two MRUs (**Table 3.2**).

3.3 EWR SITE SELECTION

Considering the criteria for site selection, the most suitable position for an EWR site is in the mountainous area that represents a PES of a B. As this section is in the best condition, it would provide good indicators for EWR determination. However, an EWR site in MRU A would not be of use in managing the river downstream of the Duiwenhoks Dam (the main operating system), and neither would it be useful in providing scenarios for estuary EWR determination at the bottom of the system. As an EWR site should also not be located in a D/E section of river (i.e. upstream of Heidelberg), it was located in Duiwenhoks MRU C (**Figure 3.3**). Access was limited but the presence of a gauging weir and associated access indicated a possible area for site selection. Google Earth scrutiny indicated a possible riffle downstream of the gauging weir and ground-truthing confirmed the locality of a suitable riffle. The river is disturbed (locally) due to the low water crossing, local sand mining and extensive alien vegetation, but as choices were limited due to access limitations, this site was selected.

Site details are provided in Appendix B and the site locality and characteristics are illustrated in **Figure 3.3**.

Table 3.1 Duiwenhoks: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Duiwenhoks A	22.02: 99.2% 19.08: 0.8%	Upper foothills: 63% Lower foothills: 14% Transitional:13% Mountain headwater: 7 % Mountain: 2%	The break is formed by the change in relief (outside of mountains and an almost 90 degree change in flow direction) as well as the different geomorphic zones downstream of the mountain.	From the source to the confluence with H80C-09208. Start: -33.943899; 21.117558 End: -34.008175; 20.919144
NRU Duiwenhoks B	22.02: 100%	Lower Foothills: 93% Upper Foothills: 5% Lowland: 2%	The downstream break is influenced by the change in geomorphic zone and the delineation ends at the start of the estuary.	To the start of the estuary End: -34.254621 20.996017

Table 3.2 Duiwenhoks: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Duiwenhoks A	22.02: 99% 19.08:1%	Upper foothills:57% Lower foothills:17% Transitional: 15% Mountain headwater: 9 % Mountain: 3%	Coincides with the area dominated by mountains and irrigation farming.	The similar relief and land use with a distinct break at the Duiwenhoks Dam result in the selection of the MRU.	Start: -33.943899; 21.117558. End: -33.997117; 20.947614.	H80A
MRU Duiwenhoks B	22.02: 100%	Lower Foothills: 68% Upper foothills: 32%	Extensive irrigation to edge of river with limited riparian zone. Includes Heidelberg with associated water quality problems at the end of the MRU.	The PES is a D/E due to the land use with the dominant impact being on the riparian zone. Heidelberg is at the end of the MRU with associated water quality problems. The end of MRU B is due to the downstream change in relief with the river now in a steep valley (gorge) which results in a riparian buffer zone being present.	End: -34.111940; 20.968688.	H80B H80C
MRU Duiwenhoks C	22.02: 100%	Lower Foothills: 96% Lowland: 4%	Subsistence grazing, rural settlements, sediments.	See above. Steep river valley with irrigation in the higher regions. End of MRU is at the estuary (refer to Volume 1).	End: -34.254621 20.996017	H80C H80D

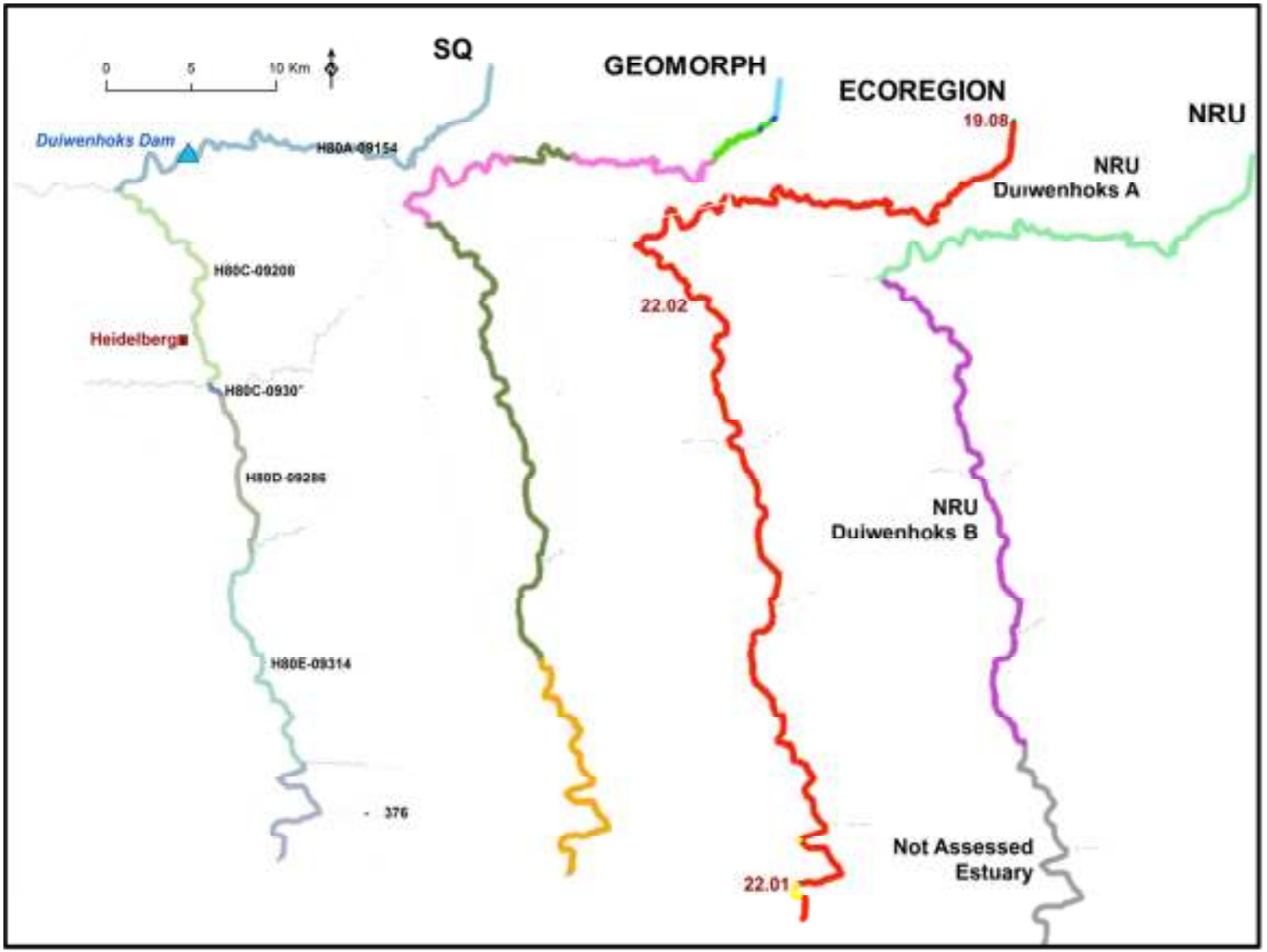


Figure 3.1 Duiwenhoks River: EcoRegions, geomorphological zones and Natural Resource Units

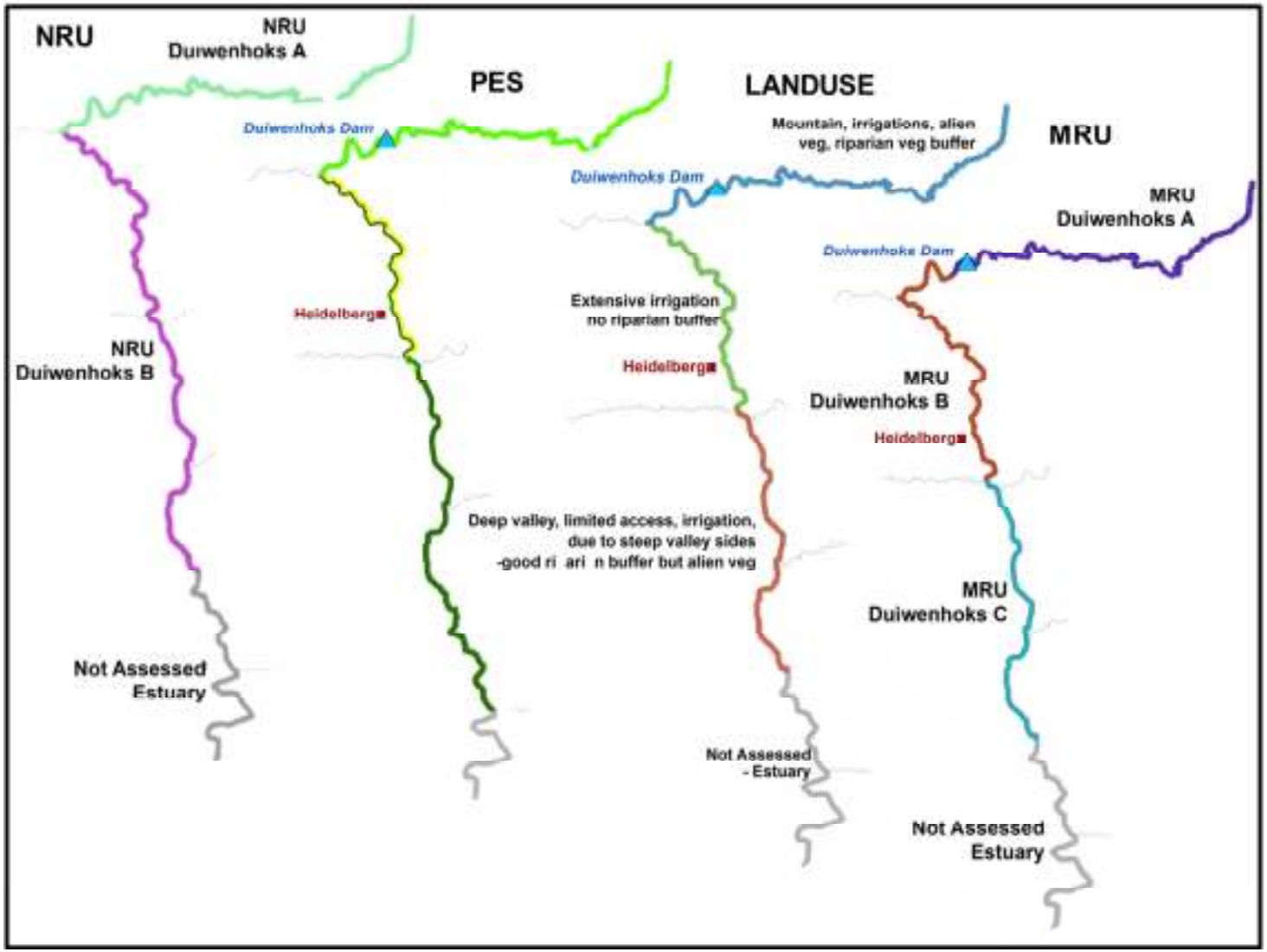


Figure 3.2 Duiwenhoks River: PES, operation, land use and Management Resource Units

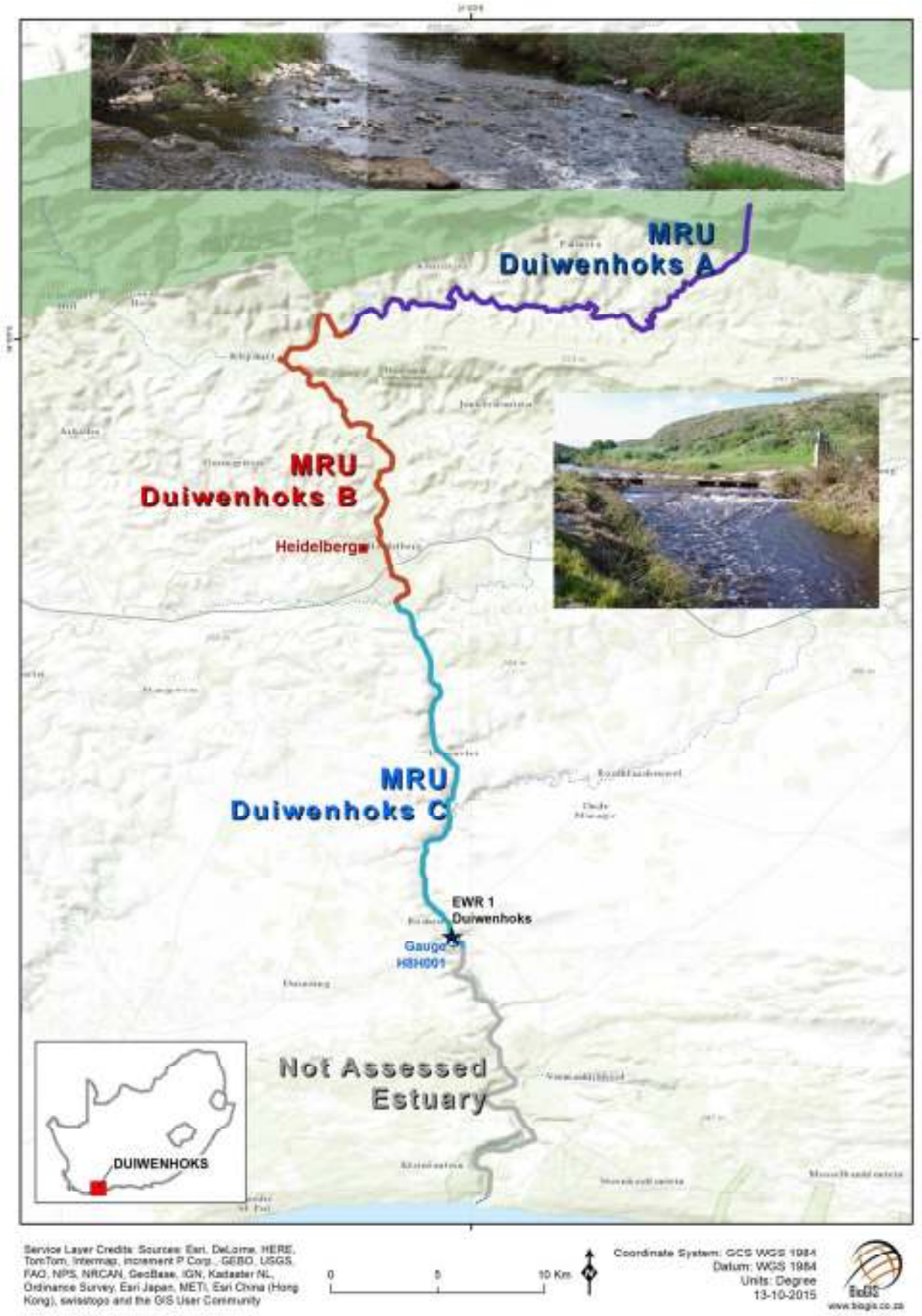


Figure 3.3 Duiwenhoks_EWR1 (Duiwenhoks River) locality and photographs

4 RESOURCE UNITS: GOUKOU RIVER

4.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Goukou River are described in **Figure 4.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls mostly in one EcoRegion (Level II), i.e. 22.02 and is dominated by the Lower Foothills geomorphic zone. Within the first mountainous section, various geomorphic zones occur. This is followed by a relatively short section of Upper Foothills. This geomorphic zone, including the variety of upstream zones, has been placed in one NRU. The lower section to the estuary which coincides with the Lower Foothills geomorphic zone forms the second NRU. The NRUs are described as NRU Goukou A and B and the delineation information are provided in **Table 4.1** and **Figure 4.1**.

4.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 4.2**. The description of the MRUs and the rationale for selection is provided in **Table 4.2**.

System operation and land use:
The Korinte-Vet Dam (8 million m³) in the Korintepoort River together with farm dams support irrigation for vineyards, fruit, pastures and vegetables as well as domestic use in Riversdale (H90C/E). Some forestry is found in the upper reaches (H90A). Irrigation farming is therefore the dominant land use. Based on the intensity of the land use, two zones were identified, the more intensive zone with centre pivots and Riversdale in the upper river and the less intensive irrigation activities with a more defined buffer zone in the lower river. A mountain zone with very little use is situated at the source area.

Present Ecological State:
The Goukou River originates in the Spioenkop Nature Reserve and later flows through the Broomvlei (Kruis River) Nature Reserve, but impacts related to agricultural activities and alien vegetation result in a PES of C. The lower Goukou (H90D-09287, H90D-09316 & H90D-09318) downstream of Riversdale is impacted by the aggregated impacts of the upstream reaches together with localised agriculture, Riversdale urban runoff and wastewater treatment works (WWTW), resulting in PES of D, with an improvement in the lower reach H90E-09343 to a C PES due to reduced localised impacts.

MRU rationale:
The PES and land use provides the motivation for the MRU delineation. The town of Riversdale is seen as a logical border for an upstream MRU. Within MRU A (**Figure 4.2**), the impact of tributaries (one which is in an E Category (Vet River)) has an incremental impact culminating with the water quality impacts at Riversdale. The change in relief and change in water quality (downstream of Riversdale) result in this reach being delineated into two MRUs (**Table 4.2**).

4.3 EWR SITE SELECTION

Considering the estuary requirements and system operation, an EWR site towards the downstream end of the system would be preferable. However, the downstream section is influenced by Riversdale impacts as well as the impacts of the Vet Tributary. Access and suitable sites are also problematic in the downstream reach. Therefore, the hotspot section in SQ H90C-09229 which lies immediately upstream of this area and includes a gauging weir was targeted for EWR site selection. A suitable riffle was found upstream of the gauging weir and was selected as the EWR site.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 4.3**.

Table 4.1 Goukou: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Goukou A	22.02: 93% 19.08: 7%	Upper Foothills: 54% Mountain: 29% Transitional :13% Mountain headwater: 4%	The break is formed by the change in geomorphic zones. This section is a mixture of zones combining the mountainous zone with the Upper Foothills zone.	From the source to the start of the Lower Foothill Zone. Start: -33.947592; 21.412137 End: -34. 040922.; 21.354109
NRU Goukou B	22.02: 90% 22.01:10%	Lower Foothills:100%	The downstream break is based on the change in geomorphic zone and the end of the zone is represented by the estuary.	End (start of the estuary): -34.296638; 21.309826

Table 4.2 Goukou: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Goukou A	22.02: 96% 19.08: 4%	Upper Foothills: 43% Lower Foothills: 31% Mountain: 16% Transitional : 7% Mountain headwater: 3%	Dominated extensively by irrigation farming. Farm dams, Riversdale, and impacts from tributaries.	The mountainous area with limited use is included in the much more extensive irrigation area as the mountainous area cannot be operated differently from the DS area. The break is at the Vet River tributary at Riversdale. This tributary is in an E and this, with the Riversdale water quality impact, changes the situation downstream.	Start: -33.947592; 21.412137 End: -34.110172; 21.284482.	H90A H90C
MRU Goukou B	22.02: 86% 22.01: 14%	Lower Foothills:100%	Irrigation but an improve riparian buffer zone due to steeper valley sides.	See above. The riparian buffer zone is in a marginally better condition than upstream, but extensive alien vegetation occurs. End of MRU is at the estuary (refer to Volume 1).	End (start of the estuary): -34.296638; 21.309826	H90D

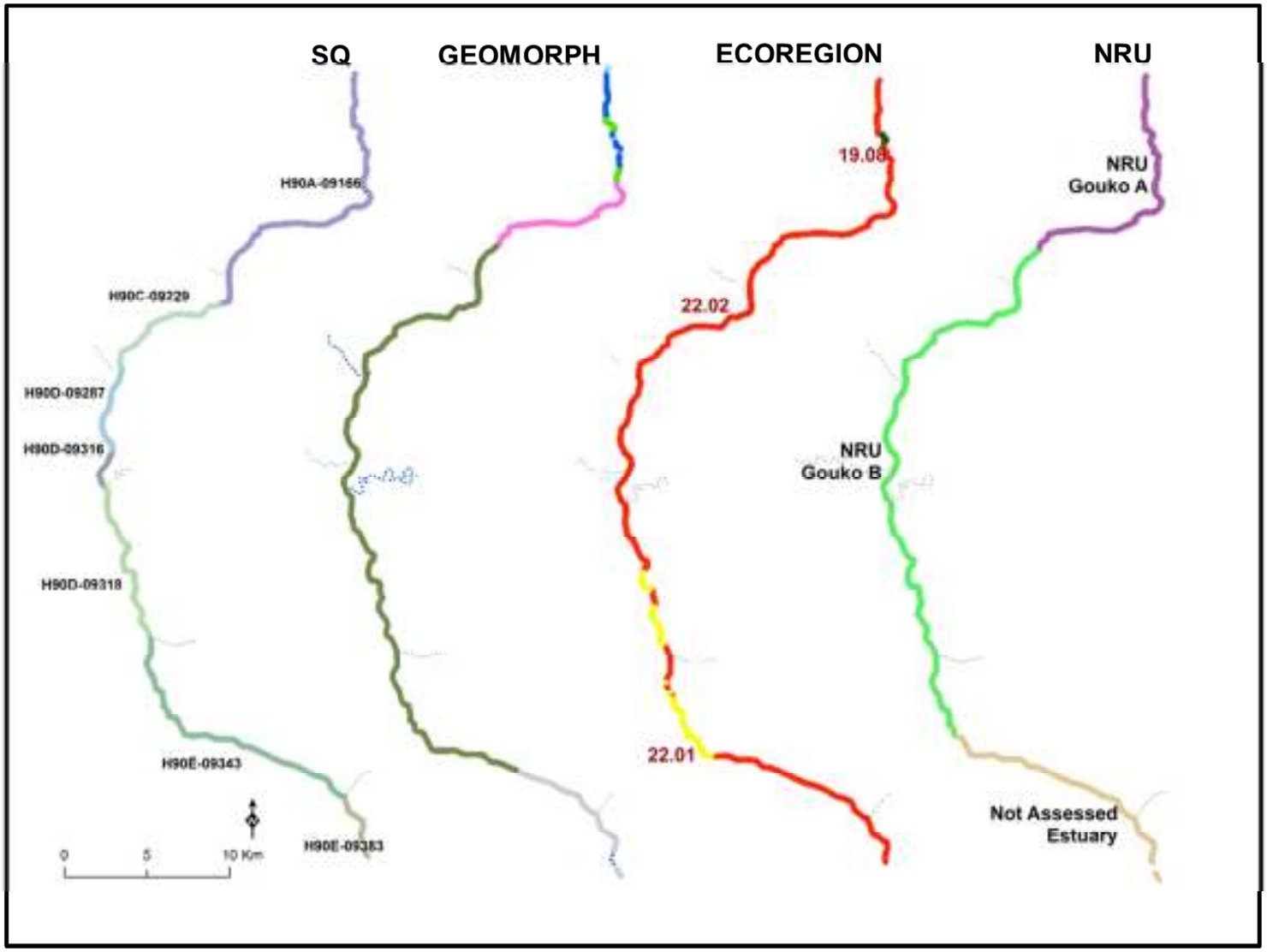


Figure 4.1 Goukou River: EcoRegions, geomorphological zones and Natural Resource Units

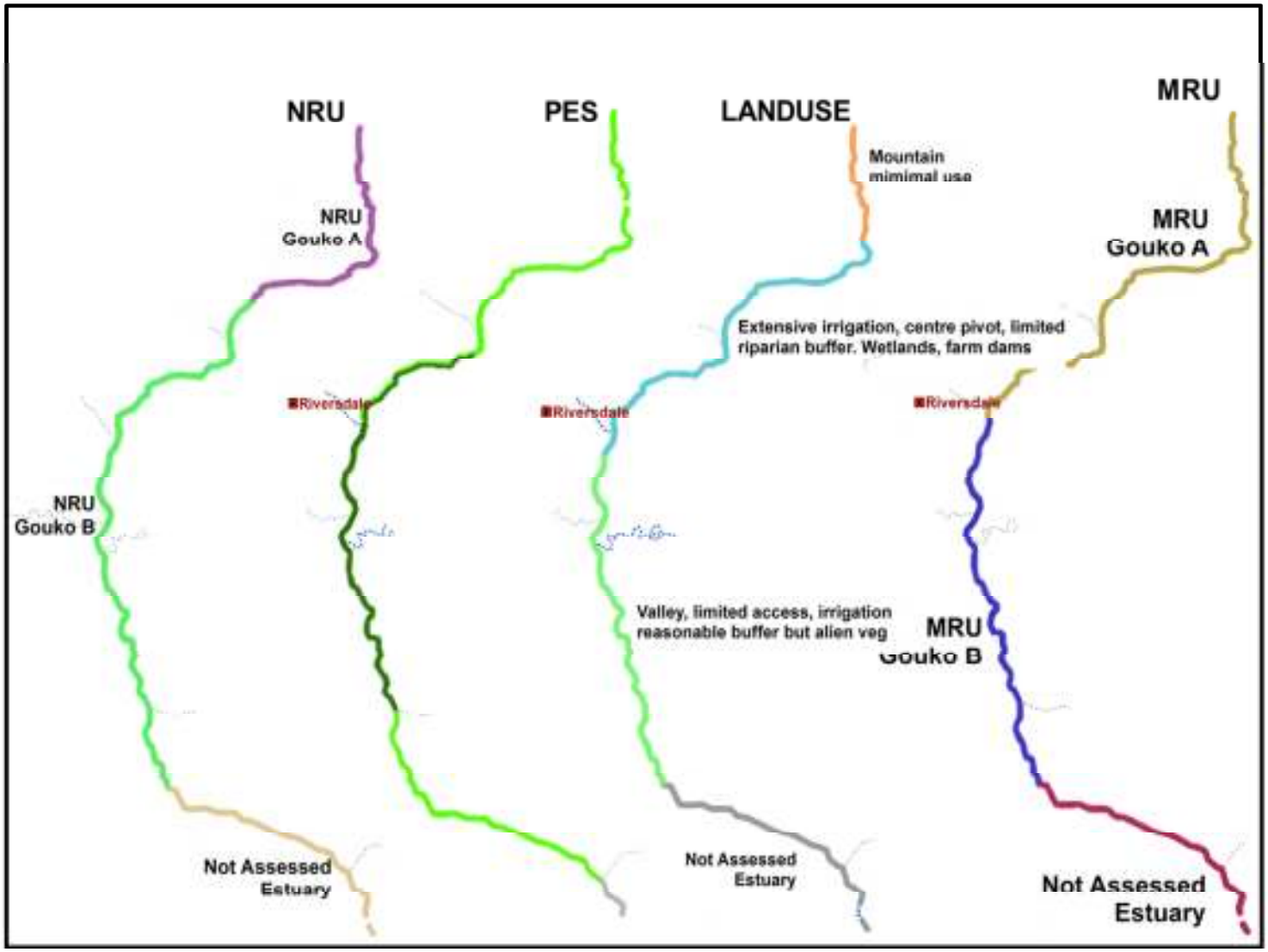


Figure 4.2 Goukou River: PES, operation, land use and Management Resource Units

Figure 4.3 Goukou_EWR2 (Goukou River) locality and photographs

5 RESOURCE UNITS: BUFFELS RIVER

5.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Buffels River are described in **Figure 5.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within five EcoRegions (Level II), i.e. 21.03, 19.07, 19.09 and 19.01 and is dominated by the Lower Foothills geomorphic zone. As the geomorphic zones do not provide any motivation for a break in NRU, the Level one EcoRegions (21 and 19) are used as the NRUs. The NRUs are described as NRU Buffels A and B and the delineation information are provided in **Table 5.1**.

5.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 5.2**. The description of the MRUs and the rationale for selection is provided in **Table 5.2**.

System operation and land use:
The main dam in the Buffels River is the Floriskraal Dam (50 million m³) at the outlet of J11G. The catchment area upstream of this dam is typical Karoo with very little development. Some irrigation (9 million m³/a) is practised downstream of this dam. The catchment is stressed as a result of irrigation demands exceeding supply. Some perennial streams in J11H and J11J rise in the Swartberg mountains. J13 shows limited irrigation from farm dams.

Present Ecological State:
Most of these streams occur in mountainous areas and have low impacts. Overall, the PES of this area is in a category B or higher. Impacts are predominantly agriculture, irrigation and small farm dams. Some alien plant species also occur in the area. Downstream of Floriskraal Dam most of the reaches are in C or D categories with the exception of J11H-08647 and J13C-09099 which are a category B. Other than the mainstream Buffels and Groot rivers being impacted by the Floriskraal Dam there is also extensive irrigation in the area and associated agriculture which fragments and deteriorates the riparian zone and associated floodplains. Alien plant species have invaded some areas.

MRU rationale:
The MRUs are largely based on the land use that links to the PES. MRU A (**Figure 5.2**) situated upstream of Floriskraal Dam forms a logical end to the MRU from an operational viewpoint. The MRU is dominated by minimal land use and therefore is largely a good PES. The lower end of the MRU has some irrigation and the town Laingsburg is situated in it, however the Floriskraal Dam downstream of this has been selected as a logical cut off point from a future management point of view.

MRU B is situated downstream of Floriskraal Dam. Irrigation occurs next to the river where the relief allows. This results in the river being in a lower PES apart from areas which are protected within two poorts. These areas have been identified as Reserve Assessment Units (RAUs) and are nested within the MRU. The RAU is used to demarcate and describe a reach of river within the MRU with the most critical habitat in the MRU. Usually the RAU would be of a too short length to warrant its own MRU, but it provides an indication of where the critical areas are in an MRU and therefore guides the selection of EWR sites. These two RAUs are referred to as RAU Buffels B.1 and RAU Buffels B.2. Both RAUs have a higher PES than the rest of the river due to the reach being protected within a poort.

5.3 EWR SITE SELECTION

The EWR site had to be selected in MRU Buffels B being downstream of Floriskraal Dam which provides the only (albeit slight) opportunity for managing the river in terms of supplying the EWR. The two RAUs provide an indication of where to select the EWR site. The downstream RAU Buffels B.2 has limited access and is not situated near a gauging weir. The upstream RAU is closer to Floriskraal Dam which does have a gauge, measuring outflows and spills and can therefore be used during flood flows. A suitable site was found and selected in RAU B.1. It must be noted that severe flooding took place on 8 and 9 January 2014 and this will complicate assessment of the EWRs.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 5.3**.

Table 5.1 Buffels: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Buffels A	21.03: 100%	Upper foothills: 52% Lower foothills:45% Transitional: 2% Mountain: 1%	The break is formed by the change in EcoRegion from 21 to 19. This section is dominated by lower and upper Foothills zone.	From the source (J11A-07820) to the start of 19.07. Start: -32.727269; 20.689912 End: -33. 238519.; 20.915843
NRU Buffels B	19.07: 69% 19.01: 18% 19.09: 10% 19.08: 3%	Lower Foothills:98% Upper Foothills: 2%	The downstream break is based on the change the change to EcoRegion 19 and consists of only the Lower Foothills geomorphic zone.	End (confluence with the Gouritz): -33.888653; 21.655907

Table 5.2 Buffels: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Buffels A	21.03 (93%) 19.07 (7%)	Lower foothills:49 % Upper foothills: 48% Transitional: 2% Mountain: 1%	Mostly mountainous areas with limited use. Laingsburg and some irrigation in the lower section.	The MRU represents the area that is very similar to NRU A and is dominated by the mountains area in good ecological condition. The downstream end of the MRU is situated at Floriskraal Dam as a logical management break. The most downstream section includes Laingsburg and some irrigation to the Dam.	From the source (J11A-07820) to the Floriskraal Dam: Start: -32.727269; 20.689912 End: -33.273725; 20.984904	J11A J11C J11E J11F
MRU Buffels B	19.07 (67%) 19.01 (19%) 19.09 (11%) 19.08 (3%)	Lower Foothills:98% Upper Foothills: 2%	Irrigation (dominant land use) where relief allows.	This area is different from upstream as it is dominated by irrigation with a worse PES.	End (confluence with the Gouritz): -33.888653; 21.655907	J11H, J, K J13A, B, C

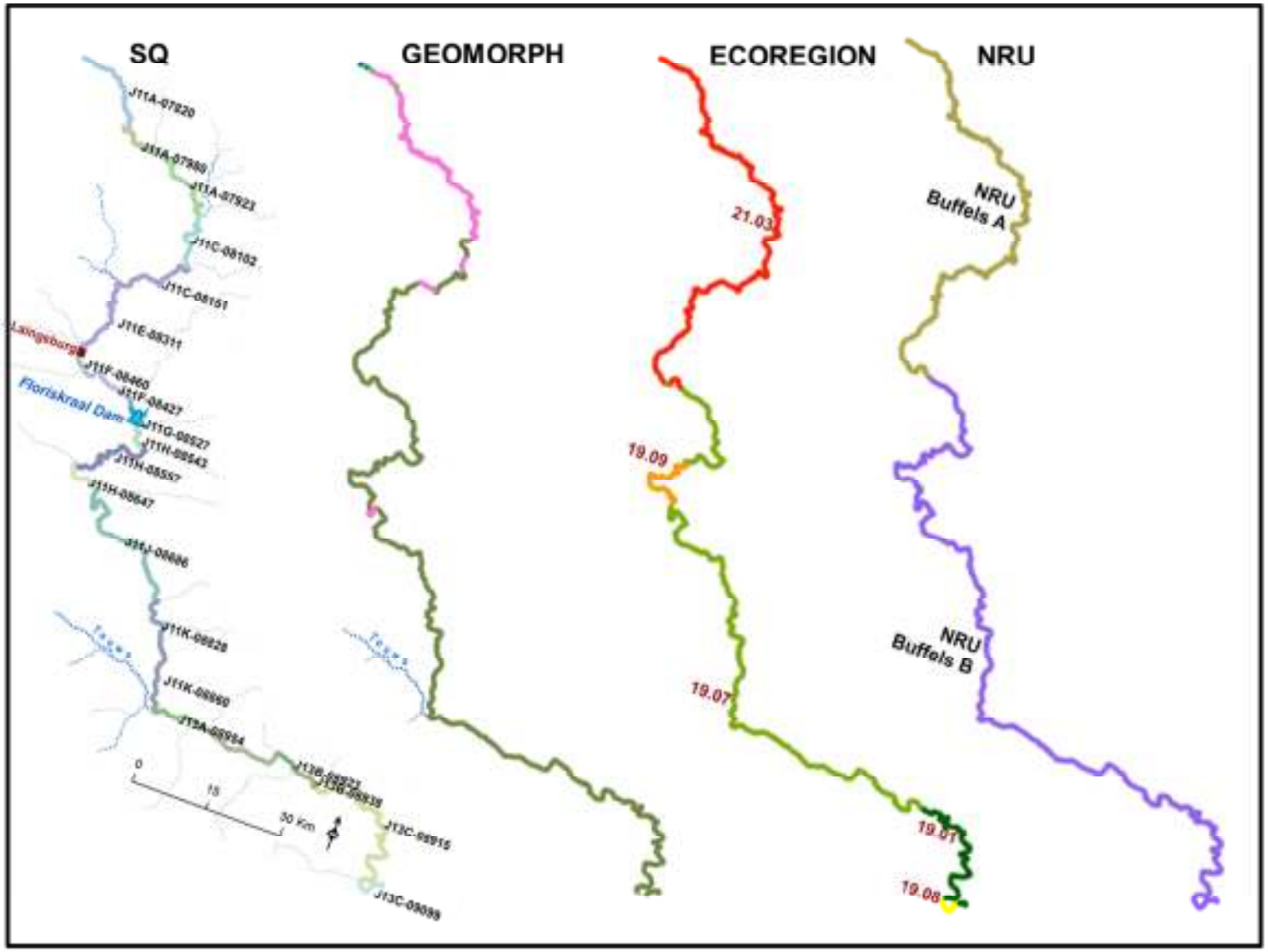


Figure 5.1 Buffels River: EcoRegions, geomorphological zones and Natural Resource Units

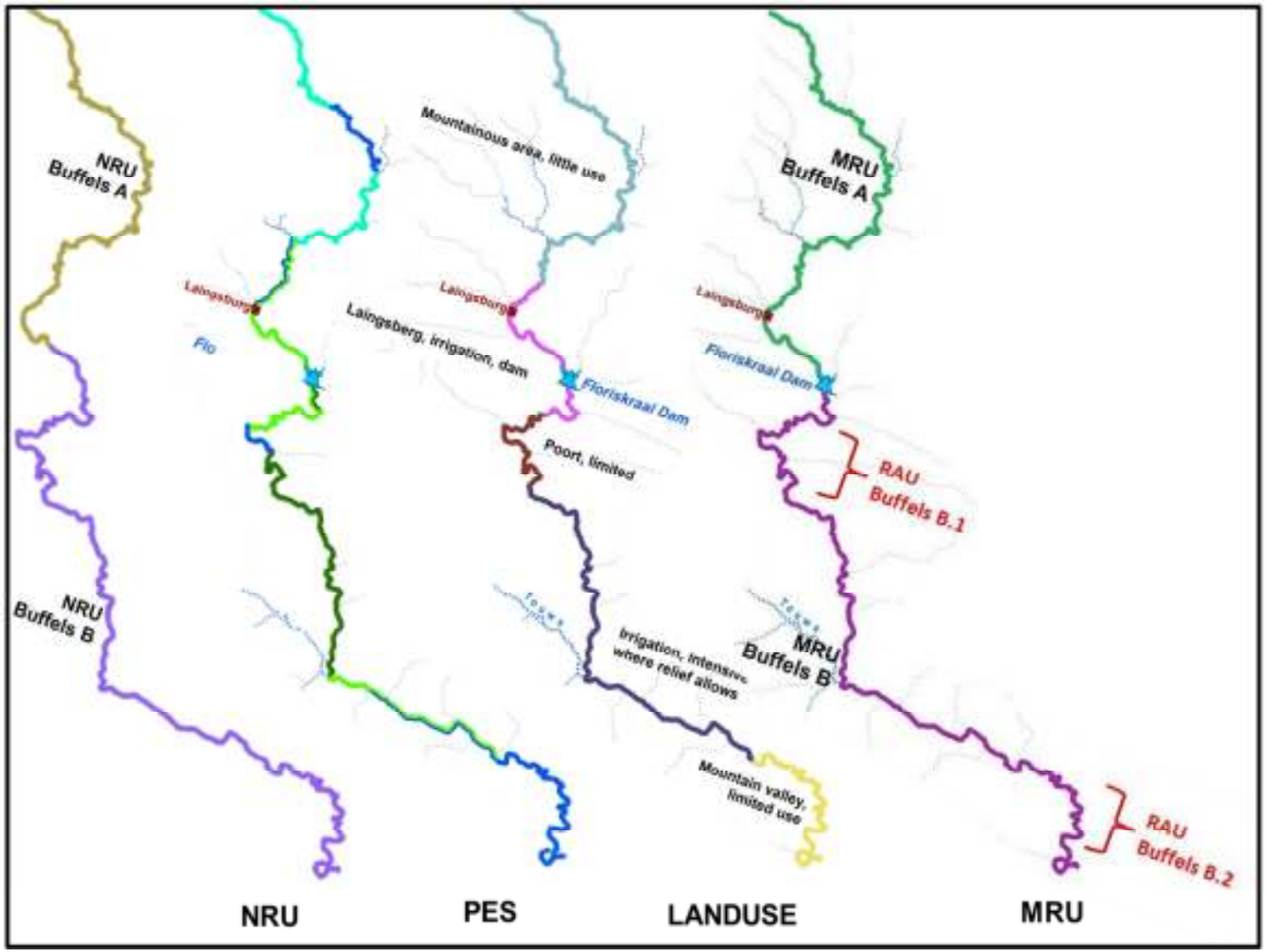


Figure 5.2 Buffels River: PES, operation, land use and Management Resource Units

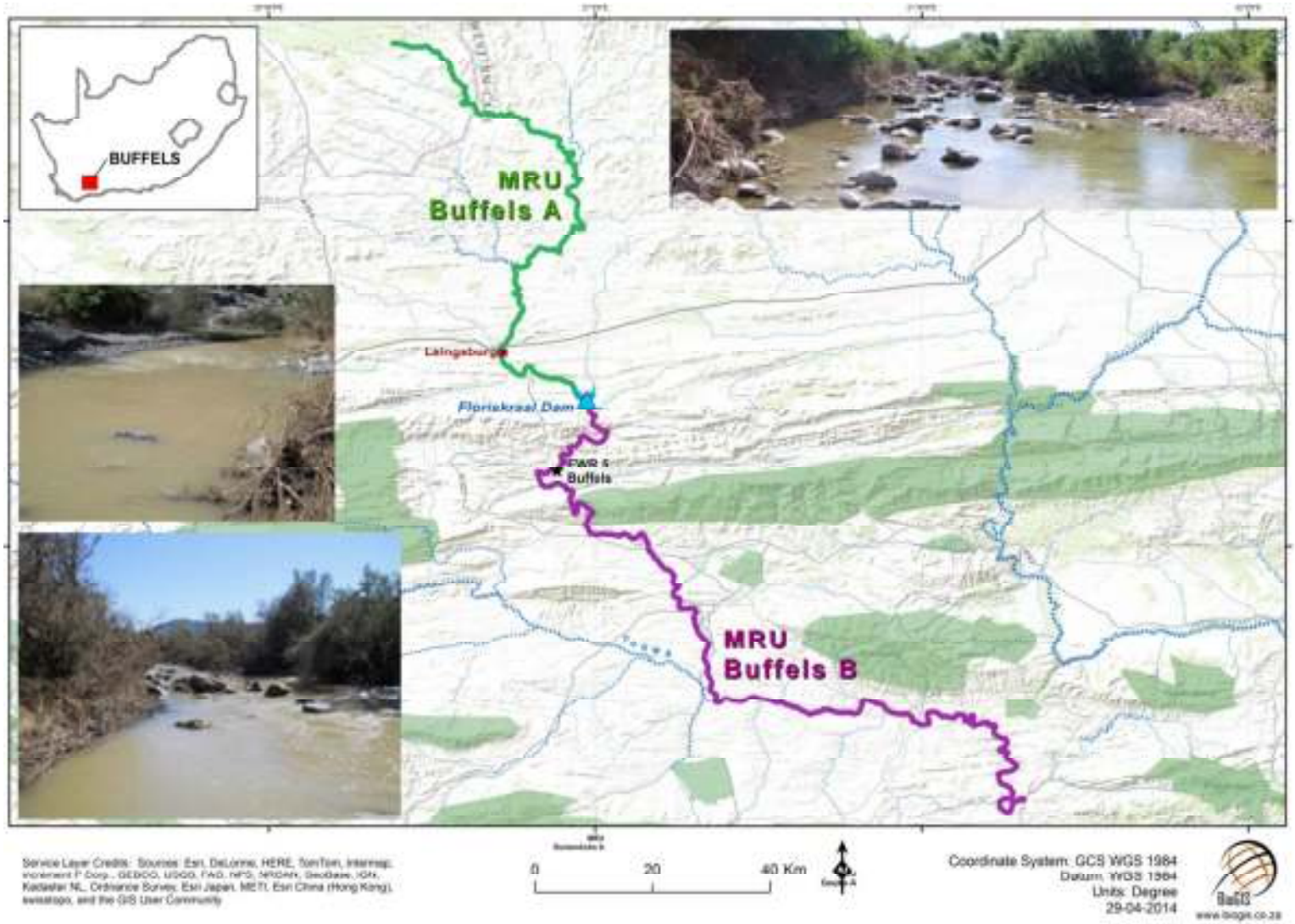


Figure 5.3 Buffels_EWR5 (Buffels River) locality and photographs

6 RESOURCE UNITS: TOUWS RIVER

6.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Touws River are described in **Figure 6.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within two EcoRegions (Level II), i.e. 23.02 and 19.07. The geomorphic zone is generally a mixture dominated by Lower Foothills. The most upstream geomorphic zones which are dominated by the Upper Foothills, and the 23.02 EcoRegion largely coincide. Based on this, the EcoRegion break from 23 to 19 was used as the end of NRU Touws A. The downstream river all falls in EcoRegion 19.07 and is largely dominated by Lower Foothills, making this a logical NRU. The NRUs are described as NRU Touws A and B; and the delineation information is provided in **Table 6.1**.

6.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 6.2**. The description of the MRUs and the rationale for selection is provided in **Table 6.2**.

System operation and land use:
Three irrigation dams are situated in tertiary catchment J12: Verkeerdevlei, Prins and Belair dams with Belair the largest at 10 million m³ but no longer in use.

Present Ecological State:
The rivers in this area are mixed in terms of their PES. After ground-truthing, some of the SQs were re-evaluated. The areas in the upstream area coinciding with the upper land use zone are mostly in a C and D PES. The main impacts on the habitat are both flow and non-flow related. Flow related impacts include multiple small farm dams in areas, irrigation (extensive in some areas), and a few large dams in the study area. Non-flow related impacts are mainly agricultural encroachment or clearing of riparian zones and/or floodplains, overgrazing in some areas and physical disturbance (manipulation) of morphological features (localised). The downstream area is mostly in a C and B Category and is improved due to the decreased irrigation in this area. Direct impacts in this zone are mostly non-flow related. Grazing with some dryland agriculture and minimal irrigation occur.

Rationale:
The MRU was selected (**Table 6.2** and **Figure 6.1**) based on the change in land use. Extensive irrigation occurs upstream and there are many farm dams in the area. The MRU A ends where the irrigation decreases and the river state improve. Most of the operational possibilities for managing the downstream MRU are situated in MRU A. In MRU A the land use changes and the state improves due to less irrigation.

6.3 EWR SITE SELECTION

The Level 3 and 4 hotspots are all situated in MRU B which is the target area for site selection. Considering the complexities of a seasonal system, it was essential to use a water level logger to obtain a variety of flow levels for hydraulic calibration. The one functioning gauge in MRU B is J1H018. A suitable site utilising the site selection criteria was selected downstream of the gauge. A water level recorder was installed at this site to obtain water level information for calibration of the hydraulic model.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 6.3**.

Table 6.1 Touws: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Touws A	23.02: 89% 23.03:11%	Lower Foothills: 46% Upper Foothills: 26% Transitional: 13% Mountain: 13% Mountain headwater: 2%	Coincides with EcoRegion 23.02. The geomorphic zones are varied, but dominated by Upper Foothills.	Start: -33.334445; 19.679956 End: -33.342820; 19.923820
NRU Touws B	19.07: 100%	Upper Foothills: 89% Lower Foothills: 11%	Coincides with EcoRegion 19.07. Dominant geomorphic zones are Lower Foothills.	End (confluence with Buffalo): -33.737178; 21.182662

Table 6.2 Touws: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Touws A	19.07 (66%) 23.02: (30%) 23.03 (4%)	Lower Foothills: 67% Upper Foothills: 24% Transitional: 4% Mountain: 4% Mountain headwater: 1%	MRU and land use zones mostly coincides due to intensive irrigation and Touwsrivier town.	The MRU A ends where the irrigation decreases and the river state improves. Most of the operational possibilities for managing the downstream MRU is situated in MRU A	Start: -33.334445; 19.679956 End of J12F-08717: -33.517128; 20.398968.	J12A, B, D, F
MRU Touws B	19.07: 100%	Upper Foothills: 96% Lower Foothills: 4%	Irrigation decreases, mostly grazing, dryland agriculture and some limited irrigation	As there are no operational changes in this section and the land use is largely homogenous, this reach comprises the downstream MRU.	End (confluence with Buffalo): -33.737178; 21.182662	J12F, H, L, M

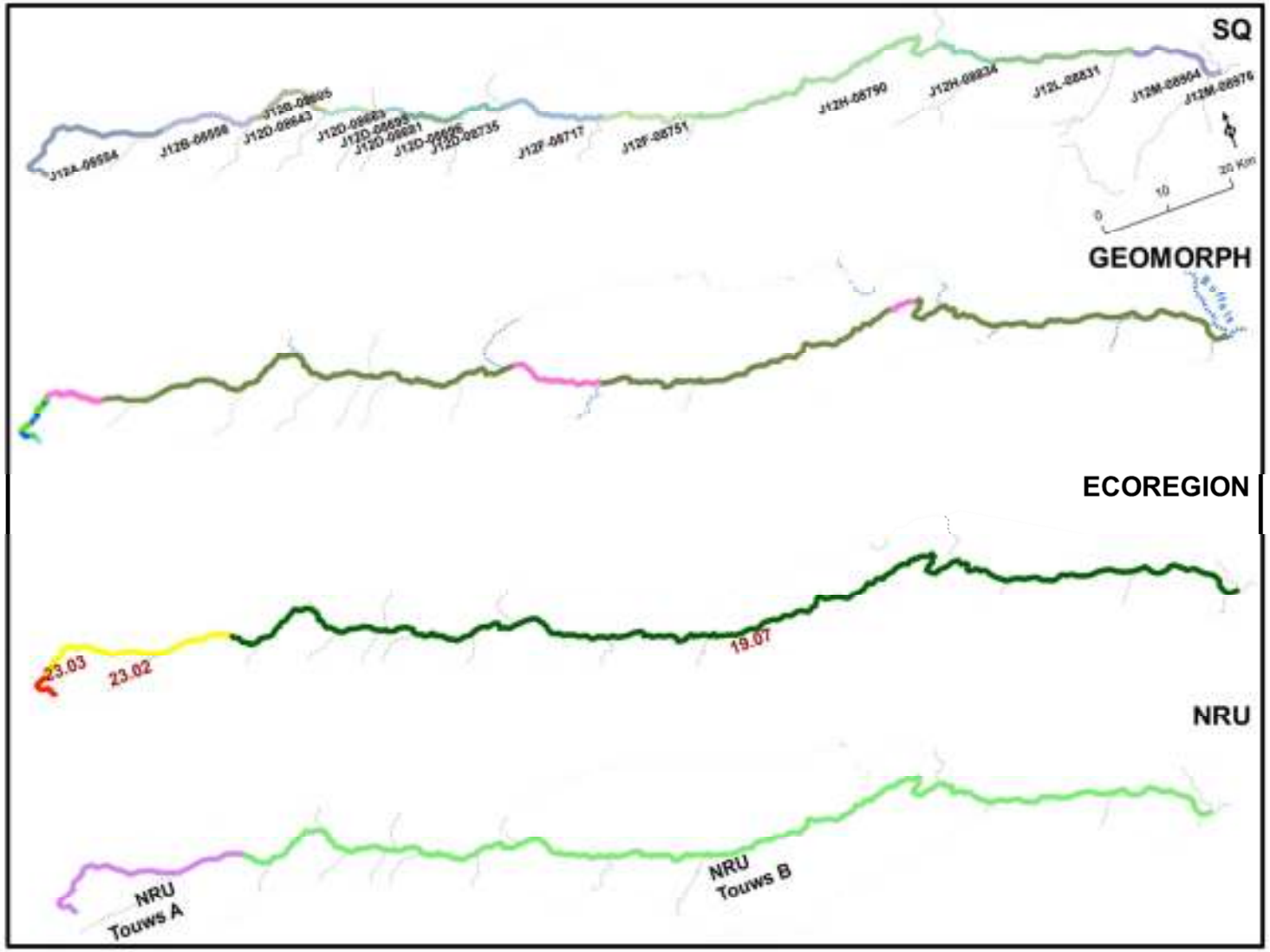


Figure 6.1 Touws River: EcoRegions, geomorphological zones and Natural Resource Units

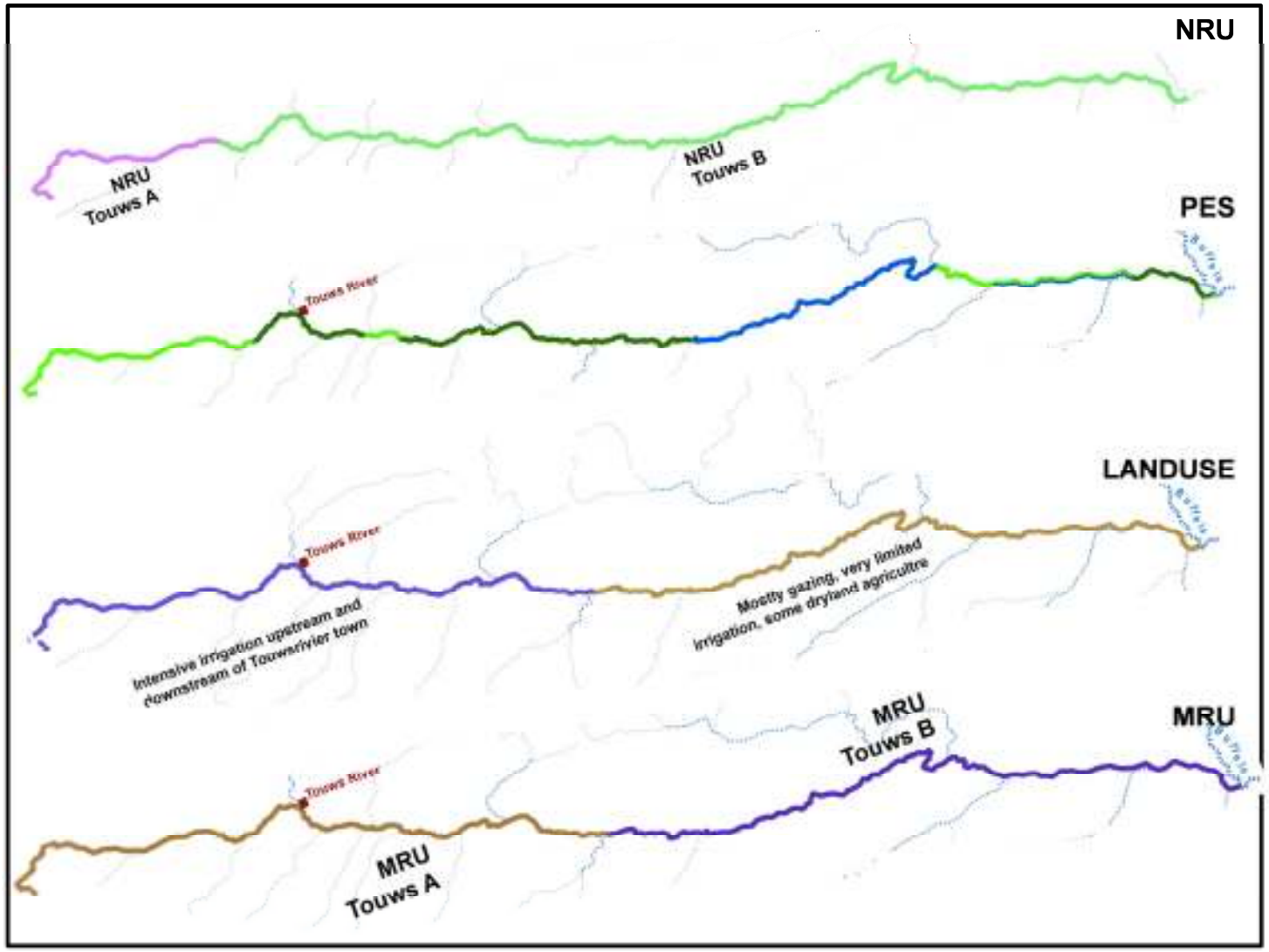


Figure 6.2 Touws River: PES, operation, land use and Management Resource Units

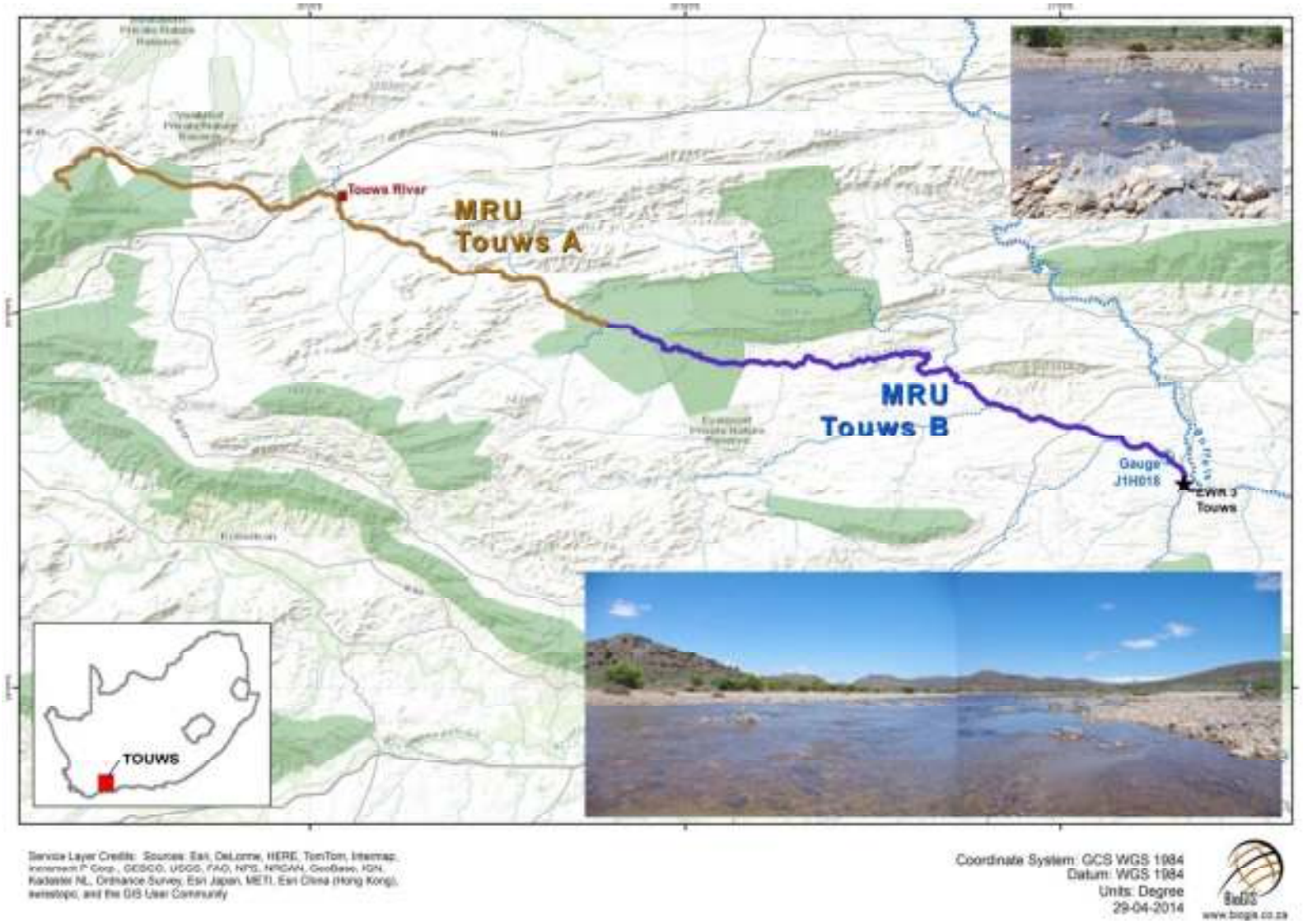


Figure 6.3 Touws_EWR3 (Touws River) locality and photographs

7 RESOURCE UNITS: GAMKA RIVER

7.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Gamka River are described in **Figure 7.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within two EcoRegions (Level I), i.e. 21 and 19. The Level I EcoRegion 21 is dominated by 21.04 EcoRegion. EcoRegion 19 consists of three relatively short Level II EcoRegions namely 19.09, 19.01 and 19.1. As the river falls largely in one geomorphic zone (Lower Foothills), the Level I EcoRegions were used as the break for the NRU. The NRUs are described as NRU Gamka A and B and the delineation information are provided in **Table 7.1**.

7.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 7.2**. The description of the MRUs and the rationale for selection is provided in **Table 7.2**.

System operation and land use:
Gamka Dam (1.8 million m³) and Springfontein Dam in the Upper Gamka River supply Beaufort West. Groundwater abstraction and limited opportunistic irrigation occurs along the floodplain downstream of the dam. The remainder of J21 is undeveloped. The Upper Gamka is in deficit as a result of irrigation requirements exceeding availability. The Gamkapoort Dam in J25A with a capacity of 44.2 million m³ supports domestic water requirements, livestock and irrigation.

Present Ecological State:
Most of the upper reaches are in a good PES ranging between categories A, A/B and B. These areas are generally seasonal or ephemeral, and impacts are limited to livestock farming, some agriculture, farm dams as well as the presence of towns.

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

The lower Gamka River (J23J, J25A, J25C, J25E) is generally in a deteriorated state due to modified flows (Gamkapoort Dam, abstraction for irrigation and towns), as well as non-flow related impacts (extensive agricultural activities along river) and water quality deterioration (irrigation return flows and town of Calitzdorp). The section of the river flowing through the Swartberg mountains in the Gamkaskloof (Die Hel) World Heritage Site is in excellent condition apart from the flow modification caused by the upstream Gamkapoort Dam.

MRU rationale:
The only significant land use activities in the main Gamka River are Beaufort West close to the source of the river, irrigation downstream of the Leeu River confluence at the town of Leeu-Gamka, and irrigation downstream of Gamkapoort Dam. Gamkapoort Dam is the only significant structure which can be used to manage the river and provided motivation for an MRU upstream of the dam and one downstream of the dam. Further information is provided in **Table 7.2** and **Figure 7.2**.

7.3 EWR SITE SELECTION

The hotspots in the Gamka River lie immediately upstream and downstream of the Gamkapoort Dam. Taking into account that the Gamkapoort Dam is the only structure from which EWRs could be operated from, and the presence of the Gamkaskloof (Die Hel World Heritage Site) situated downstream of the dam, Die Hel would be a logical place for an EWR site. Gauging is also undertaken at the Gamkapoort Dam as well as a gauging weir (J2H010) downstream of Gamkaskloof. A water level recorder was installed at this site to obtain water level information for calibration of the hydraulic model.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 7.3**.

Table 7.1 Gamka: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Gamka A	21.04: 89% 19.09: 9% 21.03: 2%	Lower Foothills: 80% Upper Foothills: 14% Transitional: 4% Mountain: 1.5% Mountain headwater: 0.5%	Dominated by Lower Foothills and one Level II EcoRegion (21.04). The break is at the start of EcoRegion 19.	Start: -32.163014; 22,633622 End: -33.237051; 21.769931
NRU Gamka B	19.01:65% 19.09: 25% 19.1: 10%	Lower Foothills:95 % Upper Foothills: 5%	Dominated by Lower Foothills and one Level I EcoRegion (19) consisting of 19.09, 19.01 and 19.1	End of J25E-08884: -33.681775; 21.715499

Table 7.2 Gamka: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Gamka A	21.04: 89% 19.09: 9% 21.03: 2%	Lower Foothills: 80% Upper Foothills: 14% Transitional: 4% Mountain: 1.5% Mountain headwater: 0.5%	Limited use apart from Beaufort West and abstraction from a dam for domestic use, some limited irrigation and grazing.	Similar land use with limited operational capability apart from Gamkapoort Dam which form the logical end point of the MRU	Start: -32.163014; 22,633622 End: -33.309193; 21.634011	J24A, B, C, D, E, F
MRU Gamka B	19.01:65% 19.09: 25% 19.1:10%	Lower Foothills:95 % Upper Foothills: 5%	No use takes place downstream of the dam in Gamkaskloof as it is situation in a Nature Reserve. Water released from dam for irrigation downstream. Intensive irrigation downstream of Calitzdorp.	Releases from dam for irrigation and extensive irrigation around Calitzdorp provide the rationale for a MRU.	End of J25E-08884: -33.681775; 21.715499	J25A, C, E.

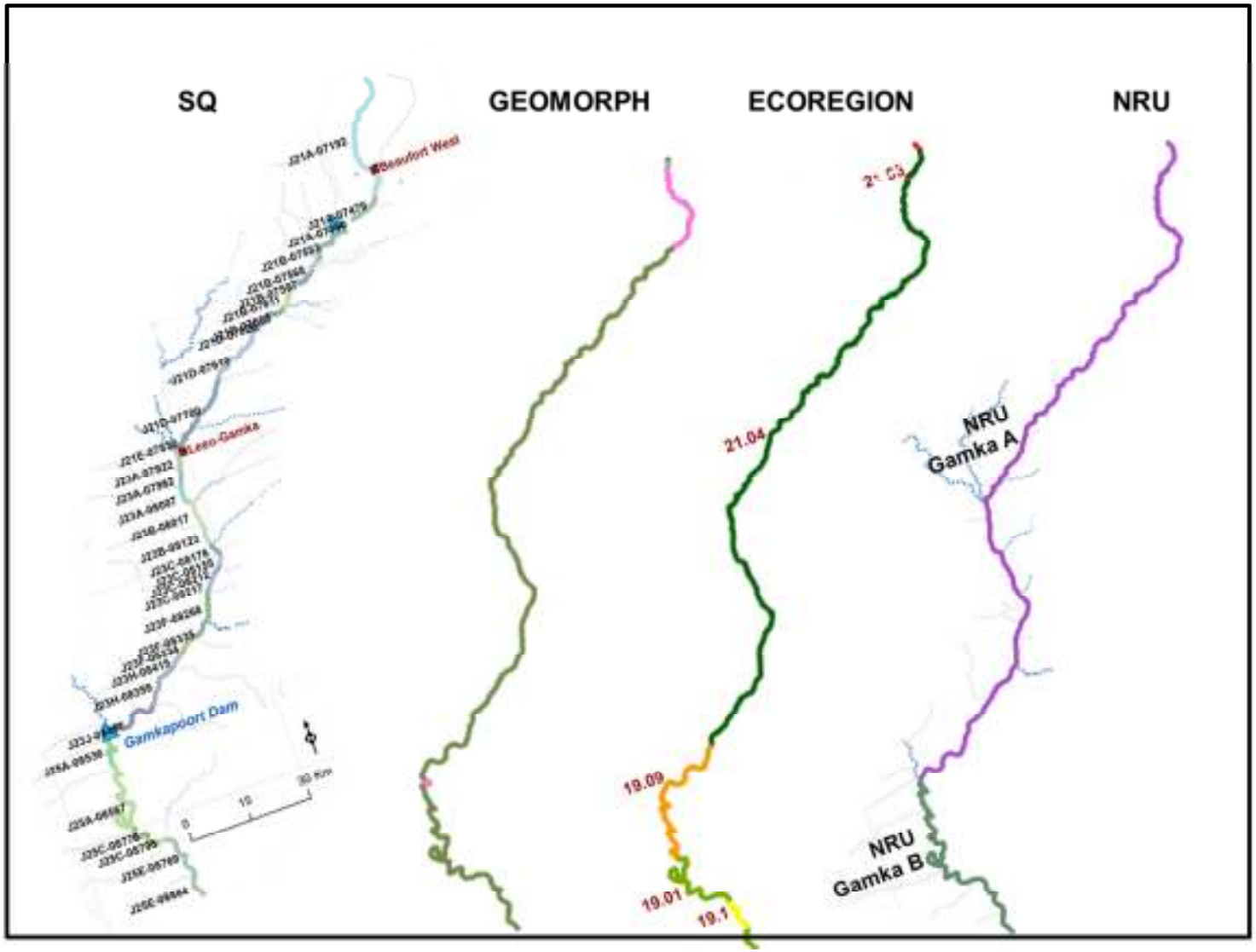


Figure 7.1 Gamka River: EcoRegions, geomorphological zones and Natural Resource Units

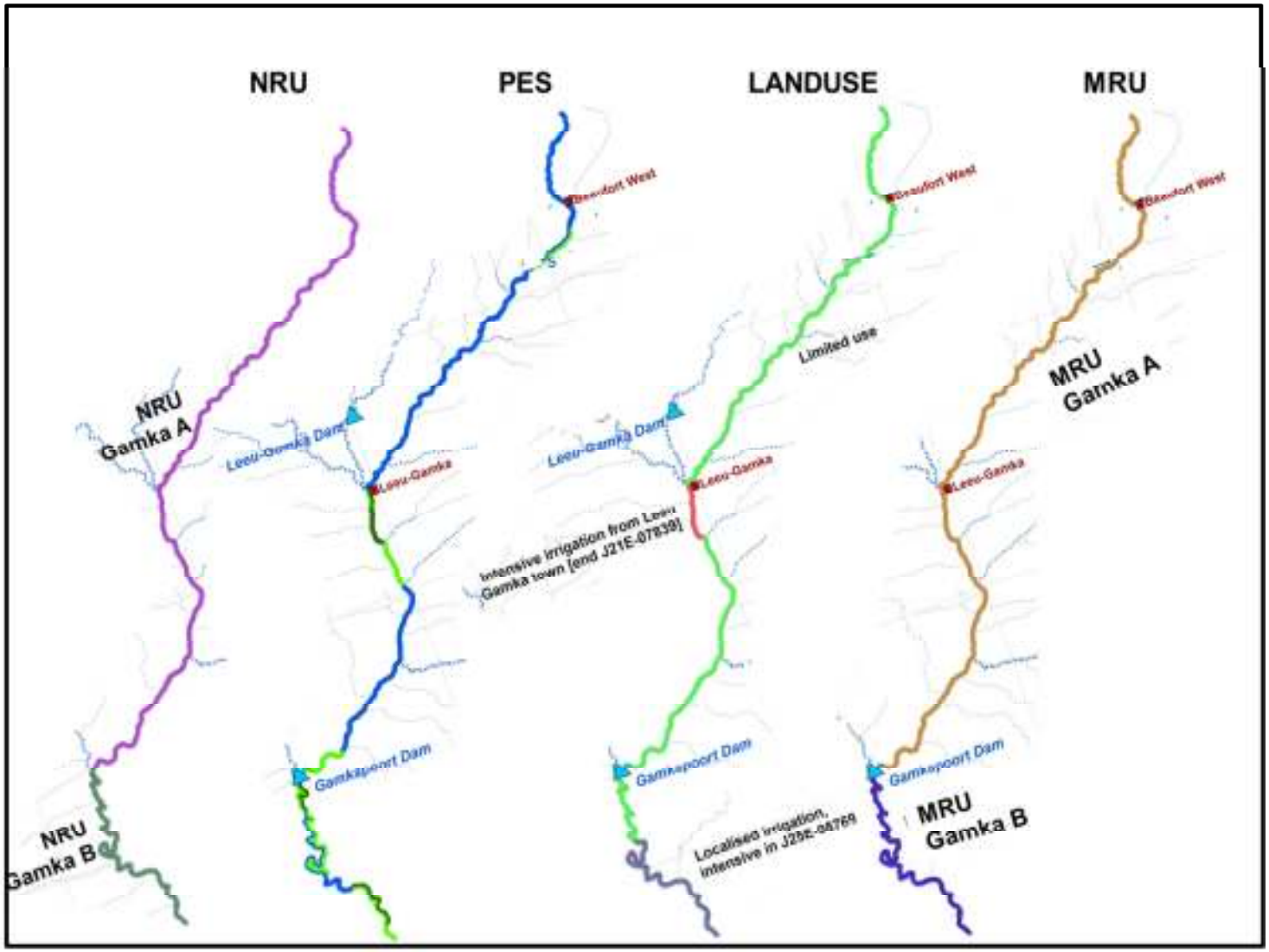


Figure 7.2 Gamka River: PES, operation, land use and Management Resource Units

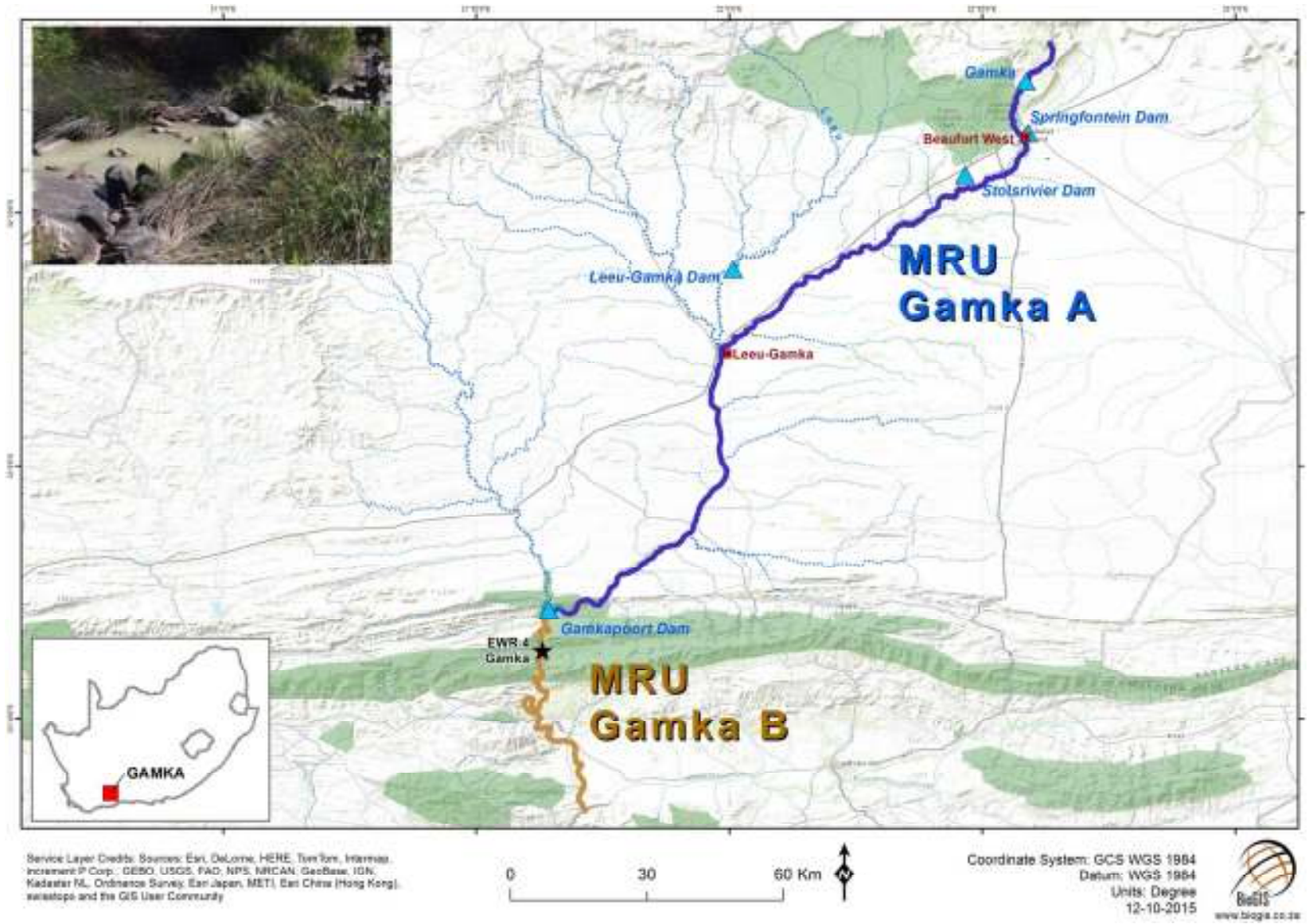


Figure 7.3 Gamka_EWR4 (Gamka River) locality and photographs

8 RESOURCE UNITS: OLIFANTS RIVER

8.1 MANAGEMENT RESOURCE UNITS

The main Olifants River was the subject of a Reserve study as part of the Oudtshoorn Agricultural Water Feasibility Study (Ninham Shand, 2007). Two EWR sites were selected in the Olifants River downstream of Stompdrift Dam. The MRUs selected during this study were:

- Stompdrift Dam to the Kammanassie confluence; and
- Kamanassie confluence to the Gouritz confluence.

The section of river not addressed during the Oudtshoorn study was the Olifants River upstream of Stompdrift Dam and the Touws at the town of Wilderness. This section forms a logical MRU as there are no operational structures within the section and there is minimal direct use of the river which flows infrequently. Land use is mostly grazing with limited and localised irrigation. This MRU will be referred to as MRU Olifants A, with the two existing MRUs being called MRU Olifants B and MRU Olifants C (**Figure 8.1**).

8.2 EWR SITE SELECTION

One EWR site had to be selected in MRU Olifants A (**Table 8.1**). The area is in a reasonable PES upstream of J33A-08736 and is suitable for EWR site selection. A riffle that often has some flow (possible 'subsurface flows' that surface at rocky areas) was selected as suitable. However, it must be acknowledged that determining flow in a river with very intermittent flow that could be groundwater based or reacts to rainfall will be extremely complicated.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 8.1**.

Table 8.1 Olifants: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Olifants A	19.01: 98% 19.09: 2%	Mountain headwater: 0.5% Mountain: 1% Transitional: 4% Upper Foothills: 35.5% Lower Foothills: 59%	Mostly grazing. Small localised areas of irrigation (groundwater dependant)	Unregulated and minimal use.	Start: -29.7751167; 30.134547 End of J33B-08749: -33.506946; 22.704145	J33B, A J31D, A.
MRU Olifants B	19.01: 83% 19.1: 15% 19.09: 2%	Lower Foothills: 100%	Intensive irrigation	Operation from Stompdrift Dam	End of J35B-08820: -33.628175; 22.209548	J33F, E.
MRU Olifants C	19.01: 70% 19.1: 30%	Lower Foothills: 100%	Intensive irrigation apart from a short section of gorge upstream of the Gouritz confluence.	Impacts from Oudtshoorn and the Grobelaars and Kammanassie Rivers.	End: -33.681681; 21.715550	J35B, D, E, F.

Figure 8.1 Olifants_EWR9 (Olifants River) locality and photographs

9 RESOURCE UNITS: KAMMANASSIE RIVER

9.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Kamanassie River are described in the **Figure 9.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within three EcoRegions (Level II) and one EcoRegion (Level I). The river is dominated by Lower foothills with a distinct break from a dominated section of upper foothills in the upstream river reaches. This break does not coincide with an EcoRegion break, but is in the vicinity of the EcoRegion break between 19.08 and 19.01. As 19.08 is very short, the decision was made to use the geomorphic zones as the NRUs. The NRUs in the Kammanassie River are described as NRU Kammanassie A and B and the delineation information are provided in **Table 9.1** and **Figure 9.1**.

9.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 9.2**. The description of the MRUs and the rationale for selection is provided in **Table 9.2**.

System operation and land use:
The land use is dominated by irrigation which is extensive downstream of the Kammanassie Dam. Upstream of the dam irrigation occurs wherever the relief allows even in the source zone. Extensive alien vegetation occurs.

Present Ecological State:
Upstream of Kammanassie Dam the impacts are related to urban impacts, agricultural fields in the riparian zone and alien vegetation. The areas which are in the best condition are due to inaccessibility being in a deep river valley. Two SQs fall in a B/C Category (J34D-08868 and 08899). The rest of the SQs fall mostly in a C and C/D PES. The Kammanassie River downstream of the Kammanassie Dam has degraded to an E and D/E PES due to the significant flow modification in the sub quaternary reaches, agricultural fields, return flows as well as extensive reed growth.

MRU rationale:
The Kammanassie Dam is the only large dam that can be used to operate the system. The dam is located in the lower reaches of the river. Upstream of the dam, flow operation can only be managed through restrictions and removal of alien vegetation. The dam therefore provides a logical break between the two MRUs. This is supported by the PES which is significantly worse downstream of the dam than upstream. Two MRUs, i.e. MRU Kammanassie A and B were selected and are illustrated in **Table 9.2** and **Figure 9.2**.

9.3 EWR SITE SELECTION

It was not possible to select a site downstream of the dam due to the extensive reed growth. A site upstream of the dam had to be selected and preferably in the area with the better PES. However, access was dangerous and time consuming and a bridge crossing upstream of this section was selected. It must be noted that due to irrigation return flows, the channel shape, structure and functioning have been changed due to the extensive reed and vegetation growth. This will complicate the EWR surveys and assessment.

Site details are provided in **Appendix B** and the site locality is illustrated in **Figure 9.3**.

Table 9.1 Kammanassie: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Kammanassie A	19.01: 68% 19.08: 32%	Upper Foothills: 93% Transitional: 6% Mountain: 1%	Dominated by Upper Foothills and representative of a more mountainous area.	Start: -33.606764; 23.257375 End: -33.682226; 22.99634
NRU Kammanassie B	19.01: 87% 19.1: 13%	Lower Foothills:97% Upper Foothills:3 %	Dominated by Lower foothills with a small section of upper foothills.	End: -33.621885; 22.2334

Table 9.2 Kammanassie: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Kammanassie A	19.08: 10% 19.01: 90%	Lower Foothiils: 66% Upper Foothills: 32% Transitional: 2%	Irrigation and alien vegetation.	Kammanassie Dam is the only operational breakpoint and was selected as the end of this MRU. PES is also better than the PES downstream of the dam.	Start: -33.606764; 23.257375 End of J34D-08868: -33.675157; 22.430201	J34A, B, C, D
MRU Kammanassie B	19.01: 70% 19.1: 30%	Lower Foothills:100%	Extensive irrigation supplied by the Kammanassie Dan and reed growth.	See above.	End: -33.621885; 22.2334	J34E, F

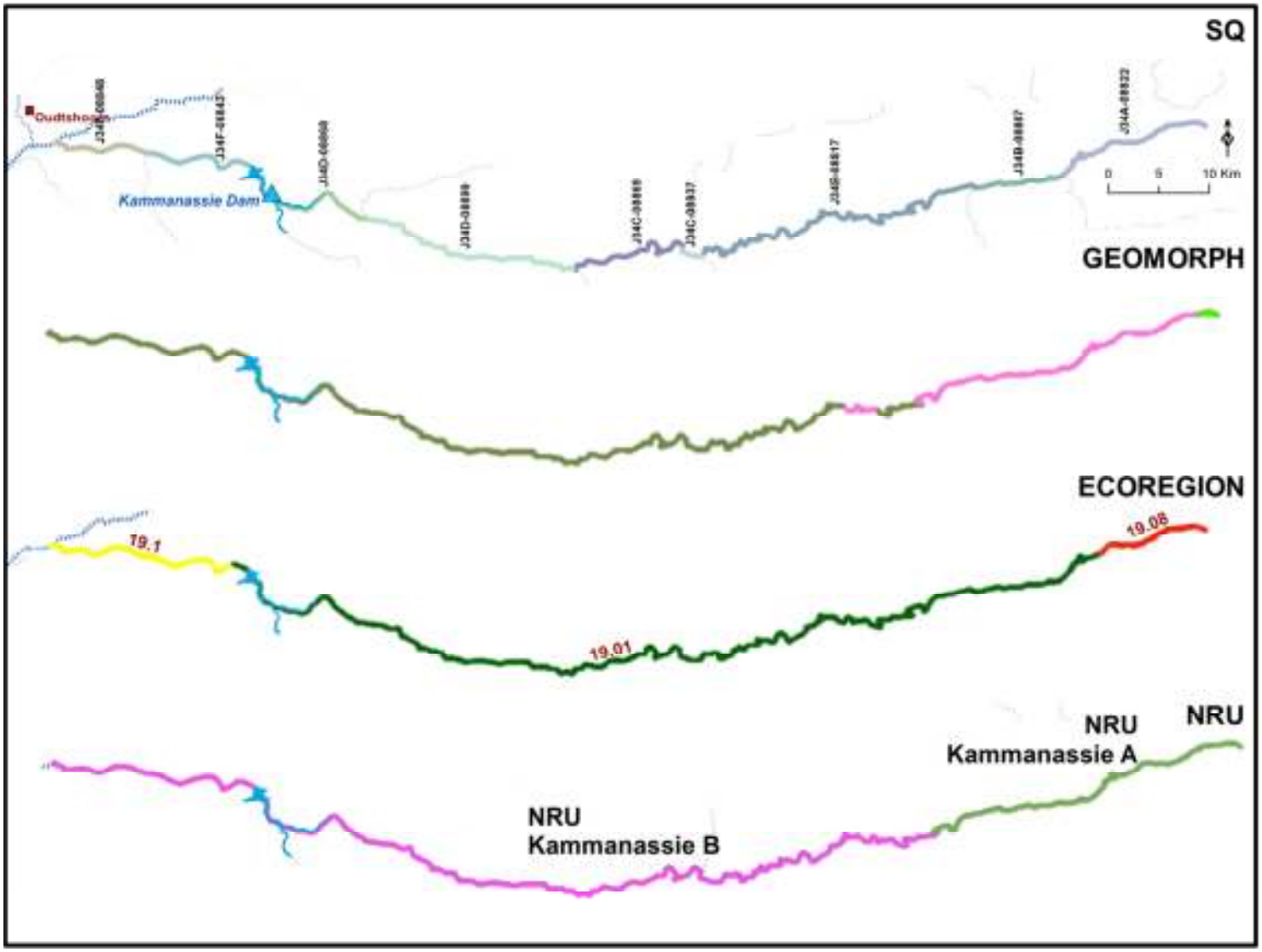


Figure 9.1 Kammanassie River: EcoRegions, geomorphological zones and Natural Resource Units

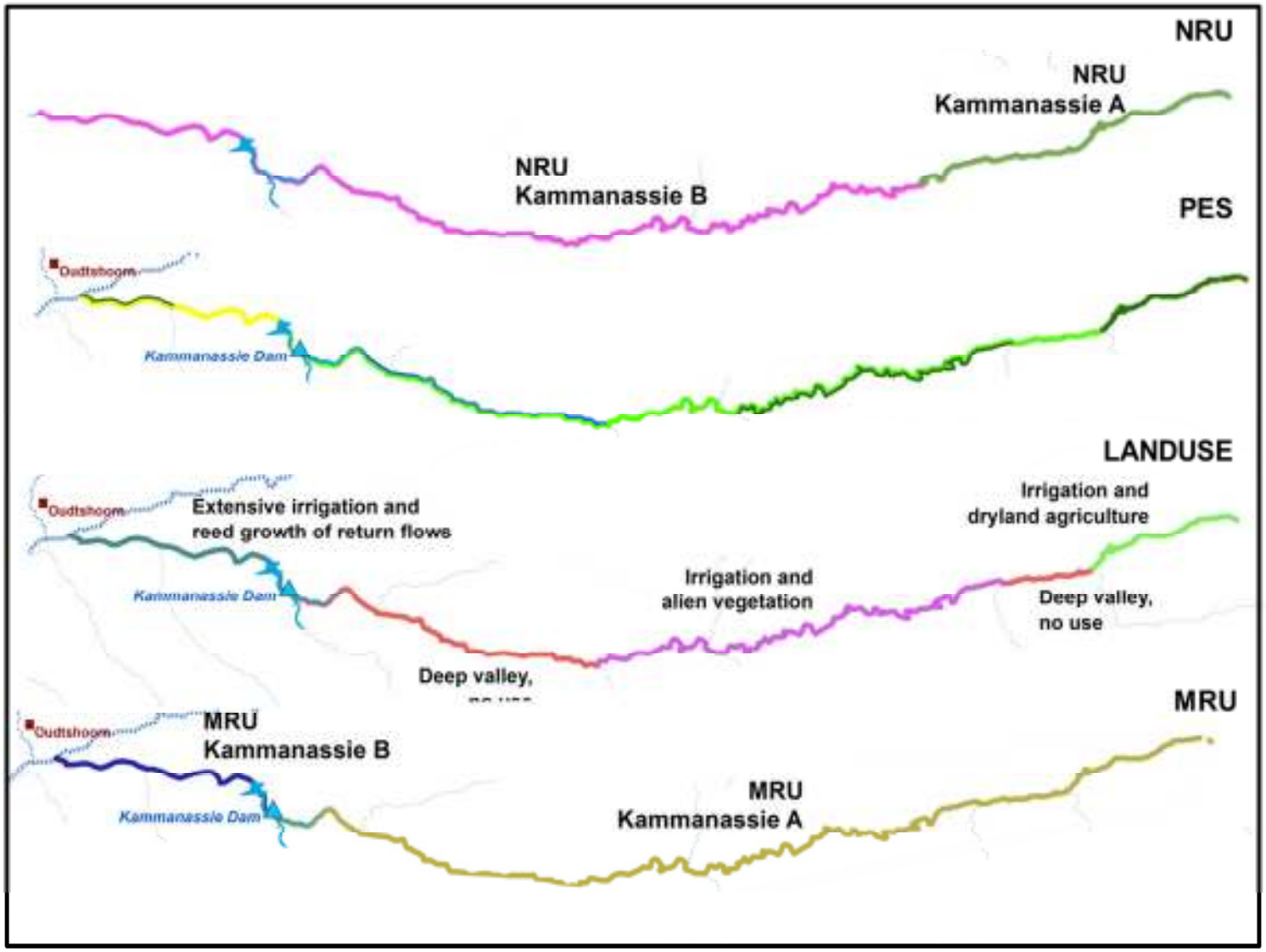


Figure 9.2 Kammanassie River: PES, operation, land use and Management Resource Units

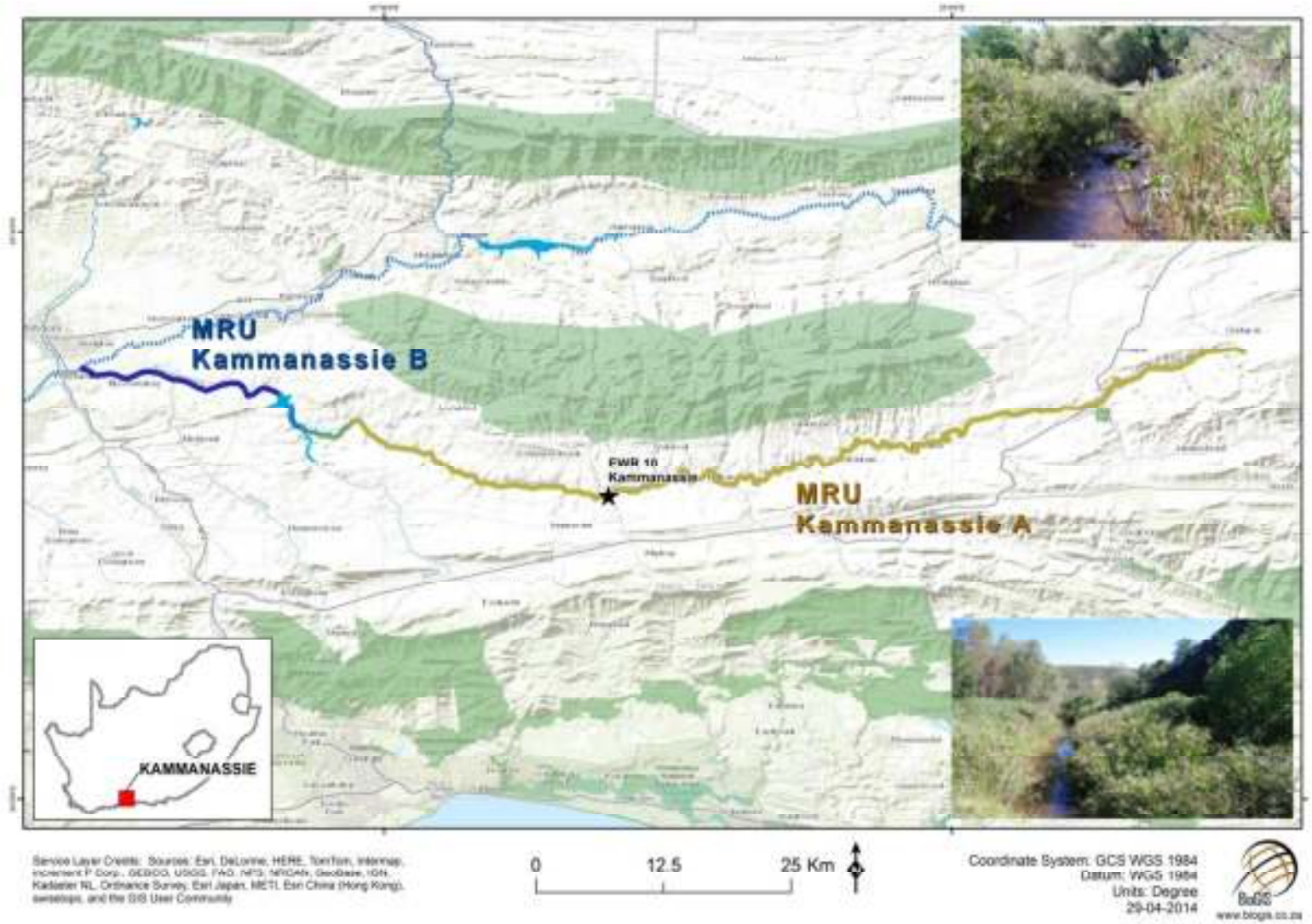


Figure 9.3 Kammanassie_EWR10 (Kammanassie River) locality and photographs

10 RESOURCE UNITS: GOURITZ RIVER

10.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Gouritz River are described in **Figure 10.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within three EcoRegions (Level II) and two EcoRegion (Level I). The river has two geomorphic zones, Lower Foothills and Lowland. The break to Lowland is close to the break in the Level I EcoRegion and this was used as the delineation criteria for the two NRU. The NRUs in the Gouritz River are described as NRU Gouritz A and B and the delineation information is provided in **Table 10.1** and **Figure 10.1**.

10.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 10.2**. The description of the MRUs and the rationale for selection is provided in **Table 10.2**.

System operation and land use:
Irrigation of mainly lucerne and pastures occurs on the banks of the Gouritz River. Also various farm dams are found in the Lower Gouritz River.

Present Ecological State:
The main stem of the Gouritz River in J40A (8924 and 9020) is primarily impacted by flow related activities in the upper catchment (J2 and J3), with limited non-flow related activities (agriculture) within this reach, resulting in a PES with a C category. The Gouritz River in J40B remains primarily impacted by upstream flow and water quality alterations, with J40B-9106 also impacted by the activities in catchment J1, but still remaining in a category C due to minimal localised impacts (agriculture). The Gouritz River in J40C remains primarily impacted by upstream flow and water quality alterations, but with the PES deteriorating to a category C/D due to the inclusion of localised agricultural impacts (flow and non-flow related). This PES is also continued downstream into J40D where localised farming impacts increase and contribute to the deterioration. The upper reaches of J40D-9178 is in a relative undisturbed state, while the lower reaches is impacted by agricultural activities, with the overall reach estimated to be in a PES of a C/D.

MRU rationale:
The land use coincides with the MRU. The upstream section is mountainous and mostly inaccessible with the dominant impact flow changes in the upstream catchments, especially J3 (Olifants). When the topography changes and it becomes a lowland river, there is sufficient place for irrigation and the land use changes. The MRU is therefore selected to coincide with this land use change, which result in a worse PES than upstream. Two MRUs, i.e. MRU Gouritz A and B were selected and are illustrated in **Table 10.2** and **Figure 10.2**.

10.3 EWR SITE SELECTION

MRU Gouritz A, being in a better state than the downstream MRU, was selected as an area to select an EWR site. The locality of the gauge at J4H005 provided added motivation, however it was later determined that the weir is a rated section and extremely unreliable for low flows. A suitable riffle was found downstream of a road crossing and upstream of the gauge. A water level logger was installed at this site to aid in obtaining hydraulic data for calibration purposes.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 10.3**.

Table 10.1 Gouritz: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Gouritz A	19.01: 83% 19.08: 10% 22.02: 7%	Lower Foothills: 100%	Geomorphic zone change very distinctive. Exact change refined with Google Earth. Coincides closely with change in Level I EcoRegion.	Start: -33.681330; 21.715768 End: -33.975935; 21.65458
NRU Gouritz B	22.02: 100%	Lowland: 85% Lower Foothills: 15%	Lowland and one EcoRegion.	End of J40E-09284, start of estuary: -34.179240; 21.7508

Table 10.2 Gouritz: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Gouritz A	19.01: 83% 19.08: 10% 22.02: 7%	Lower Foothills: 100%	Steep river valley, no direct land use.	Change from mountainous area to more open area (lowland), change in land use, change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.	Start: -33.681330; 21.715768 End: -33.975935; 21.65458	J40A,B,C
MRU Gouritz B	22.02: 100%	Lowland: 85% Lower Foothills: 15%	Irrigation.	See above. Open area, irrigation, slightly worse PES.	End of J40E-09284, start of estuary: -34.179240; 21.7508	J40C, D,E

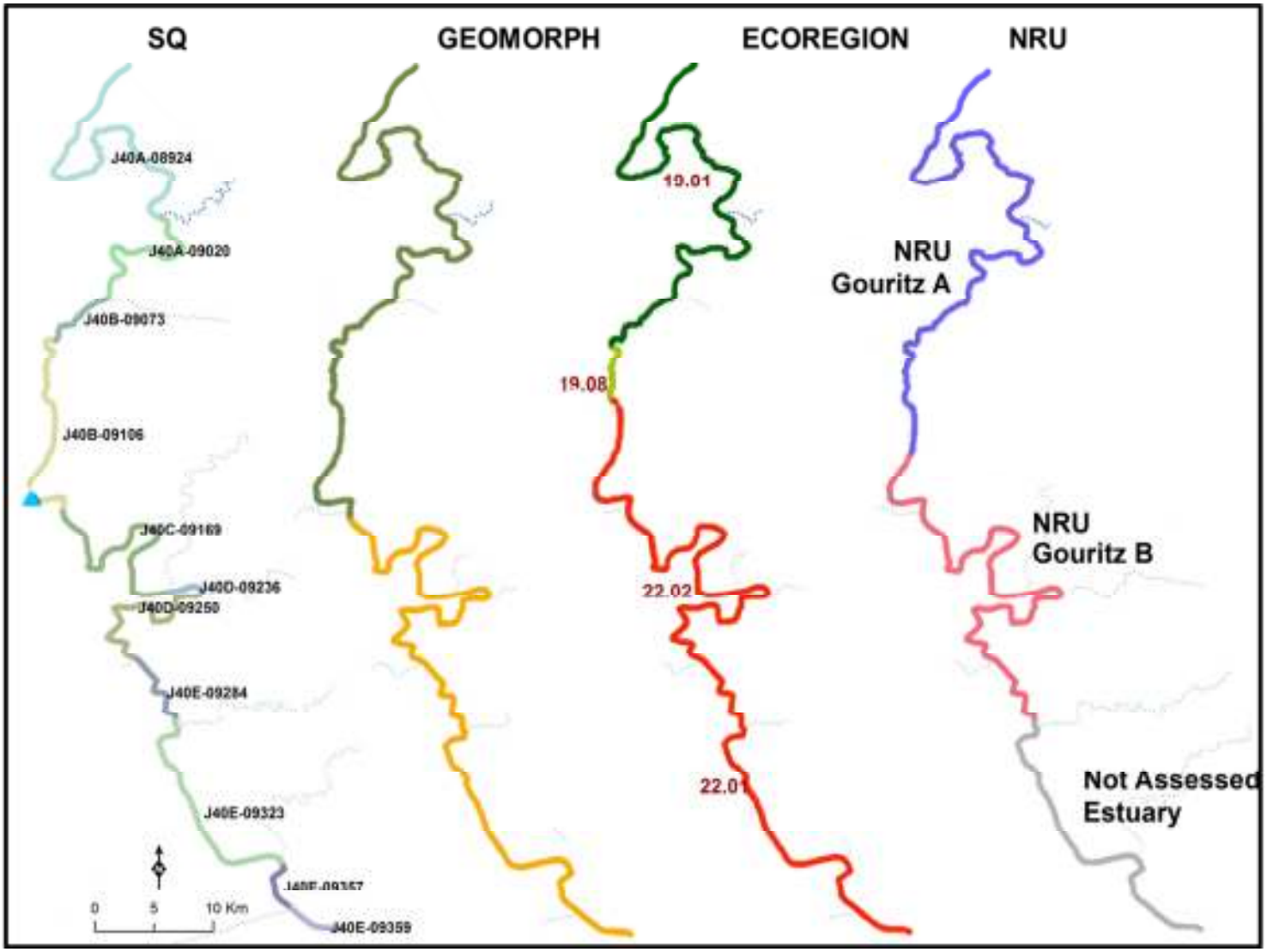


Figure 10.1 Gouritz River: EcoRegions, geomorphological zones and Natural Resource Units

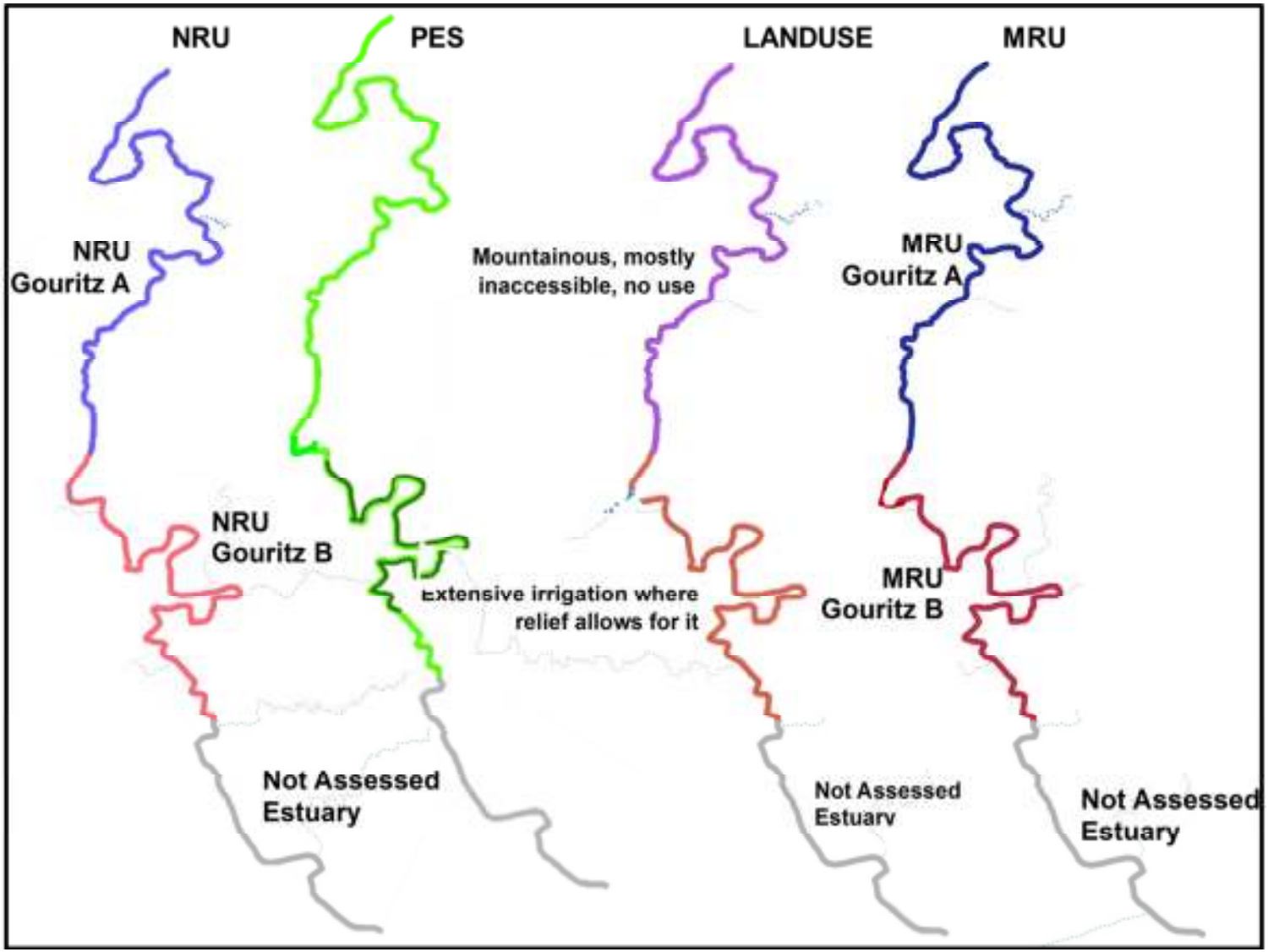


Figure 10.2 Gouritz River: PES, operation, land use and Management Resource Units

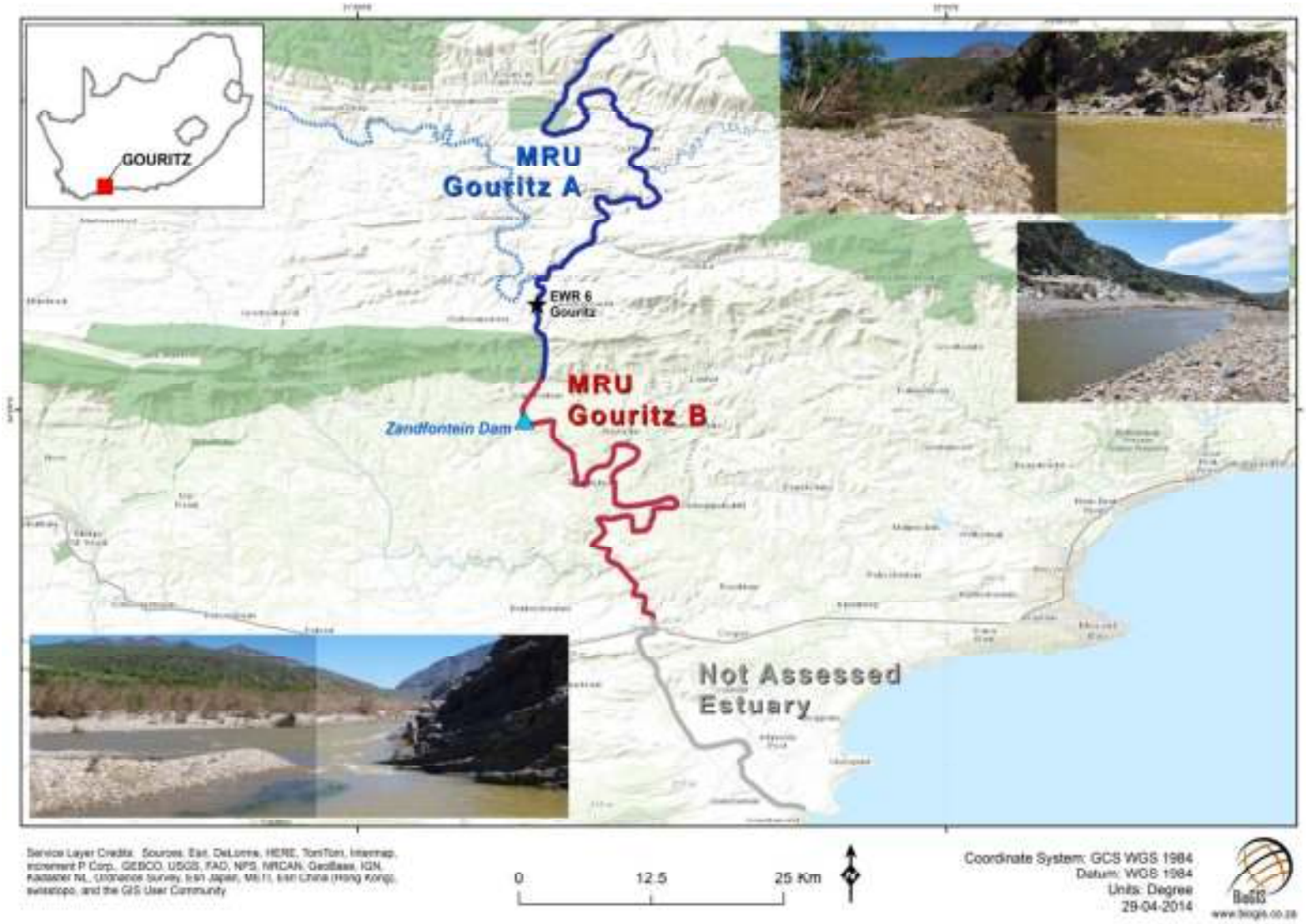


Figure 10.3 Gouritz_EWR6 (Gouritz River) locality and photographs

11 RESOURCE UNITS: KEURBOOMS RIVER

11.1 NATURAL RESOURCE UNITS

The sub-quaternary reaches (representing hydrological zones), EcoRegions and geomorphic zones of the Keurbooms River are described in **Figure 11.1**. The NRUs are derived from the EcoRegions and the geomorphic zones.

The study area falls within three EcoRegions (Level II) and two EcoRegion (Level I) and is dominated by 20.02 EcoRegion. The river has various geomorphic zones but is dominated by upper foothills. Taking into account that the river is dominated by one EcoRegion and one geomorphic zone, only one NRU was selected. The NRU in the Keurbooms River is described as NRU Keurbooms A and the delineation information are provided in **Table 11.1** and **Figure 11.1**.

11.2 MANAGEMENT RESOURCE UNITS

The river is divided into MRUs as illustrated in **Figure 11.2**. The description of the MRUs and the rationale for selection is provided in **Table 11.2**.

System operation and land use:
Roodefontein Dam (2 million m³) in the Piesang River supplies irrigation and Plettenberg Bay run-of-river transfers from the Keurbooms River to Plettenberg Bay. Water supply problems are experienced during peak season. The central water treatment works receives water via a pipeline from the Keurbooms River and a pipeline from Roodefontein Dam. The river is delineated into two land use zones. The upper area is characterised by irrigation, agriculture and forestry. The lower section has mostly forestry or indigenous (mixed with aliens) forests.

Present Ecological State:
The most upstream SQ is in a C/D PES with the impacts being non-flow related vegetation removal and the presence of alien plant species. The riparian zone of the upper portion of the Keurbooms River (K60A-08947) is largely fragmented by agricultural activities. Forestry occurs in places. Downstream of this SQ the farming activities decreases which results in a higher ecological category.

MRU rationale:
The MRU delineation is based on the land use which effects the PES negatively. Two MRUs, i.e. MRU Keurbooms A and B were selected and are illustrated in **Table 11.2** and **Figure 11.2**.

11.3 EWR SITE SELECTION

The target area for EWR site selection was close to the lower gauging weir which is also downstream of possible development areas. This is a hotspot and would be useful for EWR determination. However, the access bridge to the gauge does not exist anymore and the riffle provided poor habitat for EWR determination. An EWR site further upstream at a good riffle was selected. Problems at this site, however, are the distance from the gauging weir as well the

extensive alien vegetation at the site. A water level logger was installed at this site to aid in obtaining hydraulic data for calibration purposes.

Site details are provided in **Appendix B** and the site locality and characteristics are illustrated in **Figure 11.3**.

Table 11.1 Keurbooms: Description of Natural Resource Units

NRU	EcoRegion Level II	Geomorphic zone	Rationale	Delineation
NRU Keurbooms A	20.02: 83% 19.08: 12% 19.01:5 %	Upper Foothills:65 % Transitional: 24% Lower foothills:8% Mountain: 3%	Dominated by one geomorphic zone and EcoRegion and therefore only one NRU.	Start: -33.737912; 23.039211 End at start of estuary: -33.95223 E23.40181

Table 11.2 Keurbooms: Description of Management Resource Units

MRU	EcoRegion Level II	Geomorphic zone	Land cover	Rationale	Delineation	Quat.
MRU Keurbooms A	20.02: 67% 19.08:24 % 19.01: 9%	Upper Foothills: 65% Transitional: 24% Lower foothills:8% Mountain: 3%	Steep river valley, no direct land use	Change from mountainous area to more open area (lowland), change in land use and change in PES resulted in the MRU ending at the end of the mountains which coincide with the NRU.	Start: -33.737912; 23.039211 End: -33.824574; 23.20321	K60A, B
MRU Keurbooms B	20.02: 100%	Upper Foothills: 85% Lower foothills:15%	Irrigation	See above. Open area, irrigation, slightly worse PES.	End at start of estuary: -33.95223 E23.40181	K60B, C, E

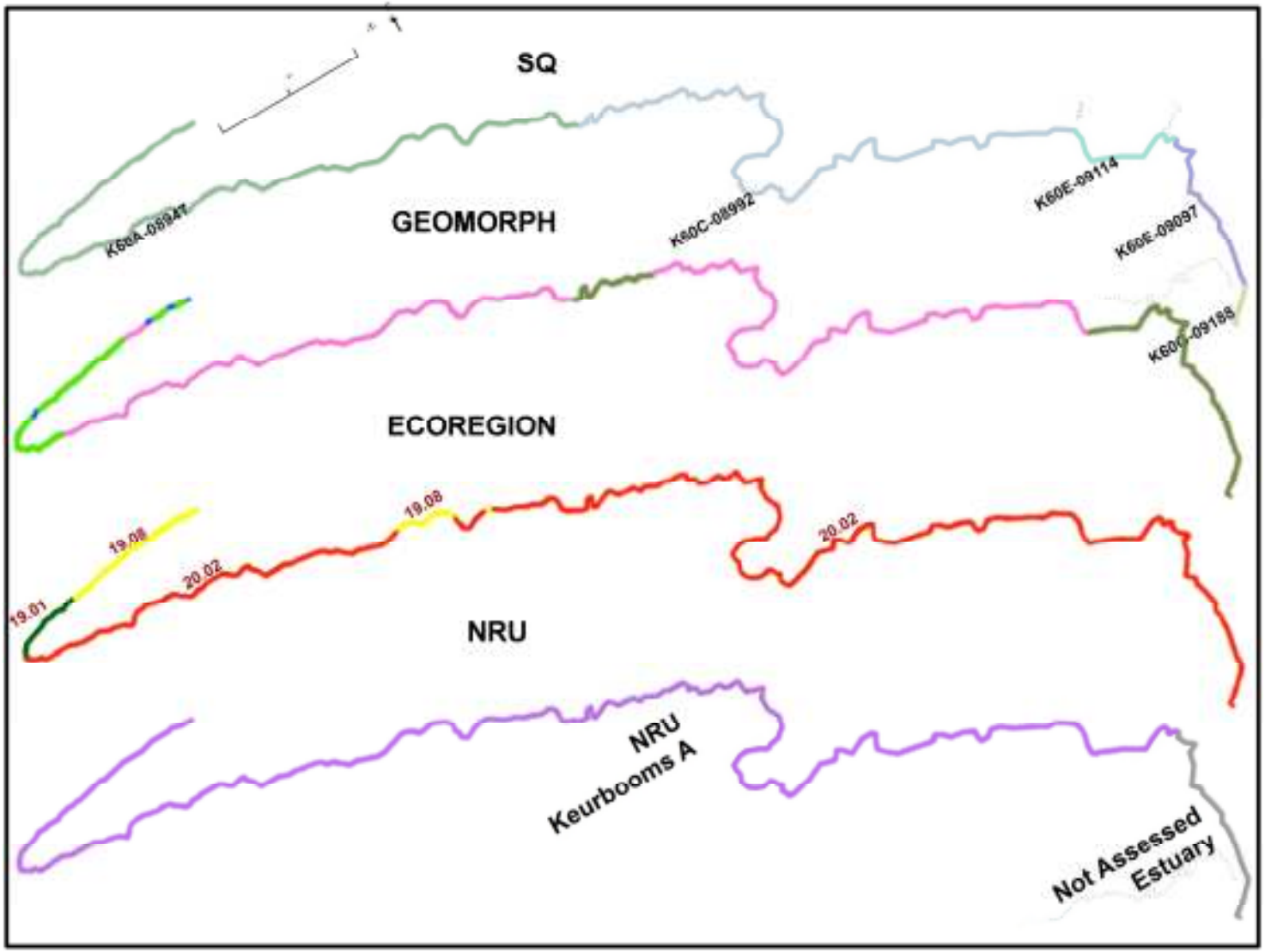


Figure 11.1 Keurbooms River: EcoRegions, geomorphological zones and Natural Resource Units

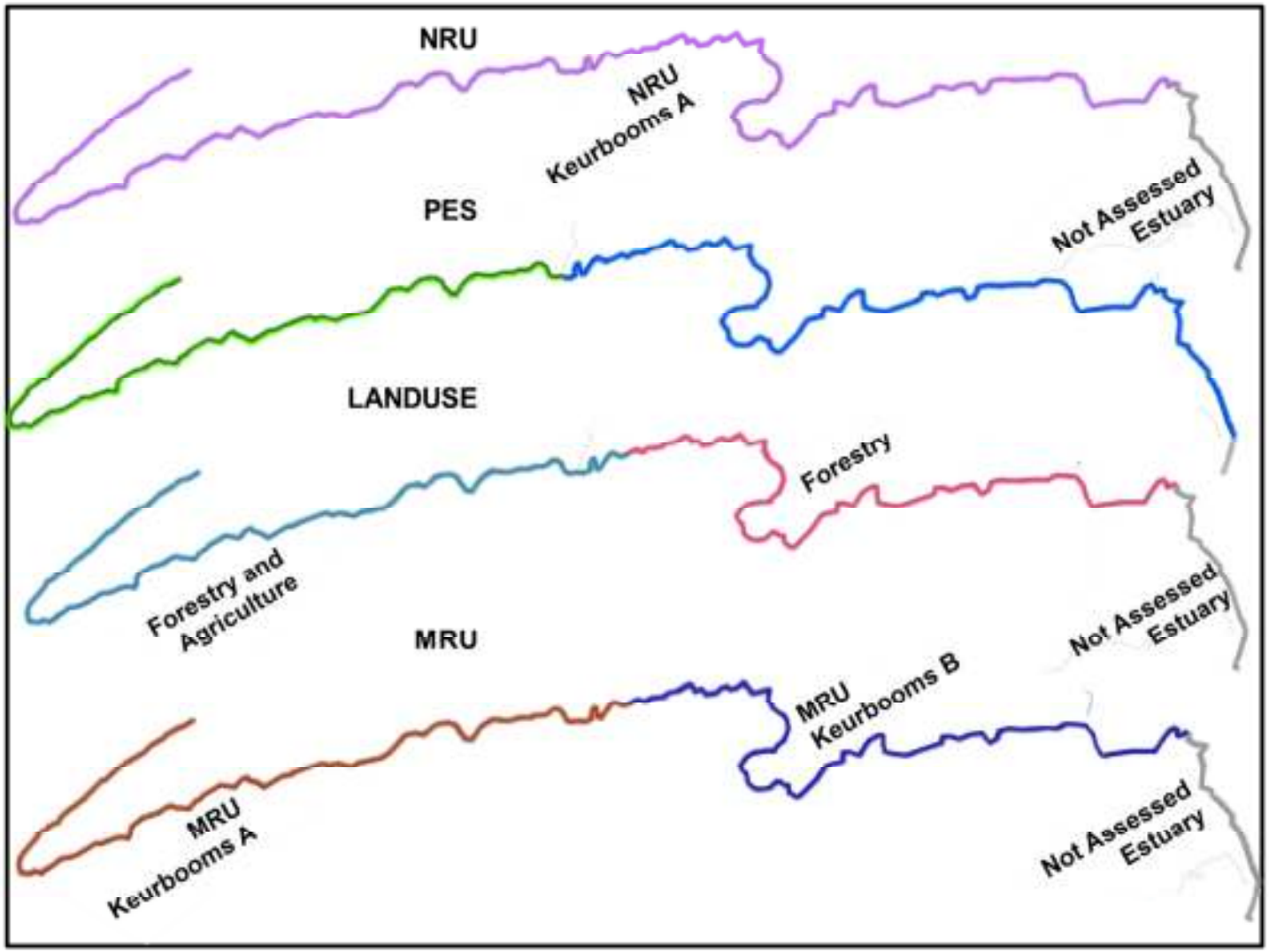


Figure 11.2 Keurbooms River: PES, operation, land use and Management Resource Units

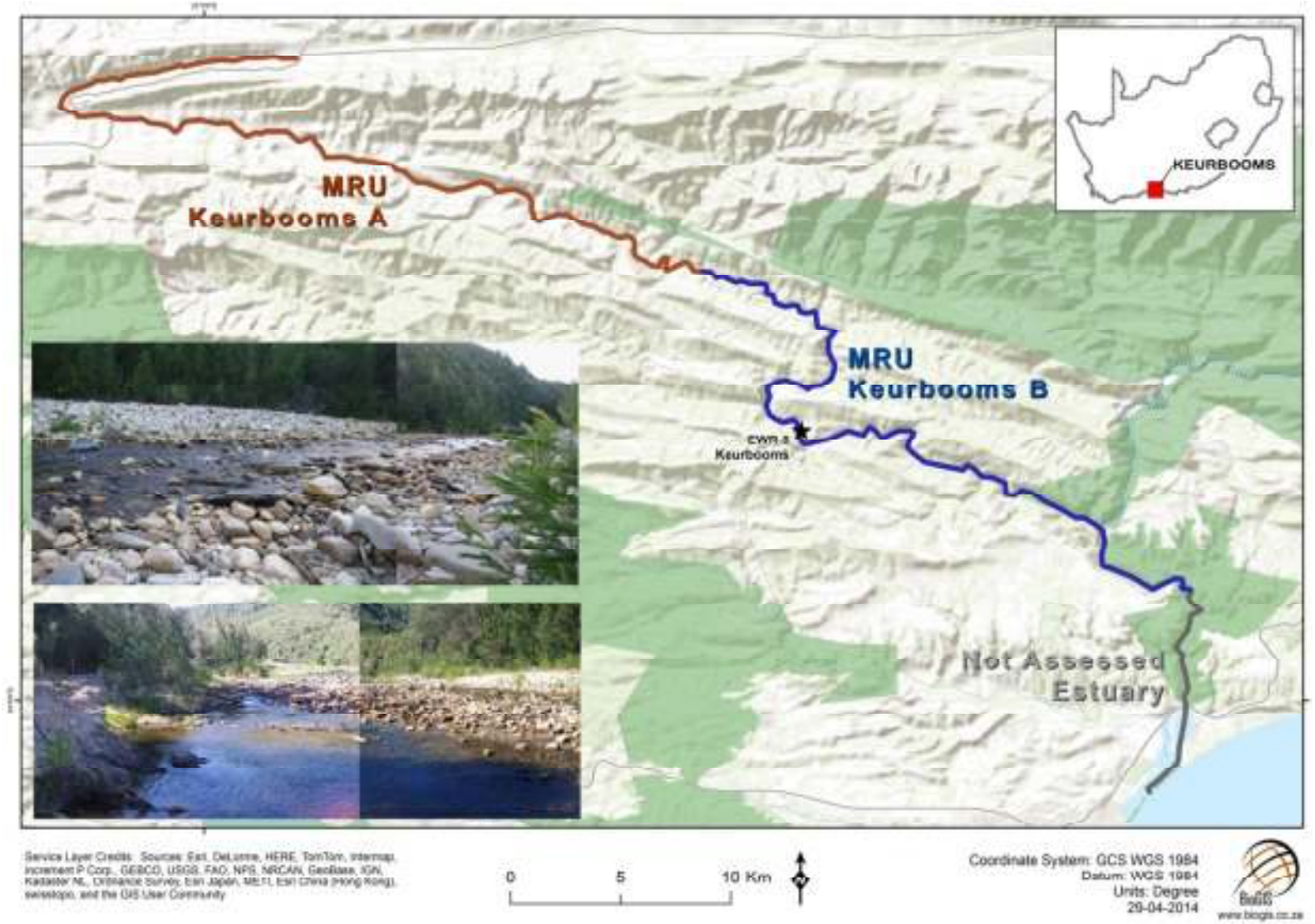


Figure 11.3 Keurbooms_EWR8 (Keurbooms River) locality and photographs

12 REFERENCES

Department of Water Affairs (DWA). 2013a. Review and update of the Desktop Present Ecological State (PES) and Ecological Importance (EI) – Ecological Sensitivity (ES) of South African Rivers according to sub-quaternary catchments: Gouritz, Breede and Berg Water Management Areas.

Department of Water Affairs (DWA). 2013b. Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Status quo assessment, IUA and biophysical node delineation and identification. Report Number: RDM/WMA11/00/CON/CLA/0113. Prepared by Rivers for Africa.

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

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

Department of Water Affairs and Forestry (DWAF). 1999. Resource Directed Measures for Protection of Water Resources. Volume 3: River Ecosystems Version 1.0, Pretoria

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

Department of Water Affairs and Forestry (DWAF). 2008. Comprehensive Reserve Determination Study for Selected Water Resources (Rivers, Groundwater and Wetlands) in the Inkomati Water Management Area, Mpumalanga. Sabie and Crocodile Systems: Resource Unit Delineation: Prepared by Water for Africa, authored by Louw, MD. Report no. 26/8/3/10/12/006

Kleynhans, C.J. and Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT329-08.

Kleynhans, C.J., Thirion, C. and Moolman, J. 2005. A Level I River 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.

Kleynhans, C.J., Thirion, C., Moolman, J. and Gaulana, L. 2007. A Level II River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/000/00/REQ0XXX. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Louw, M.D. and Hughes, D.A. 2002. Prepared for the Department of Water Affairs and Forestry, South Africa. Resource Directed Measures for Protection of Water Resources: River Ecosystems – Revision of a quantity component.

Louw M.D., Kemper, N. and Birkhead, A.L. (1999). Procedure for selecting sites in intermediate and comprehensive determination of the Ecological Reserve (water quantity component).

Appendix 18 in Resource Directed Measures for Protection of Water Resources: River Ecosystems. Published by Department of Water Affairs, South Africa.

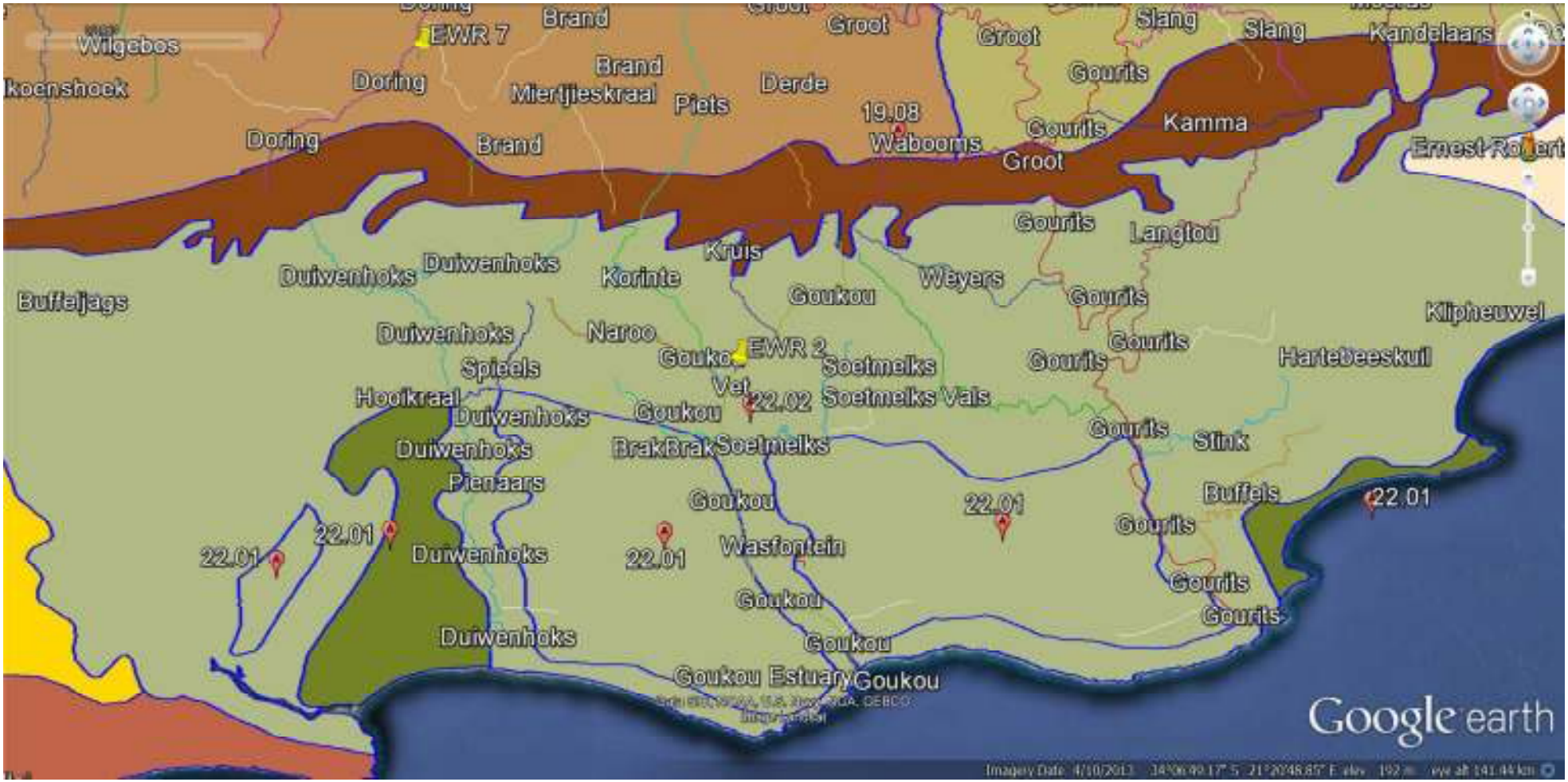
Ninham Shand. 2007. Oudtshoorn Agricultural Water Feasibility Study, Department of Agriculture Report No. 411/2005/02. Rapid III Ecological Reserve Determination - Olifants, Kammanassie, Groot, Le Roux and Grobbelaars Rivers. Prepared IWR Source-to-Sea. January 2006.

Noble, R.G., Hemens, J. 1978. Inland water ecosystems in South Africa - a review of research needs. South African National Scientific Programmes Report No. 34: 150 pp.

Omernik, J.M. 1987. Ecoregions of the conterminous United Sites. Annals of the Association of American Geographers 77:118 – 125.

Rowntree, K.M. and Wadeson, R.A. 1999. A hierarchical framework for categorising the geomorphology of river systems, Water Research Commission Report. Report No. 497/1/99. WRC, Pretoria.

APPENDIX A: ECOREGION MAP



APPENDIX B: EWR SITES

EWR site name	SQ	River	Latitude	Longitude	EcoRegion (Level II)	Geomorphic Zone	Altitude (m)	MRU	Quat	Gauge
Duiwenhoks_EWR1	H80E-09314	Duiwenhoks	S34.25167	E20.99194	22.02	E Lower Foothills	15	MRU Duiwenhoks C	H80E	H8H001
Goukou_EWR2	H90C-09229	Goukou	S34.09324	E21.29300	22.02	E Lower Foothills	87	MRU Goukou A	H90C	H9H005
Touws_EWR3	J12M-08904	Touws	S33.72707	E21.16507	19.07	E Lower Foothills	271	MRU Touws B	J12M	J1H018
Gamka_EWR4	J25A-08567	Gamka	S33.36472	E21.63051	19.09	E Lower Foothills	375	MRU Gamka B	J25A	J2H016
Buffels_EWR5	J11H-08557	Buffels	S33.38452	E20.94169	19.09	E Lower Foothills	499	MRU Buffels B	J11H	
Gouritz_EWR6	J40B-09106	Gouritz	S33.90982	E21.65233	19.08	E Lower Foothills	121	MRU Gouritz A	J40B	J4H002
Doring_EWR7	J12L-09895	Doring	S33.79137	E20.92699	19.07	E Lower Foothills	370	N/A	J12L	
Keurbooms_EWR8	K60C-09882	Keurbooms	S33.88955	E23.24392	20.02	D Upper Foothills	161	MRU Keurbooms B	K60C	K6H001, K6H019
Olifants_EWR9	J31D-08592	Olifants	S33.43813	E23.20587	19.01	E Lower Foothills	621	MRU Olifants A	J31D	
Kammanassie_EWR10	J34C-8869	Kammanassie	S33.73286	E22.69740	19.01	E Lower Foothills	445	MRU Kammanassie A	J34C	

APPENDIX C: REPORT COMMENTS AND RESPONSE REGISTER

Section	Report Statement	Comments	Addressed in Report?	Author Comment
Comments: Thapelo Machaba – DWA, May 2014				
Editorial comments			Yes	
Comments: Barbara Weston – DWA, August 2014				
Section 1.2		Add a map indicating the positioning of the dams (this is important for discussing scenarios later on) and indicating (priority water resources).	No	The maps show important towns and dams that influenced the delineation of the reach. A map which includes dams in the area will be included in the Scenario Report.
Section 1.4		The variances between the different colours are too close to each other especially the CD and the AB use different colours perhaps also different line styles	No	Standard colours and line styles have been used for a series of DWA reports. Changes at this stage may confuse the general reader.
Section 2.2.1		Include the EcoRegion map here as an example.	Yes	This will be shown as Appendix A.
Section 2.3		Refer to a map here where these rivers and catchments are clearly defined.	Yes	Reference is made to the Desktop EcoClassification Report for the study, which has a series of hotspot maps.
Various	MRU Delineation figures	Show a proper map with the dams and town etc. on it	No	The maps show important towns and dams that influenced the delineation of the reach.
Figure 3.1 and other similar figures	MRU Delineation figures	Just to clarify this does not reflect the PES. I think you should add the PES for each SQR.	No	The focus of this report is on the delineation of reaches. Therefore the colours of the reaches do not relate to the PES of the reach but indicates different EcoRegions, geomorphological zones and Natural Resource Units. The PES for each SQ reach is discussed in detail in the Desktop EcoClassification report and

Section	Report Statement	Comments	Addressed in Report?	Author Comment
				therefore not addressed in this report, although the PES is provided for the different RUs – Figure 3.2.
General comment	Give a conclusion before you go into the references it ends up very blunt perhaps to say what the next step is after the delineation and the report that follow on this and perhaps a website reference.		No	This is covered in the introduction of the next report, i.e. the RDM reports for the study. Steps are also outlined in the Inception Report. The website reference is shown in the cover pages of the report.
General comment	Please align figures and sub and bottom names of tables and figures		Yes	